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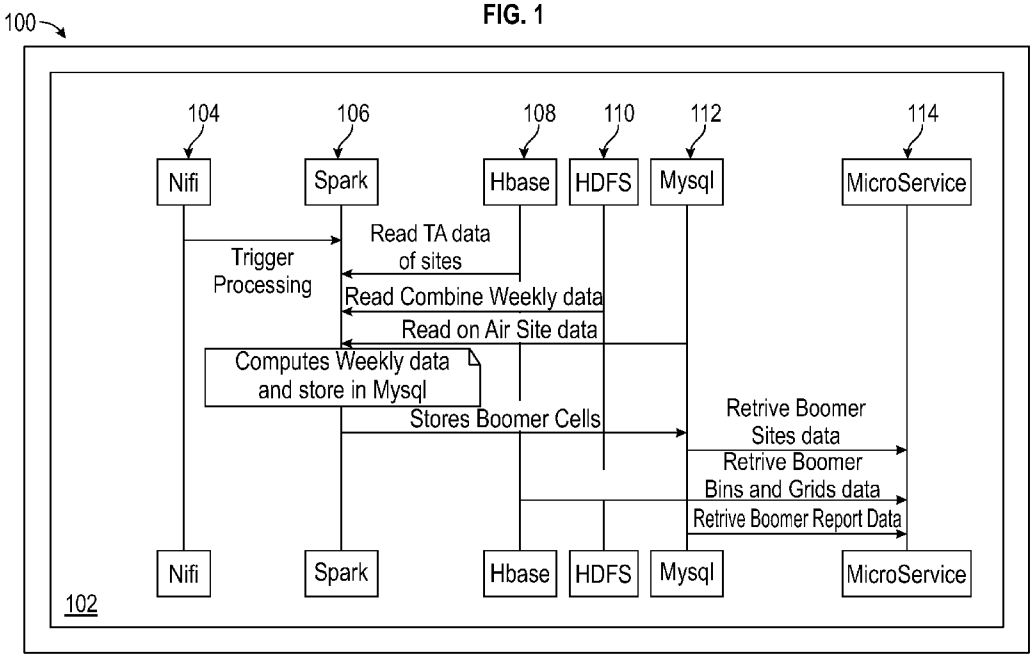
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(54) **Title:** ELECTRONIC TILT COVERAGE

FIG. 1



(57) **Abstract:** A booming cell start distance and recommended electronic tilt is identified by retrieving a list of cells served by a first base station. A plurality of grids is generated from the first base station to a predetermined threshold distance. A plurality of selected grids is identified between an acceptable coverage limit and a threshold distance. An evaluation is made regarding whether the first base station is not the dominant cell in each of the selected grids based. The number of grids where the first base station is not the dominant cell site is determined based on a dominant carrier threshold. A column of grids where the first base station is no longer the dominant cell site is determined based on the dominant carrier threshold. A bad booming distance of the cell is determined based on the distance from the first base station and the determined column of grids.

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ELECTRONIC TILT COVERAGE

PRIORITY CLAIM AND CROSS-REFERENCE

This application claims priority to U.S. Non-Provisional Application No. 17/646,145 filed December 28, 2021, which is hereby incorporated by reference in its entirety.

BACKGROUND

[0001] Open Radio Access Network (RAN) is a standard for RAN interfaces that allow interoperability of equipment between vendors. Open RAN networks allow processing of information to manage the network at a central location. Because of unique properties at the base station, deployed radios encounter interference from other radios in the neighborhood.

[0002] Radio interference results in sub-optimal network coverage. Often sub-optimal networks require expensive deployment of additional base stations.

BRIEF DESCRIPTION OF THE DRAWINGS

[0003] Aspects of the present disclosure are best understood from the following detailed description when read with the accompanying figures. It is noted that, in accordance with the standard practice in the industry, various features are not drawn to scale. In fact, the dimensions of the various features may be arbitrarily increased or reduced for clarity of discussion.

[0004] FIG. 1 is a diagram of a system for electronic tilt determination,

according to at least one embodiment of the present system.

[0005] FIG. 2 is a diagram of a sector generated for electronic tilt determination, according to at least one embodiment of the present system.

[0006] FIG. 3 is a diagram for a grid generated, according to at least one embodiment of the present system.

[0007] FIG. 4 is an operational flow of a method for automatic cell range determination, according to at least one embodiment of the present system.

[0008] FIG. 5 is an operational flow of a method for identifying suspected booming cells, according to at least one embodiment of the present system.

[0009] FIG. 6 is an operational flow of a method for determining acceptable coverage limit, according to at least one embodiment of the present system.

[0010] FIG. 7 is an operational flow of a method for determining electronic tilt, according to at least one embodiment of the present system.

[0011] FIG. 8 is a block diagram of an exemplary hardware configuration for automatic cell range detection, according to at least one embodiment of the present system.

DETAILED DESCRIPTION

[0012] The following disclosure provides many different embodiments, or examples, for implementing different features of the provided subject matter. Specific examples of components, values, operations, materials, arrangements, or the like, are described below to simplify the present disclosure. These are, of course, merely examples and are not intended to be limiting. Other components, values, operations, materials, arrangements,

or the like, are contemplated. In addition, the present disclosure may repeat reference numerals and/or letters in the various examples. This repetition is for the purpose of simplicity and clarity and does not in itself dictate a relationship between the various embodiments and/or configurations discussed.

[0013] In some embodiments, a system determines an electronic tilt based on signal information received and processed in a cloud environment for managing a radio network. For example, the system is able to determine an electronic tilt to change the tilt of a base station radio to correct booming.

[0014] In some embodiments, the system is able to use the booming start distance to dynamically manage the open ran network. For example, the system uses the booming start distance information to change the electronic tilt of the radio on the base station to target a location within the cell site where a majority of the users are present. In at least one example, the system uses the booming start distance in real-time to optimize the radio network during transient changes to usage patterns. In at least one example, the system uses the booming start distance in real-time to optimize the radio network instead of deploying additional base stations or radios based on the number of users in a specific location that are experiencing bad network coverage. In at least one example, the system uses the booming start distance information to determine whether deploying additional base stations is more optimal compared to leasing additional network coverage from a partner network.

[0015] In an embodiment, a system determines a booming cell start distance and recommended electronic tilt. In some embodiments, the system

retrieves a list of cells that are served by a first base station from a site database that includes a predetermined threshold of sufficient geo-located samples that are beyond the good coverage limit. In some embodiments, the system generates a plurality of girds from the first base station to a predetermined threshold distance in the direction of the azimuth of the first base station. In some embodiments, the system identifies a plurality of selected grids that are between the acceptable coverage limit and the predetermined threshold distance from the plurality of grids. In some embodiments, the system determines an average reference signal received power from the first base station in the cell site located within each of the plurality of selected grids. In some embodiments, the system determines a median grid level reference signal received power for cell sites from base stations that are received at each of the plurality of selected gird. In some embodiments, the system evaluates whether the first base station is not the dominant cell in each of the plurality of selected grids based on the average reference signal received power and the median grid level reference signal. In some embodiments, the system determines the number of grids in the plurality of selected grids where the first base station is not the dominant cell site based on a dominant carrier threshold. In some embodiments, the system determines a column of grids where the first base station is no longer the dominant cell site based on the dominant carrier threshold. In some embodiments, the system determines the bad booming distance of the cell based on the distance from the first base station and the determined column of girds. In some embodiments, the system determines a column of grids where the first base station is no longer the dominant cell site based on a

booming start threshold. In some embodiments, the system marks the determined column of grids as the booming start distance. In some embodiments, the system determines an electric tilt based on the booming start distance.

[0016] FIG. 1 is a diagram of a system 100 for electronic tilt determination, according to at least one embodiment of the present system. The diagram includes system 100 for hosting a cloud architecture 102. The system 100 includes components described hereinafter in FIG. 8. In some embodiments, the system 100 is hosted on a cluster of servers, such as a cloud service. In some embodiments, the system 100 hosts a public cloud. In some embodiments, the system 100 hosts a private cloud.

[0017] The system 100 includes a NiFi component 104, a spark component 106, an HBase component 108, a HDFS component 110, a MySQL component 112, and a micro service component 114.In some examples, the operations of the components of the system 100 are executed by a processor. In some examples, the operations of the components of the system 100 are executed on different processors. In some examples, the operations of the components of the system 100 are split between multiple processors.

[0018] The NIFI component 104 is configured to ingest streaming data from multiple sources, such as devices connected to a cloud service, other servers and sources in real-time or from a database. In some embodiments, NIFI component 104 operates in a cluster. In at least one example, the cluster includes a group of nodes hosted on virtual machines and connected within a virtual private cloud. Examples of NIFI components include an event hub or a kinesis service in a cloud service. The NIFI component 104 is

configured to assist in flow-based programming, such as data from radio access networks. In some embodiments, NIFI component 104 triggers processing based on data arriving from the radio access network. In some embodiments, NiFi component 104 triggers processing periodically. In some embodiments, NiFi component 104 triggers processing when the data ingested exceeds a predetermined data threshold.

[0019] The spark component 106 is configured to parallel process a large set of data such as streaming data from a radio access network. In some embodiments the spark component 106 operates in a cluster. The spark component 106 is configured to handle a stream of data either in real-time or in batches.

[0020] The Hbase component 108 is configured to store column oriented non-relational data in a database. In some embodiments, the Hbase component 108 runs on top of Hadoop Distributed File System (HDFS) component 110. Hbase component 108 is configured to store large data sets such as data produced by a cellular network.

[0021] The HDFS component 110 is configured to store raw data from multiple sources, such as devices connected to a cloud service, other servers and sources in real-time or from a database. In some embodiments, batch processing data is stored in the HDFS component 110 before the data is processed through the spark component 106. The MySQL component 112 is configured to store processed data. In some embodiments, the MySQL component 112 serves any real-time user interface elements. In some embodiments, the MySQL component 112 stores aggregated and correlated data after processing.

[0022] The micro services component 114 is configured to run as a collection of services. In some embodiments, the micro services component 114 provides a collection of services that are easy to maintain, easy to test, are loosely coupled between the services, and independently deployable.

[0023] In some embodiments, the Nifi component 104 triggers processing when the data is received from a radio device or a base station. The Nifi component 104 passes information to the spark component 106. The spark component 106 processes information from multiple sources such as reading the data from the Hbase component 108, the hdfs component 110 and the MySQL component 112. For example, the spark component 16 can process information about the data from the cell sites stored in the Hbase component 108, the combined weekly data from the cell sites stored in the hdfs component 109 and the on air side data stored in the MySQL component 112 to compute the boomer cells to store the information in the MySQL component 112.

[0024] In at least one example, the micro service component 114 retrieves information from the MySQL component 112, the Hbase component 108, and the HDFS component to visualize the information for presentation using a graphical user interface. In some embodiments, the micro services component 114 retrieves the bomber bins and grids data from the Hbase component 108. In some embodiments, the micro services component 114 retrieves information from the MySQL component about the booming sites to visualize the information.

[0025] The system 100 is configured to perform auto cell range determination. In some embodiments, the system 100 includes a cloud

architecture that receives data from a radio access network. Example of the data received includes a site database. In some embodiments, the site database is hosted on the MySQL component 112. In some embodiments, the site database includes information from one or more of the cell sites or base stations in the radio access network including the Latitude, Longitude, Azimuth, band details, on-air status, on-air date, evolved NodeB IDentifier, E-UTRAN Cell Global Identifier, Antenna height, Electrical tilt, Mechanical tilt and the like. In some embodiments, the cloud architecture receives clutter data of the base station or cell site such as morphology of the cell site or base station.

[0026] In some embodiments, the system 100 receives geographical boundaries. In at least one example, a geographical boundary is a cell network boundary, a good coverage limit for a base station and the like. In some embodiments, the system 100 receives a best server plot. In some embodiments, the best server plot data is received from a predictive coverage tool for on-air sites or base station.

[0027] In some embodiments, the system 100 receives geo-located data collected using drive test tools, as well as passively collected data from users in the network. For example, the geo-located data is based on user equipment data from the last seven days. In some embodiments, the system 100 receives data such as the above mean sea level heights of radios, antennas or both at a cell site or a base station. In some embodiments, the system 100 receives PM KPI including timing advance distribution sample counts, mean CQL, DL MCS, Mean UL MCS and the like.

[0028] In some embodiments, the system 100 receives information such

as the tilt parameters for electrical tilt. In some embodiments, the system 100 receives data about new cell sites or base stations in the network in the past seven days.

[0029] The system 100 is configured to automatically detect cell range for a first base station 230 or a cell site. In some embodiments, the system 100 determines a sector 202 (FIG. 2) at a first base station 230. In some embodiments, the system 100 determines the sector 202 (shown in FIG. 2) based on the morphology, the longitude, latitude and azimuth of the radio or antenna. In some embodiments, the sector 202 encloses a 210 degree sector with a center at the longitude and latitude of the cell site or a first base station in the direction of the beam of the radio network.

[0030] In some embodiments, the system 100 determines a sector 105 degrees to the left and the right side of the azimuth line of the radio or antenna. In some embodiments, the system 100 divides the sector 202 into subsectors 204a-g. In some embodiments, the system 100 divides the section of 210 degrees into seven subsectors 204a-g of 30 degrees each. In some embodiments, the number of subsectors is based on the bearing angle and coverage of the radio signals. In some embodiments, the number of subsectors is based on the processing load on the system 100, which increases without a significant improvement in performance of the system 100. If the number of subsectors is too small, the system 100 has difficulty determining a nearest neighbor because of the bearing angle and the width of the coverage of the radio networks in the field. In some embodiments, the system 100 determines the sector size using a maximum search limit threshold. In at least one example, the maximum search limit threshold is

6000 meters. In some embodiments, the maximum search limit threshold is based on manufacturer specifications detailing the range where the equipment provides optimal coverage. In some embodiments, if the maximum search limit threshold is too high the processing load on the system 100 increases without a significant improvement in performance of the system 100. In some embodiments, the system 100 determines a nearest neighbor cell site or base station from the first base station at the center of the sector.

[0031] In some embodiments, the system 100 determines the nearest neighbor base station from the first base station 230 for each subsector (204a-204g). In some embodiments, the system 100 stores the distance between the first base station 230 and the nearest neighboring cell site or base station.

[0032] In some embodiments, the system 100 saves the location of each of the neighboring cells in each of the subsectors 204a-g. For example, the system 100 saves the latitude, longitude and azimuth for the neighboring cell site or base station found in each of the subsectors 204a-g. In some embodiments, the system 100 calculates the average distance from the nearest neighboring cell site or base station and the first base station or cell site for each of the subsectors 204a-g. In some embodiments, the system 100 determines the standard deviation of the average distance for each subsector 204a-g.

[0033] In some embodiments, the system 100 determines whether the nearest neighboring base station or cell site in each subsector 204a-g is opposite to the first base station 230 or cell site. The system 100 determines

the average distance using the average distance of the subsectors 204a-g with a base station opposite the first base station 230. In some embodiments, the system 100 discards the information such as nearest neighboring cell in the first subsector 204a and the last subsector 204g which are not facing the first base station 230 while calculating the average and the standard deviation.

[0034] In some embodiments, the system 100 determines a mean distance V based on the average distance in the subsector and the standard deviation of average distance. In some embodiments, the system 100 determines whether the distance of the nearest neighboring cell or the base station is greater than the mean distance V. In response to a determination that the distance of the nearest neighboring cell or the base station is greater than the mean distance v, the system 100 flags the cells as opposing the first base station 230 or cell site. In some embodiments, the system 100 flags the middle three subsectors 204b-204f which are closest to the azimuth of the first base station 230 as directly opposite to the first base station 230 or cell site. For example, the system 100 can set a standard deviation flag of 1 to indicate the nearest neighboring base station or cell site is opposite to the first base station 230. In another example, the system 100 can determine a multiplying factor based on whether bearing angle of the nearest neighboring cell site. In at least one example, the system 100 can determine the bearing angle B of the line joining the longitude and latitude of the first base station 230 or cell site and the nearest neighboring cell site. In some embodiments, the system 100 can determine whether the difference between the bearing angle of the first base station 230 or cell site and the nearest neighboring

cell site or base station in a subsector is within a range of -30 degrees to + 30 degrees. The system 100 can determine the multiplying factor based on the difference between the bearing angles of the radio beam. The multiplying factor can indicate the degree of orthogonality of the neighboring base station or cell site in the subsector and the first base station 230 or cell site. For example, the multiplying factor is 0.7 if the difference in bearing angle is within a range of -30 degrees to +30 degrees. In another example, the multiplying factor is 1.5 when the difference between the bearing angles is outside the range of -30 degrees to +30 degrees.

[0035] In some embodiments, the system 100 determines the gain for each subsector. In at least one example, the system 100 determines the gain for subsectors closest to the azimuth of the first base station or cell site is two and the gain for the sectors that are further away from the azimuth of the first base station or cell site is one. In some embodiments, the system 100 determines the cell range for the base station based on the distance of the first base station 230 or cell site from the neighboring base station and the gain of the neighboring base station. For example, the system 100 determines the cell range use the formula, Cell Range = sum (D_i * M_i * G_i * StdDev_i) / sum (G_i * If Neighbor Found (i) * StdDev_i), where D_i is the distance between the first base station and the nearest neighboring base station, M_i is the multiplying factor for the first base station and the nearest neighboring base station M in a subsector, G_i is the gain of the subsector and StdDev_i is the standard deviation flag of the subsector.

[0036] In some embodiments, the system 100 sets a default value, such as 11 kilometers if the calculated cell range is zero or infinity. For example, the

default value is based on the manufacturer's specifications.

[0037] In some embodiments, the system 100 determines whether a cell site in a subsector 204a-g is a suspected booming site based on the timing advance distribution key performance indicator data. The system 100 retrieves information about on-air cell sites or base stations from the site database. In at least one example, the system 100 determines the count of the continuous gaps in the timing advance distribution key performance indicator data to determine the range beyond a cell site may be booming. In some embodiments, the system 100 determines the booming samples measured during a drive test. In some embodiments, the system 100 determines the booming samples based on data logged in the system 100 from user equipment in the subsectors. In some embodiments, system 100 determines the booming samples that are received beyond the configured count of the continuous gaps. The system 100, determines the percentage of booming samples based on the sum of the booming samples detected after the defined continuous gap and the total number of timing advance distribution samples for a cell. In some embodiments, the system 100 determines whether the percentage of booming samples is greater than a booming sample threshold. In some embodiments, the system 100 discards the cell site if the booming sample threshold is less than the percentage of the booming samples.

[0038] In some embodiments, the system 100 excludes on-air cell sites or base stations from the site database to determine the distant suspected cell site. In some embodiments, the system 100 retrieves the timing advance distribution key performance indicator data from the site database. In some

embodiments, the system 100 identifies the new acceptable coverage limit or cell range based on the automatic cell range algorithm as disclosed above. In some embodiments, the system 100 can determine whether the booming samples in the timing advance distribution key performance indicator is beyond the calculated cell range. Based on a determination that the booming samples are beyond the calculated cell range, the system 100 can identify the percentage of booming samples based on the sum of booming samples that are beyond the calculated cell range and the total number of timing analysis samples for the cell.

[0039] In some embodiments, the system 100 determines whether the percentage of booming samples is greater than a booming sample threshold. The booming sample threshold can be based on historical data. In some embodiments, the system 100 discards the cell site if the booming sample threshold is less than the percentage of the booming samples.

[0040] In some embodiments, the system 100 can determine whether a suspected booming cell site needs more information before it is identified as a booming cell site based on the good coverage limit. In some embodiments, the system 100 determines whether to mark a cell as a booming cell based on the good coverage limit such as the manufacturer specification limits. In some embodiments, the system 100 determines whether to mark a cell as a booming cell based on the automated cell range algorithm described above. In some embodiments, the system 100 can retrieve cells identified as suspected booming cell sites from the site database. The system 100 can determine whether the good coverage limit is available. Based on a determination that the good coverage limit value is not available, the system

100 can assign the automated cell range to the cell. The system 100 can determine whether the count of the geo-located samples in a cell is greater than a minimum threshold of samples. Based on a determination, that the count of the geo-located samples in the cell is greater than the minimum threshold of samples, the system 100 can exclude or discard the data on the cell site from further calculation. The system 100 can identify the cell sites or base station where more information is to be collected based on the minimum threshold of samples and the count of the geo-located samples.

[0041] FIG. 2 is a diagram of a sector generated for Electronic Tilt determination, according to at least one embodiment of the present system. In some embodiments, the system 100 determines a sector 105 degrees to the left and the right side of the azimuth line of the radio or antenna. In some embodiments, the system 100 divides the sector 202 into subsectors 204a-g. In some embodiments, the system 100 divides the section of 210 degrees into seven subsectors 204a-g of 30 degrees each. In some embodiments, the number of subsectors is based on the bearing angle and coverage of the radio signals.

[0042] FIG. 3 is a diagram of a grid layout generated by the system 100 for determining good coverage limit and generating an electronic recommendation, according to at least one embodiment of the present system. In some embodiments, the system 100 retrieves a list of cells that are served by the first base station 230 from the site database. In some embodiments, the system 100 retrieved data that includes a predetermined threshold of geo-located samples that are beyond a good coverage limit 204. In some embodiments, the system 100 generates grids 232a-n of z meters

by z meters (only some grids are highlighted in the figure) from the first base station 230 to a predetermined threshold distance in the direction of the azimuth of the first base station 230. In at least one example, the grids 232 are 50meter x 50meter grids.

[0043] In some embodiments, the system 100 identifies a plurality of selected grids that are between an acceptable coverage limit provided by the manufacturer and the predetermined threshold distance from the plurality of grids. In some embodiments, the system, 100 determines an average reference signal received power from the first base station 230 in a cell site located within each of the selected grids. In some embodiments, the system 100, determines a median grid level reference signal received power for cell sites from neighboring base stations that are received at each of the selected girds. In some embodiments, the system 100 evaluates whether the first base station 230 is a dominant cell in each of the plurality of selected grids based on the average reference signal received power and the median grid level reference signal. In some embodiments, the system 100 determines a count of grids in the plurality of selected grids where the first base station 230 is a dominant cell site based on a dominant carrier threshold. In at least one example, the dominant carrier threshold is a percentage of the average reference power signal and the median grid level reference signal.

[0044] In some embodiments, the system, 100 determines a column of grids 214 where the first base station 230 is no longer a dominant cell site based on the dominant carrier threshold. In some embodiments, the system 100 determines the good coverage limit based on the distance from the first base station 230 and the determined column of grids 214. In some

embodiments, the system 100 determines whether the average reference signal received power is greater than the median reference signal received power based on a threshold difference parameter indicating the deviation between the values that is acceptable. In some embodiments, the system 100 based on the determination that the average reference signal received power is greater, marks the first base station 230 as the dominant cell.

[0045] In some embodiments, the system 100 retrieves a list of cells that are served by a first base station 230 from a site database. In some embodiments, the system 100 retrieves a predetermined threshold of geo-located samples that are beyond a good coverage limit 204. In some embodiments, the system 100 generates a plurality of girds from the first base station 230 to a predetermined threshold distance in the direction of the azimuth of the first base station 230. In some embodiments, the system 100 identifies selected grids that are between the acceptable coverage limit and the predetermined threshold distance from the first base station 230. In some embodiments, the system 100, determines an average reference signal received power from the first base station 230 in a cell site located within each of the selected grids. In some embodiments, the system 100 determines a median grid level reference signal received power for cell sites from base stations that are received at each of the selected girds. In some embodiments the system 100 evaluates whether the first base station 230 is a dominant cell in each of the selected grids based on the average reference signal received power and the median grid level reference signal. In some embodiments, the system 100 determines a count of grids in the selected grids where the first base station 230 is a dominant cell site based

on a dominant carrier threshold. In some embodiments, the system 100 determines a column of grids where the first base station 230 is no longer a dominant cell site based on the dominant carrier threshold. In some embodiments, the system 100 determines a good coverage limit based on the distance from the first base station 230 and the determined column of girds.

[0046] FIG. 4 is an operational flow for determining a cell range for a first base station in accordance with at least one embodiment. In some embodiments, the first base station corresponds to the first base station 230 (FIG. 2). In some embodiments, the method 400 is implemented using a controller of a system, such as system 100 (FIG. 1), or another suitable system. In at least some embodiments, the method is performed by the system 100 or a controller shown in FIG. 8 including sections for performing certain operations, such as the system shown in FIG. 8 which will be explained hereinafter. At S402, the controller, such as the controller in FIG. 8, determines a sector straddling an azimuth line of a first base station as shown in FIG. 2 with a center at the coordinates of a first base station 230.

[0047] In some embodiments, at S404, the controller divides the sector into a plurality of sub-sectors. In at least one example, the sector is divided into a plurality of subsectors 204a-j as shown in FIG 2, for example using system 100 (FIG. 1). In some embodiments, at S406 the controller determines a nearest neighbor base station from the first base station in each of the plurality of subsectors. In at least one example, the controller determines the nearest neighbor base station from the first base station 230 in each of the plurality of subsectors 204a-j.

[0048] In some embodiments, at S408 the controller determines a set of coordinates for the nearest neighbor base station in each of the plurality of subsectors. In at least one example, the controller determines a set of coordinates for the nearest neighbor base station in each of the plurality of subsectors 204a-j, for example using system 100 (FIG 1). In some embodiments, at S410 the controller determines a distance between each of the nearest neighbor base stations in each of the plurality of subsectors and the first base station. In at least one example, the controller determines the distance between each of the nearest neighbor base stations in each of the plurality of subsectors 204a-j and the first bases station 230, for example using system 100 (FIG 1). In some embodiments, the controller at S412 determines an average distance between each of the nearest neighbor base stations in each of the plurality of subsectors and the first base station. In at least one example, the controller determines an average distance between each of the nearest neighbor base stations in each of the plurality of subsectors 204a-j and the first base station 230, for example using system 100 (FIG 1). In some embodiments, the controller at S414 determines a bearing angle difference between the nearest neighbor base station in each of the plurality of subsectors and the first base station based on the set of coordinates of the nearest neighbor base station in each of the plurality of subsectors. In at least one example, the controller determines a bearing angle difference between the nearest neighbor base station in each of the plurality of subsectors and the first base station 230 based on the set of coordinates of the nearest neighbor base station in each of the plurality of subsectors, for example using system 100 (FIG 1). In some embodiments,

the controller at S416 determines a gain for each of the plurality of subsectors based on the bearing angle difference. In some embodiments, at S416 the controller determines a cell range for the first base station based on the determined gain, for example using system 100 (FIG 1).

[0049] FIG. 5 is an operational flow for suspected cell identification, according to at least one embodiment of the present system. In some embodiments, the method 500 is implemented using a controller of a system, such as system 100 (FIG. 1), or another suitable system.

[0050] In some embodiments at S502, the controller retrieves data about an on-air base station from a site database. In at least one example, the controller such as the controller in FIG. 8 retrieves data about an on-air base station 230 from a site database, for example using the system 100 (FIG. 1). In some embodiments, at S504, the controller retrieves a timing advance distribution key performance indicator data for a cell site served by the on-air base station from the on-air base station data. In at least one example, the controller such as the controller in FIG. 8 retrieves a timing advance distribution key performance indicator data for a cell site served by the on-air base station 230 from the on-air base station data. In some embodiments at S506, the controller determines a count of configured gaps for the cell site in the timing advance distribution key performance indicator data. In at least one example, the controller such as the controller in FIG. 8., determines a count of configured gaps for the cell site in the timing advance distribution key performance indicator data. In some embodiments at S508, the controller determines a count of booming samples that lie beyond the configured count of gaps for the cell site based on the timing advance

distribution key performance indicator data. In at least one example, the controller such as the controller in FIG. 8., determines a count of booming samples that lie beyond the configured count of gaps for the cell site based on the timing advance distribution key performance indicator data. In some embodiments, at S510, the controller determines a sum of the count of the timing advance distribution key performance indicator data available for the cell site. . In at least one example, the controller such as the controller in FIG. 8., determines a sum of the count of the timing advance distribution key performance indicator data available for the cell site. In some embodiments, at S512, the controller determines a percentage of booming cells based on the count of booming samples and the sum of the count of the timing advance distribution key performance indicator. In at least one example, the controller such as the controller in FIG. 8., the controller determines a percentage of booming cells based on the count of booming samples and the sum of the count of the timing advance distribution key performance indicator.

[0051] FIG. 6 is an operational flow for good coverage limit, according to at least one embodiment of the present system. In some embodiments, the method 600 is implemented using a controller of a system, such as system 100 (FIG. 1), or another suitable system. In some embodiments at S602, the controller retrieves a list of cells that are served by a first base station from a site database that includes a predetermined threshold of geo-located samples that are beyond a good coverage limit. In at least one example, the controller retrieves a list of cells that are served by a first base station 230 from a site database that includes a predetermined threshold of geo-located

samples that are beyond a good coverage limit 204 as shown in FIG. 3 for example using system 100 (FIG. 1). In some embodiments at S504, the controller generates grids from the first base station to a predetermined threshold distance in the direction of the azimuth of the first base station. In at least one example, the predetermined threshold distance is based on the theoretical limit of the radio transmission from the base station. In at least one examples, the predetermined threshold distance is based on the distance beyond which the processing power required to receive the signals by a user equipment results in quick power drain of the user equipment without substantial improvement in coverage. In at least one example, the controller generates grids 232a-n from the first base station 230 to a predetermined threshold distance in the direction of the azimuth of the first base station 230 as shown in FIG. 3 for example using system 100 (FIG. 1). In some embodiments at S606, the controller identifies a plurality of selected grids that are between an acceptable coverage limit provided by the manufacturer and the predetermined threshold distance from the first base station. In at least one example, at S606, the controller identifies a plurality of selected grids that are between an acceptable coverage limit provided by the manufacturer and the predetermined threshold distance from the first base station 230 for example using system 100 (FIG. 1). In some embodiments at S508, the controller determines an average reference signal received power from the first base station in a cell site located within each of the plurality of selected grids, for example using system 100 (FIG. 1).. In at least one example, the controller determines an average reference signal received power from the first base station 230 in a cell site located within each of the

plurality of selected grids. In some embodiments at S510, the controller determines a median grid level reference signal received power for cell sites from base stations that are received at each of the plurality of selected gird. In at least one example, the controller determines a median grid level reference signal received power for cell sites from base stations that are received at each of the plurality of selected gird. In some embodiments at S512, the controller evaluates whether the first base station is a dominant cell in each of the plurality of selected grids based on the average reference signal received power and the median grid level reference signal. In at least one example, the controller evaluates whether the first base station 230 is a dominant cell in each of the plurality of selected grids based on the average reference signal received power and the median grid level reference signal, for example using system 100 (FIG. 1). In some embodiments, the controller determines a count of grids in the plurality of selected grids where the first base station is a dominant cell site based on a dominant carrier threshold. In at least one example, the controller determines a count of grids in the plurality of selected grids where the first base station 230 is a dominant cell site based on a dominant carrier threshold, for example using system 100 (FIG. 1). In some embodiments, the controller determines a column of grids where the first base station is no longer a dominant cell site based on the dominant carrier threshold. In at least one example, the controller determines a column of grids 212 where the first base station 230 is no longer a dominant cell site based on the dominant carrier threshold, for example using system 100 (FIG. 1). In at least one example, the dominant carrier threshold is based on the threshold at which one carrier signal is

available with a higher signal strength compared to the other carrier signal. In at least one example, the dominant carrier threshold is based on the threshold that reduces the power consumption of the user equipment when the dominant carrier signal is used. In some embodiments, the controller determines the good coverage limit based on the distance from the first base station and the determined column of girds. In at least one example, the controller determines the good coverage limit 204 based on the distance from the first base station 230 and the determined column of girds 204a-j, for example using system 100 (FIG. 1).

[0052] FIG. 7 is an operational flow for determining electronic tilt, according to at least one embodiment of the present system. In some embodiments, the method 700 is implemented using controller of a system, such as system 100 or another suitable system.

[0053] In some embodiments, at S702, the controller retrieves a list of cells that are served by a first base station from a site database that includes a predetermined threshold of geo-located samples that are beyond a good coverage limit. In at least one example, the controller such as the controller in FIG. 8 the controller retrieves a list of cells that are served by a first base station from a site database that includes a predetermined threshold of geo-located samples that are beyond a good coverage limit, for example using system 100 (FIG. 1). In some embodiments, at S704, the controller generates a plurality of girds from the first base station to a predetermined threshold distance in the direction of the azimuth of the first base station. In at least one example, the controller generates a plurality of girds from the first base station 230 to a predetermined threshold distance in the direction

of the azimuth of the first base station 230, for example using the system 100 (FIG. 1).

[0054] In some embodiments, at S706, the controller identifies a plurality of selected grids that are between an acceptable coverage limit provided by the manufacturer and the predetermined threshold distance from the plurality of grids. In at least one example, the controller identifies a plurality of selected grids that are between an acceptable coverage limit provided by the manufacturer and the predetermined threshold distance from the plurality of grids, for example using the system 100 (FIG. 1). In some embodiments, at S708 the controller determines an average reference signal received power from the first base station in a cell site located within each of the plurality of selected grids. In at least one example, the controller determines an average reference signal received power from the first base station in a cell site located within each of the plurality of selected grids, for example using the system 100 (FIG. 1). In some embodiments, at S710, the controller determines a median grid level reference signal received power for cell sites from base stations that are received at each of the plurality of selected gird. In at least one example, the controller such as the controller in FIG. 8 determines a median grid level reference signal received power for cell sites from base stations that are received at each of the plurality of selected gird, for example using the system 100 (FIG. 1). In some embodiments, at S712, the controller evaluates whether the first base station is not a dominant cell in each of the plurality of selected grids based on the average reference signal received power and the median grid level reference signal. In at least one example, the controller such as the controller in FIG.

8 evaluates whether the first base station is not a dominant cell in each of the plurality of selected grids based on the average reference signal received power and the median grid level reference signal, for example using the system 100 (FIG. 1).

[0055] In some embodiments, at S714, the controller determines a count of grids in the plurality of selected grids where the first base station is not a dominant cell site based on a dominant carrier threshold. In at least one example, the controller such as the controller in FIG. 8 determines a count of grids in the plurality of selected grids where the first base station is not a dominant cell site based on a dominant carrier threshold, for example using the system 100 (FIG. 1). In some embodiments, at S716, the controller determines a column of grids where the first base station is no longer a dominant cell site based on the dominant carrier threshold. In at least one example, the controller such as the controller in FIG. 8 determines a column of grids where the first base station is no longer a dominant cell site based on the dominant carrier threshold, for example using the system 100 (FIG. 1).

[0056] In some embodiments, at S718, the controller determines a bad booming distance based on the distance from the first base station and the determined column of girds. In at least one example, the controller such as the controller in FIG. 8 determines a bad booming distance based on the distance from the first base station and the determined column of girds, for example using the system 100 (FIG. 1). In some embodiments, at S720, the controller determines a second column of grids where the first base station is no longer a dominant cell site based on a booming start threshold.

In at least one example, the controller such as the controller in FIG. 8 determines a second column of grids where the first base station is no longer a dominant cell site based on a booming start threshold, for example using the system 100 (FIG. 1).

[0057] In some embodiments, the controller stores the determined column of grids as the booming start distance. In some embodiments, at S722, the controller determines a recommended electronic tilt reduction based on at least one of an above mean sea level antenna height, an above mean sea level receiver height, a good coverage limit, and a booming end distance. In some embodiments, the controller determines the proposed e-tilt based on the formula:

Proposed E-Tilt Reduction = Ceil (- (Degrees (ATAN (AMSL Antenna Height – AMSL Receiver Height)/Good Coverage Limit) - ATAN (AMSL Antenna Height – AMSL Receiver Height)/Boomer End Distance))))

Where, AMSL means Above Mean Sea Level, AMSL Antenna Height is the sum of Antenna Height of a cell added to the calculated AMSL value of the same cell, AMSL Receiver Height is the sum of Receiver Height plus the calculated AMSL. FIG. 8 is a block diagram of an exemplary hardware configuration for application artifact registration, according to at least one embodiment of the present system.

[0058] The exemplary hardware configuration includes the system 100, which communicates with network 809, and interacts with input device 807. In at least some embodiments, apparatus 800 is a computer or other computing device that receives input or commands from input device 807. In at least some embodiments, the system 100 is a host server that connects

directly to input device 807, or indirectly through network 809. In at least some embodiments, the system 100 is a computer system that includes two or more computers. In at least some embodiments, the system 100 is a personal computer that executes an application for a user of the system 100.

[0059] The system 100 includes a controller 802, a storage unit 804, a communication interface 808, and an input/output interface 806. In at least some embodiments, controller 802 includes a processor or programmable circuitry executing instructions to cause the processor or programmable circuitry to perform operations according to the instructions. In at least some embodiments, controller 802 includes analog or digital programmable circuitry, or any combination thereof. In at least some embodiments, controller 802 includes physically separated storage or circuitry that interacts through communication. In at least some embodiments, storage unit 804 includes a non-volatile computer-readable medium capable of storing executable and non-executable data for access by controller 802 during execution of the instructions. Communication interface 808 transmits and receives data from network 809. Input/output interface 806 connects to various input and output units, such as input device 807, via a parallel port, a serial port, a keyboard port, a mouse port, a monitor port, and the like to accept commands and present information.

[0060] Controller 802 includes a NiFi component 884, a spark component 882, an HBase component 881, a HDFS component 880, and a micro service component 878.NiFI component 884 is the circuitry or instructions of controller 802 configured to process a stream of information from a device or a server. In at least some embodiments, NiFi component 884 is configured

to receive information such as information from an open-RAN network. In at least some embodiments, the NiFI component is configured for deployment of a software service in a cloud native environment to process information in real-time. In at least some embodiments, the NiFi component 884 records information to storage unit 804, such as the site database 890, and utilize information in storage unit 804. In at least some embodiments, the NiFI component 884 includes sub-sections for performing additional functions, as described in the foregoing flow charts. In at least some embodiments, such sub-sections may be referred to by a name associated with their function.

[0061] The spark component 882 is the circuitry or instructions of controller 802 configured to create service specifications. In at least some embodiments, the spark component 882 is configured to determine an automatic cell range. In at least some embodiments, the spark component 82 utilizes information in storage unit 804, the Hbase component 881, and the HDFS component 880. In at least some embodiments, the spark component 882 includes sub-sections for performing additional functions, as described in the foregoing flow charts. In at least some embodiments, such sub-sections may be referred to by a name associated with their function.

[0062] In at least some embodiments, the apparatus is another device capable of processing logical functions in order to perform the operations herein. In at least some embodiments, the controller and the storage unit need not be entirely separate devices, but share circuitry or one or more computer-readable mediums in some embodiments. In at least some embodiments, the storage unit includes a hard drive storing both the computer-executable instructions and the data accessed by the controller,

and the controller includes a combination of a central processing unit (CPU) and RAM, in which the computer-executable instructions are able to be copied in whole or in part for execution by the CPU during performance of the operations herein.

[0063] In at least some embodiments where the apparatus is a computer, a program that is installed in the computer is capable of causing the computer to function as or perform operations associated with apparatuses of the embodiments described herein. In at least some embodiments, such a program is executable by a processor to cause the computer to perform certain operations associated with some or all of the blocks of flowcharts and block diagrams described herein.

Various embodiments of the present system are described with reference to flowcharts and block diagrams whose blocks may represent (1) steps of processes in which operations are performed or (2) sections of a controller responsible for performing operations. Certain steps and sections are implemented by dedicated circuitry, programmable circuitry supplied with computer-readable instructions stored on computer-readable media, and/or processors supplied with computer-readable instructions stored on computer-readable media. In some embodiments, dedicated circuitry includes digital and/or analog hardware circuits and may include integrated circuits (IC) and/or discrete circuits. In some embodiments, programmable circuitry includes reconfigurable hardware circuits comprising logical AND, OR, XOR, NAND, NOR, and other logical operations, flip-flops, registers, memory elements, etc., such as field-programmable gate arrays (FPGA), programmable logic arrays (PLA), etc.

[0064] Various embodiments of the present system include a system, a method, and/or a computer program product. In some embodiments, the computer program product includes a computer readable storage medium (or media) having computer readable program instructions thereon for causing a processor to carry out aspects of the present system.

[0065] In some embodiments, the computer readable storage medium includes a tangible device that is able to retain and store instructions for use by an instruction execution device. In some embodiments, the computer readable storage medium includes, for example, but is not limited to, an electronic storage device, a magnetic storage device, an optical storage device, an electromagnetic storage device, a semiconductor storage device, or any suitable combination of the foregoing. A non-exhaustive list of more specific examples of the computer readable storage medium includes the following: a portable computer diskette, a hard disk, a random access memory (RAM), a read-only memory (ROM), an erasable programmable read-only memory (EPROM or Flash memory), a static random access memory (SRAM), a portable compact disc read-only memory (CD-ROM), a digital versatile disk (DVD), a memory stick, a floppy disk, a mechanically encoded device such as punch-cards or raised structures in a groove having instructions recorded thereon, and any suitable combination of the foregoing. A computer readable storage medium, as used herein, is not to be construed as being transitory signals per se, such as radio waves or other freely propagating electromagnetic waves, electromagnetic waves propagating through a waveguide or other transmission media (e.g., light pulses passing through a fiber-optic cable), or electrical signals transmitted through a wire.

[0066] In some embodiments, computer readable program instructions described herein are downloadable to respective computing/processing devices from a computer readable storage medium or to an external computer or external storage device via a network, for example, the Internet, a local area network, a wide area network and/or a wireless network. In some embodiments, the network may include copper transmission cables, optical transmission fibers, wireless transmission, routers, firewalls, switches, gateway computers and/or edge servers. A network adapter card or network interface in each computing/processing device receives computer readable program instructions from the network and forwards the computer readable program instructions for storage in a computer readable storage medium within the respective computing/processing device.

[0067] In some embodiments, computer readable program instructions for carrying out operations described above are assembler instructions, instruction-set-architecture (ISA) instructions, machine instructions, machine dependent instructions, microcode, firmware instructions, state-setting data, or either source code or object code written in any combination of one or more programming languages, including an object oriented programming language such as Smalltalk, C++ or the like, and conventional procedural programming languages, such as the "C" programming language or similar programming languages. In some embodiments, the computer readable program instructions are executed entirely on the user's computer, partly on the user's computer, as a stand-alone software package, partly on the user's computer and partly on a remote computer or entirely on the remote computer or server. In some embodiments, in the latter scenario, the

remote computer is connected to the user's computer through any type of network, including a local area network (LAN) or a wide area network (WAN), or the connection may be made to an external computer (for example, through the Internet using an Internet Service Provider). In some embodiments, electronic circuitry including, for example, programmable logic circuitry, field-programmable gate arrays (FPGA), or programmable logic arrays (PLA) execute the computer readable program instructions by utilizing state information of the computer readable program instructions to individualize the electronic circuitry, in order to perform aspects of the present system.

[0068] While embodiments of the present system have been described, the technical scope of any subject matter claimed is not limited to the above described embodiments. It will be apparent to persons skilled in the art that various alterations and improvements can be added to the above-described embodiments. It will also be apparent from the scope of the claims that the embodiments added with such alterations or improvements are included in the technical scope of the system.

[0069] The operations, procedures, steps, and stages of each process performed by an apparatus, system, program, and method shown in the claims, embodiments, or diagrams can be performed in any order as long as the order is not indicated by "prior to," "before," or the like and as long as the output from a previous process is not used in a later process. Even if the process flow is described using phrases such as "first" or "next" in the claims, embodiments, or diagrams, it does not necessarily mean that the processes must be performed in this order.

[0070] While embodiments of the present system have been described, the technical scope of any subject matter claimed is not limited to the above described embodiments. It will be apparent to persons skilled in the art that various alterations and improvements can be added to the above-described embodiments. It will also be apparent from the scope of the claims that the embodiments added with such alterations or improvements are included in the technical scope of the system.

[0071] The operations, procedures, steps, and stages of each process performed by an apparatus, system, program, and method shown in the claims, embodiments, or diagrams can be performed in any order as long as the order is not indicated by "prior to," "before," or the like and as long as the output from a previous process is not used in a later process. Even if the process flow is described using phrases such as "first" or "next" in the claims, embodiments, or diagrams, it does not necessarily mean that the processes must be performed in this order. According to at least one embodiment of the present system a booming cell start distance and recommended electronic tilt determination is made in an application by retrieving a list of cells that are served by a first base station from a site database that includes a predetermined threshold of sufficient geo-located samples that are beyond the good coverage limit, generating a plurality of girds from the first base station to a predetermined threshold distance in the direction of the azimuth of the first base station, identifying a plurality of selected grids that are between the acceptable coverage limit and the predetermined threshold distance from the plurality of grids, determining an average reference signal received power from the first base station in the cell site located within each

of the plurality of selected grids, determining a median grid level reference signal received power for cell sites from base stations that are received at each of the plurality of selected gird, evaluating whether the first base station is not the dominant cell in each of the plurality of selected grids based on the average reference signal received power and the median grid level reference signal, determining the number of grids in the plurality of selected grids where the first base station is not the dominant cell site based on a dominant carrier threshold, determining a column of grids where the first base station is no longer the dominant cell site based on the dominant carrier threshold, determining the bad booming distance of the cell based on the distance from the first base station and the determined column of girds, determining a column of grids where the first base station is no longer the dominant cell site based on a booming start threshold, and marking the determined column of grids as the booming start distance.

[0072] Some embodiments include the instructions in a computer program, the method performed by the processor executing the instructions of the computer program, and a system that performs the method. In some embodiments, the system includes a controller including circuitry configured to perform the operations in the instructions.

[0073] The foregoing outlines features of several embodiments so that those skilled in the art may better understand the aspects of the present disclosure. Those skilled in the art should appreciate that they may readily use the present disclosure as a basis for designing or modifying other processes and structures for carrying out the same purposes and/or achieving the same advantages of the embodiments introduced herein.

Those skilled in the art should also realize that such equivalent constructions do not depart from the spirit and scope of the present disclosure, and that they may make various changes, substitutions, and alterations herein without departing from the spirit and scope of the present disclosure.

WHAT IS CLAIMED IS:

1. A computer-readable medium including instructions executable by a computer to perform operations comprising:

retrieving a list of cells that are served by a first base station from a site database that includes a predetermined threshold of geo-located samples that are beyond a good coverage limit;

generating a plurality of girds from the first base station to a predetermined threshold distance in the direction of the azimuth of the first base station;

identifying a plurality of selected grids that are between an acceptable coverage limit and the predetermined threshold distance from the plurality of grids;

determining an average reference signal received power from the first base station in a cell site located within each of the plurality of selected grids;

determining a median grid level reference signal received power for cell sites from base stations that are received at each of the plurality of selected gird;

evaluating whether the first base station is not a dominant cell in each of the plurality of selected grids based on the average reference signal received power and the median grid level reference signal;

determining a count of grids in the plurality of selected grids where the first base station is not a dominant cell site based on a dominant carrier threshold;

determining a column of grids where the first base station is no longer a dominant cell site based on the dominant carrier threshold;

determining a bad booming distance based on the distance from the first base station and the determined column of girds;

determining a second column of grids where the first base station is no longer a dominant cell site based on a booming start threshold; and

marking the determined column of grids as the booming start distance.

2. The computer-readable medium of claim 1, wherein the instructions executable by the computer are configured to cause the computer to:

determine a recommended electronic tilt reduction based on at least one of an above mean sea level antenna height, an above mean sea level receiver height, a good coverage limit, and a booming end distance.

3. The computer-readable medium of claim 1, wherein to evaluate whether the first base station is not a dominant cell in each of the plurality of selected grids based on the average reference signal received power and the median grid level reference signal, wherein the instructions executable by the computer are configured to cause the computer to:

determine whether the average reference signal received power is less than the median reference signal received power based on an acceptable threshold difference; and

based on the determination that the average reference signal received power is greater, the first base station is identified as a dominant

cell.

4. The computer-readable medium of claim 1, wherein wherein the instructions executable by the computer are configured to cause the computer to determine whether the base station is no longer a dominant cell site based on a the dominant carrier threshold of seventy percent.

5. The computer-readable medium of claim 1, wherein to determine a list of cells that exceed the predetermined threshold of geo-located samples that are beyond the cell range, the instructions executable by the computer are configured to cause the computer to:

retrieve data about an on-air base station from the site database;

retrieve a timing advance distribution key performance indicator data for a cell site served by the on-air base station;

determine a count of configured gaps for the cell site in the timing advance distribution key performance indicator data;

determine a count of booming samples that lie beyond the configured count of gaps for the cell site based on the timing advance distribution key performance indicator data;

determine a sum of the timing advance distribution key performance indicator data available for the cell site; and

determine a percentage of booming cells based on the count of booming samples and the sum of the timing advance distribution key performance indicator.

6. The computer-readable medium of claim 1, wherein to determine a list of cells that exceed the predetermined threshold of geo-located samples that are beyond the cell range,the instructions executable by the computer are configured to cause the computer to:

retrieve data about an on-air base station that is not a sustained booming cell site from the site database;

retrieve a timing advance distribution(TAD) key performance indicator data for a cell site served by the on-air base station;

determine a cell range for the on-air base station based on an automated cell range algorithm;

determine a count of booming samples that lie beyond the cell range for the cell site based on the timing advance distribution key performance indicator data;

determine a sum of the timing advance distribution key performance indicator data available for the cell site; and

determine a percentage of booming cells based on the count of booming samples and the sum of the timing advance distribution key performance indicator.

7. A method comprising:

retrieving a list of cells that are served by a first base station from a site database that includes a predetermined threshold of geo-located samples that are beyond a good coverage limit;

generating a plurality of girds from the first base station to a predetermined threshold distance in the direction of the azimuth of the first

base station;

identifying a plurality of selected grids that are between an acceptable coverage limit and the predetermined threshold distance from the plurality of grids;

determining an average reference signal received power from the first base station in a cell site located within each of the plurality of selected grids;

determining a median grid level reference signal received power for cell sites from base stations that are received at each of the plurality of selected gird;

evaluating whether the first base station is not a dominant cell in each of the plurality of selected grids based on the average reference signal received power and the median grid level reference signal;

determining a count of grids in the plurality of selected grids where the first base station is not a dominant cell site based on a dominant carrier threshold;

determining a column of grids where the first base station is no longer a dominant cell site based on the dominant carrier threshold;

determining a bad booming distance based on the distance from the first base station and the determined column of girds;

determining a second column of grids where the first base station is no longer a dominant cell site based on a booming start threshold; and

marking the determined column of grids as the booming start distance.

8. The method of claim 7, comprising:

determining a recommended electronic tilt reduction based on at least one of an above mean sea level antenna height, an above mean sea level receiver height, a good coverage limit, and a booming end distance.

9. The method of claim 7, comprising:

determining whether the average reference signal received power is less than the median reference signal received power based on an acceptable threshold difference; and

based on the determination that the average reference signal received power is greater, the first base station is identified as a dominant cell.

10. The method of claim 7, wherein the dominant carrier threshold is seventy percent.

11. The method of claim 7, wherein to determine a list of cells that exceed a predetermined threshold of geo-located samples that are beyond the cell range, the method comprises:

retrieving data about an on-air base station from the site database;

retrieving a timing advance distribution(TAD) key performance indicator data for a cell site served by the on-air base station;

determining a count of configured gaps for the cell site in the timing advance distribution key performance indicator data;

determining a count of booming samples that lie beyond the

configured count of gaps for the cell site based on the timing advance distribution key performance indicator data;

determining a sum of the timing advance distribution key performance indicator data available for the cell site; and

determining a percentage of booming cells based on the count of booming samples and the sum of the timing advance distribution key performance indicator.

12. The method of claim 7, comprises:

retrieving an on-air base station that is not a sustained booming cell site from the site database;

retrieving a timing advance distribution(TAD) key performance indicator data for a cell site served by the on-air base station;

determining a cell range for the on-air base station based on an automated cell range algorithm;

determining a count of booming samples that lie beyond the cell range for the cell site based on the timing advance distribution key performance indicator data;

determining a sum of the timing advance distribution key performance indicator data available for the cell site; and

determining a percentage of booming cells based on the count of booming samples and the sum of the timing advance distribution key performance indicator.

13. The method of claim 7, wherein to evaluate whether the first base

station is a dominant cell in each of the plurality of selected grids based on the average reference signal received power and the median grid level reference signal, the method comprises:

determining whether the average reference signal received power is greater than the median reference signal received power based on an acceptable threshold difference; and

based on the determination that the average reference signal received power is greater, the first base station is identified as a dominant cell.

14. The method of claim 7, wherein to determine a list of cells that exceed a predetermined threshold of geo-located samples that are beyond the cell range, the method comprises:

retrieving data about an on-air base station from the site database;

retrieving a timing advance distribution key performance indicator data for a cell site served by the on-air base station;

determining a count of configured gaps for the cell site in the timing advance distribution key performance indicator data;

determine a count of booming samples that lie beyond the configured count of gaps for the cell site based on the timing advance distribution key performance indicator data;

determining a sum of the timing advance distribution key performance indicator data available for the cell site; and

determining a percentage of booming cells based on the count of booming samples and the sum of the timing advance distribution key

performance indicator.

15. The method of claim 7, wherein to determine a list of cells that exceed a predetermined threshold of geo-located samples that are beyond the cell range, the method comprises:

retrieving data an on-air base station that is not a sustained booming cell site from the site database;

retrieving a timing advance distribution key performance indicator data for a cell site served by the on-air base station;

determining a cell range for the on-air base station based on an automated cell range algorithm;

determining a count of booming samples that lie beyond the cell range for the cell site based on the timing advance distribution key performance indicator data;

determining a sum of the timing advance distribution key performance indicator data available for the cell site; and

determining a percentage of booming cells based on the count of booming samples and the sum of the timing advance distribution key performance indicator.

16. A system comprising:

a controller including circuitry configured to:

retrieve a list of cells that are served by a first base station from a site database that includes a predetermined threshold of geo-located samples that are beyond a good coverage limit;

generate a plurality of girds from the first base station to a predetermined threshold distance in the direction of the azimuth of the first base station;

identify a plurality of selected grids that are between an acceptable coverage limit and the predetermined threshold distance from the plurality of grids;

determine an average reference signal received power from the first base station in a cell site located within each of the plurality of selected grids;

determine a median grid level reference signal received power for cell sites from base stations that are received at each of the plurality of selected gird;

evaluate whether the first base station is not a dominant cell in each of the plurality of selected grids based on the average reference signal received power and the median grid level reference signal;

determine a count of grids in the plurality of selected grids where the first base station is not a dominant cell site based on a dominant carrier threshold;

determine a column of grids where the first base station is no longer a dominant cell site based on the dominant carrier threshold;

determine a bad booming distance based on the distance from the first base station and the determined column of girds;

determine a second column of grids where the first base station is no longer a dominant cell site based on a booming start threshold; and

mark the determined column of grids as the booming start distance.

17. The system of claim 16, wherein the controller is configured to:

determine a recommended electronic tilt reduction based on at least one of an above mean sea level antenna height, an above mean sea level receiver height, a good coverage limit, and a booming end distance.

18. The system of claim 16, wherein to evaluate whether the first base station is not a dominant cell in each of the plurality of selected grids based on the average reference signal received power and the median grid level reference signal, the controller is configured to:

determine whether the average reference signal received power is less than the median reference signal received power based on an acceptable threshold difference; and

based on the determination that the average reference signal received power is greater, identify the first base station as a dominant cell.

19. The system of claim 16, wherein the dominant carrier threshold is seventy percent.

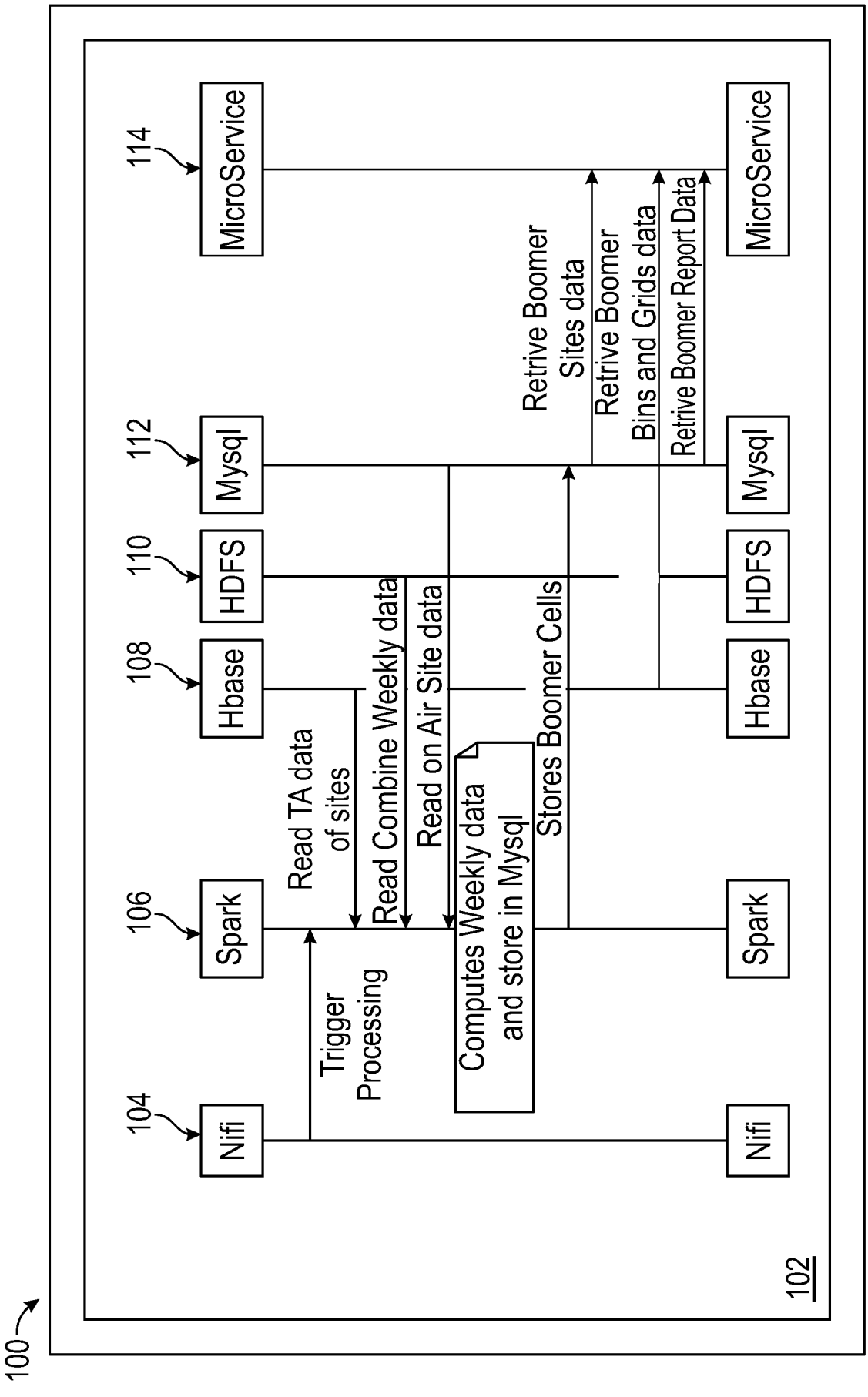

100
102
104
Nifi
106
Spark
108
Hbase
110
HDFS
112
Mysql
114
MicroService
Trigger Processing
Read TA data of sites
Read Combine Weekly data
Read on Air Site data
Computes Weekly data and store in Mysql
Stores Boomer Cells
Retrive Boomer Sites data
Retrive Boomer Bins and Grids data
Retrive Boomer Report Data
Nifi
Spark
Hbase
HDFS
Mysql
MicroService

FIG. 1

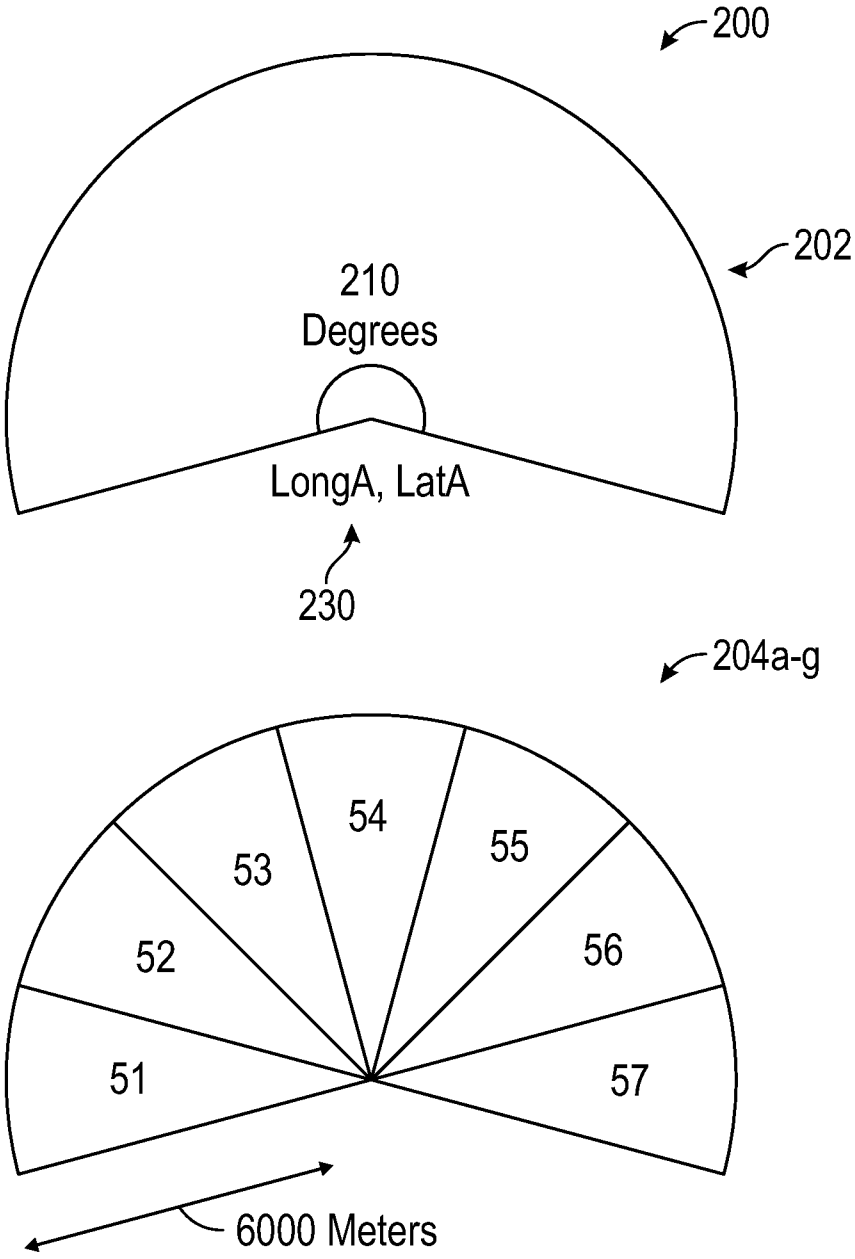

200
202
210
Degrees
LongA, LatA
230
204a-g
54
55
53
56
52
57
51
6000 Meters

FIG. 2

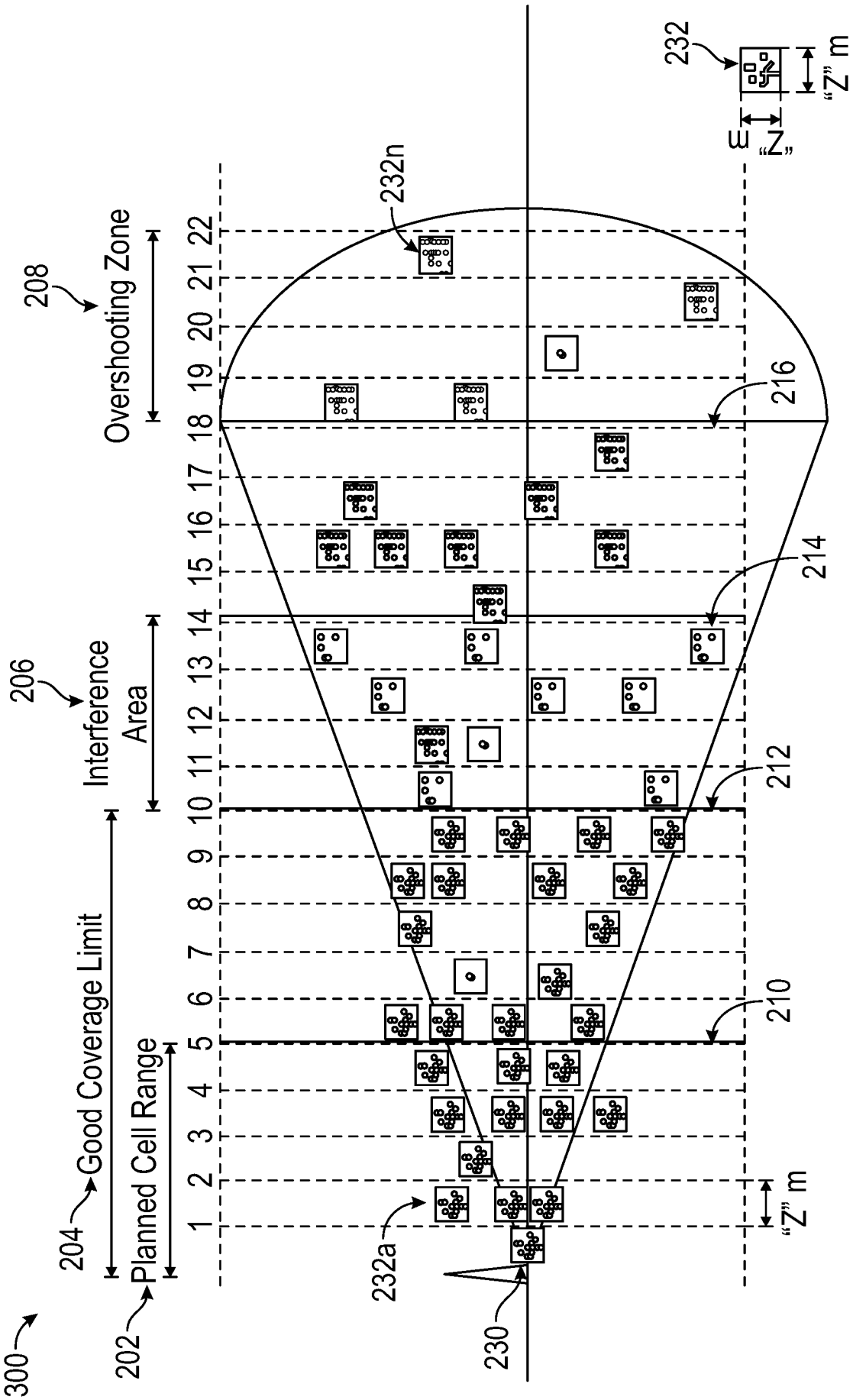

300
202
Planned Cell Range
204
Good Coverage Limit
206
Interference Area
208
Overshooting Zone
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22
232a
232n
230
210
212
214
216
232
"Z" m
"Z" m
"Z"

FIG. 3

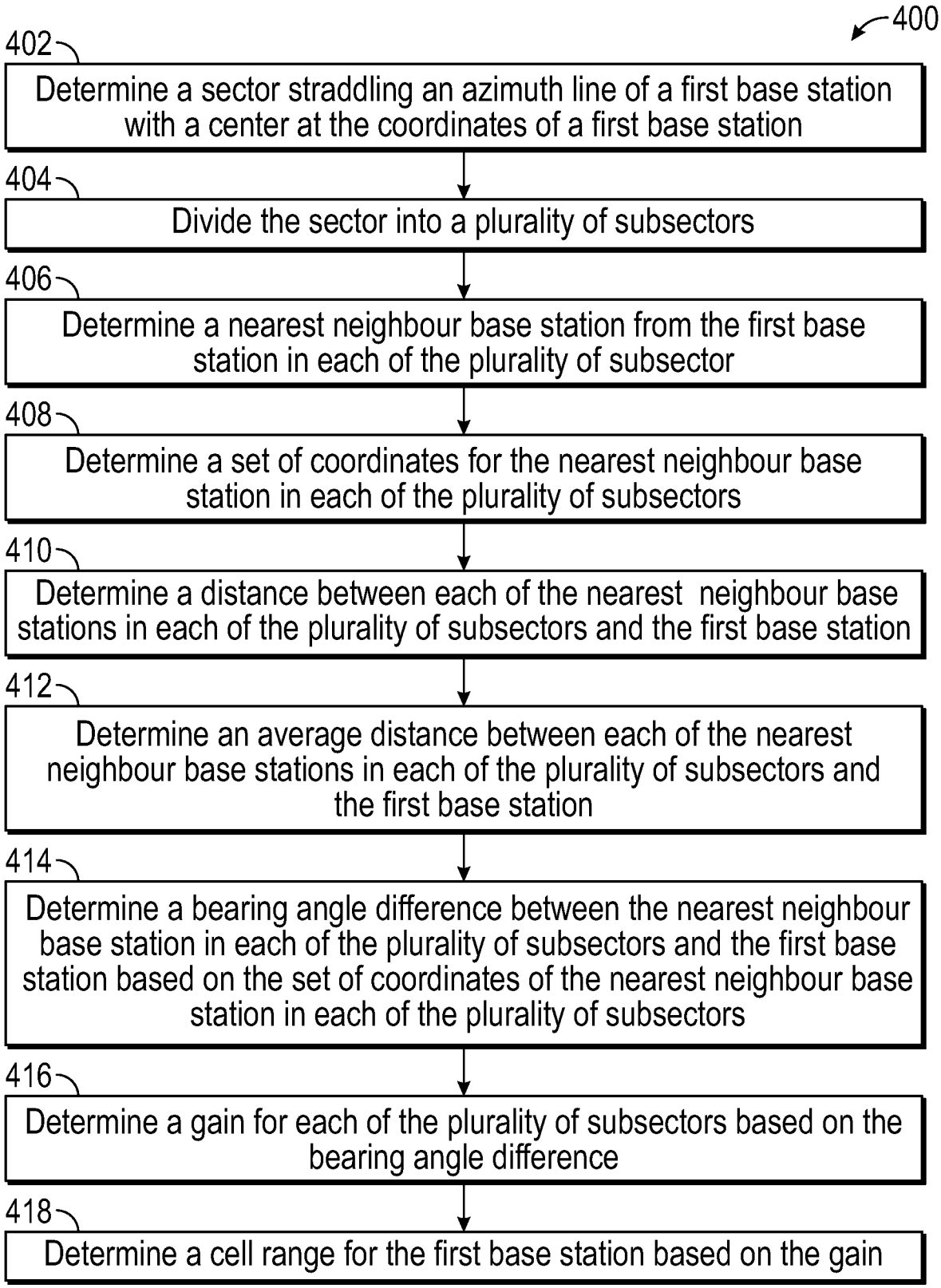

400
402
Determine a sector straddling an azimuth line of a first base station with a center at the coordinates of a first base station
404
Divide the sector into a plurality of subsectors
406
Determine a nearest neighbour base station from the first base station in each of the plurality of subsector
408
Determine a set of coordinates for the nearest neighbour base station in each of the plurality of subsectors
410
Determine a distance between each of the nearest neighbour base stations in each of the plurality of subsectors and the first base station
412
Determine an average distance between each of the nearest neighbour base stations in each of the plurality of subsectors and the first base station
414
Determine a bearing angle difference between the nearest neighbour base station in each of the plurality of subsectors and the first base station based on the set of coordinates of the nearest neighbour base station in each of the plurality of subsectors
416
Determine a gain for each of the plurality of subsectors based on the bearing angle difference
418
Determine a cell range for the first base station based on the gain

FIG. 4

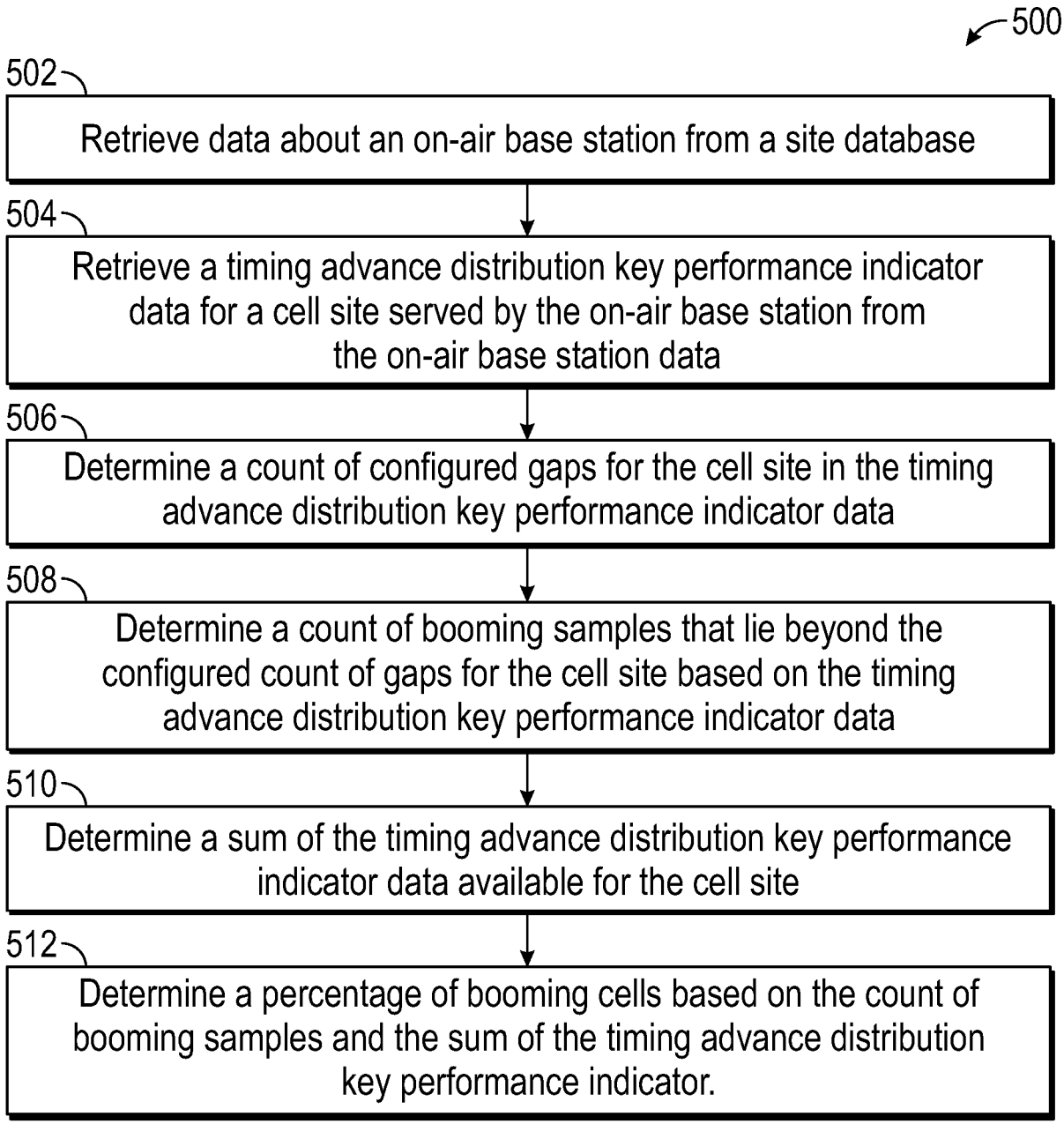

500
502
Retrieve data about an on-air base station from a site database
504
Retrieve a timing advance distribution key performance indicator data for a cell site served by the on-air base station from the on-air base station data
506
Determine a count of configured gaps for the cell site in the timing advance distribution key performance indicator data
508
Determine a count of booming samples that lie beyond the configured count of gaps for the cell site based on the timing advance distribution key performance indicator data
510
Determine a sum of the timing advance distribution key performance indicator data available for the cell site
512
Determine a percentage of booming cells based on the count of booming samples and the sum of the timing advance distribution key performance indicator.

FIG. 5

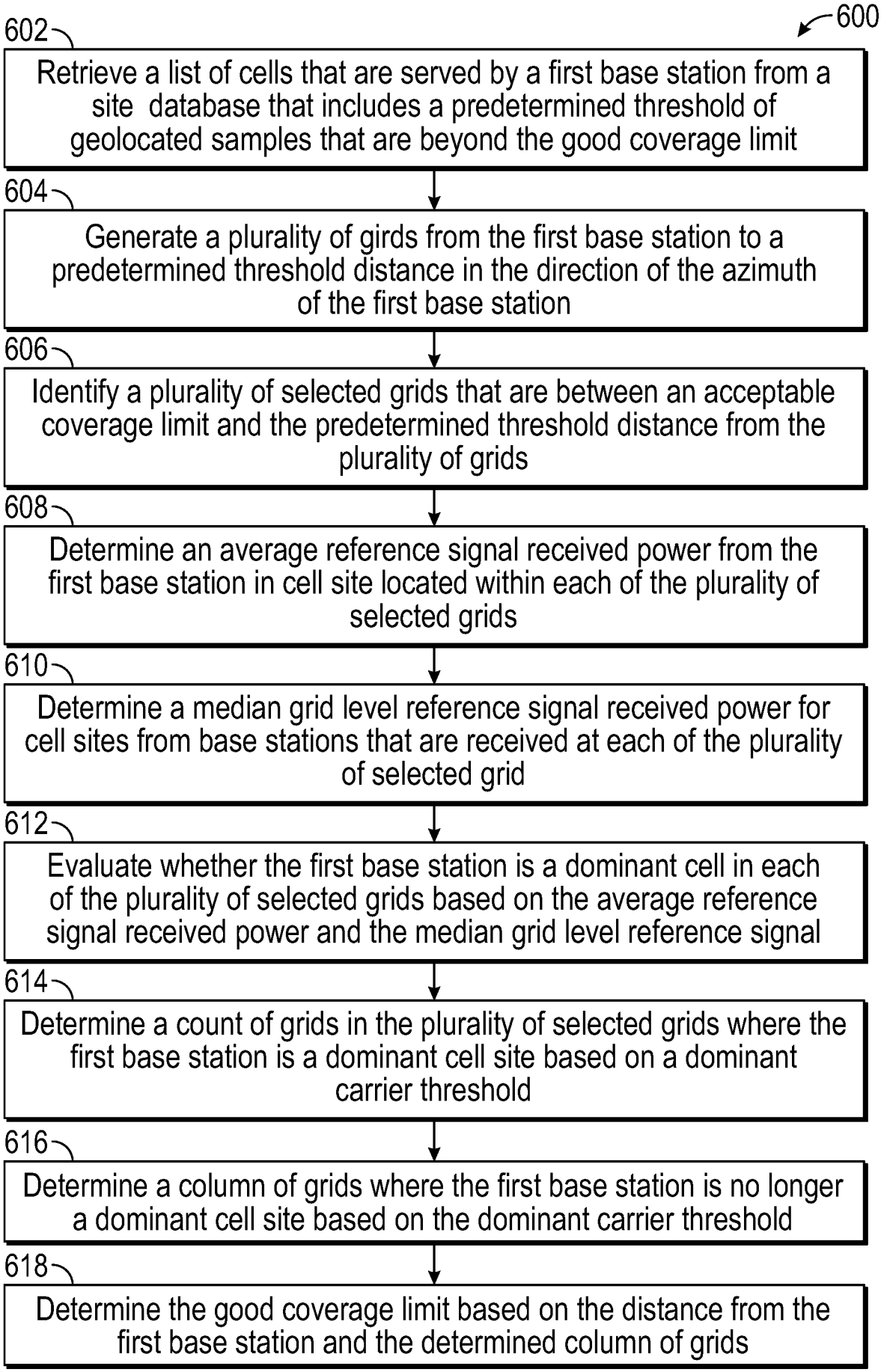

600
602
Retrieve a list of cells that are served by a first base station from a site database that includes a predetermined threshold of geolocated samples that are beyond the good coverage limit
604
Generate a plurality of girds from the first base station to a predetermined threshold distance in the direction of the azimuth of the first base station
606
Identify a plurality of selected grids that are between an acceptable coverage limit and the predetermined threshold distance from the plurality of grids
608
Determine an average reference signal received power from the first base station in cell site located within each of the plurality of selected grids
610
Determine a median grid level reference signal received power for cell sites from base stations that are received at each of the plurality of selected grid
612
Evaluate whether the first base station is a dominant cell in each of the plurality of selected grids based on the average reference signal received power and the median grid level reference signal
614
Determine a count of grids in the plurality of selected grids where the first base station is a dominant cell site based on a dominant carrier threshold
616
Determine a column of grids where the first base station is no longer a dominant cell site based on the dominant carrier threshold
618
Determine the good coverage limit based on the distance from the first base station and the determined column of grids

FIG. 6

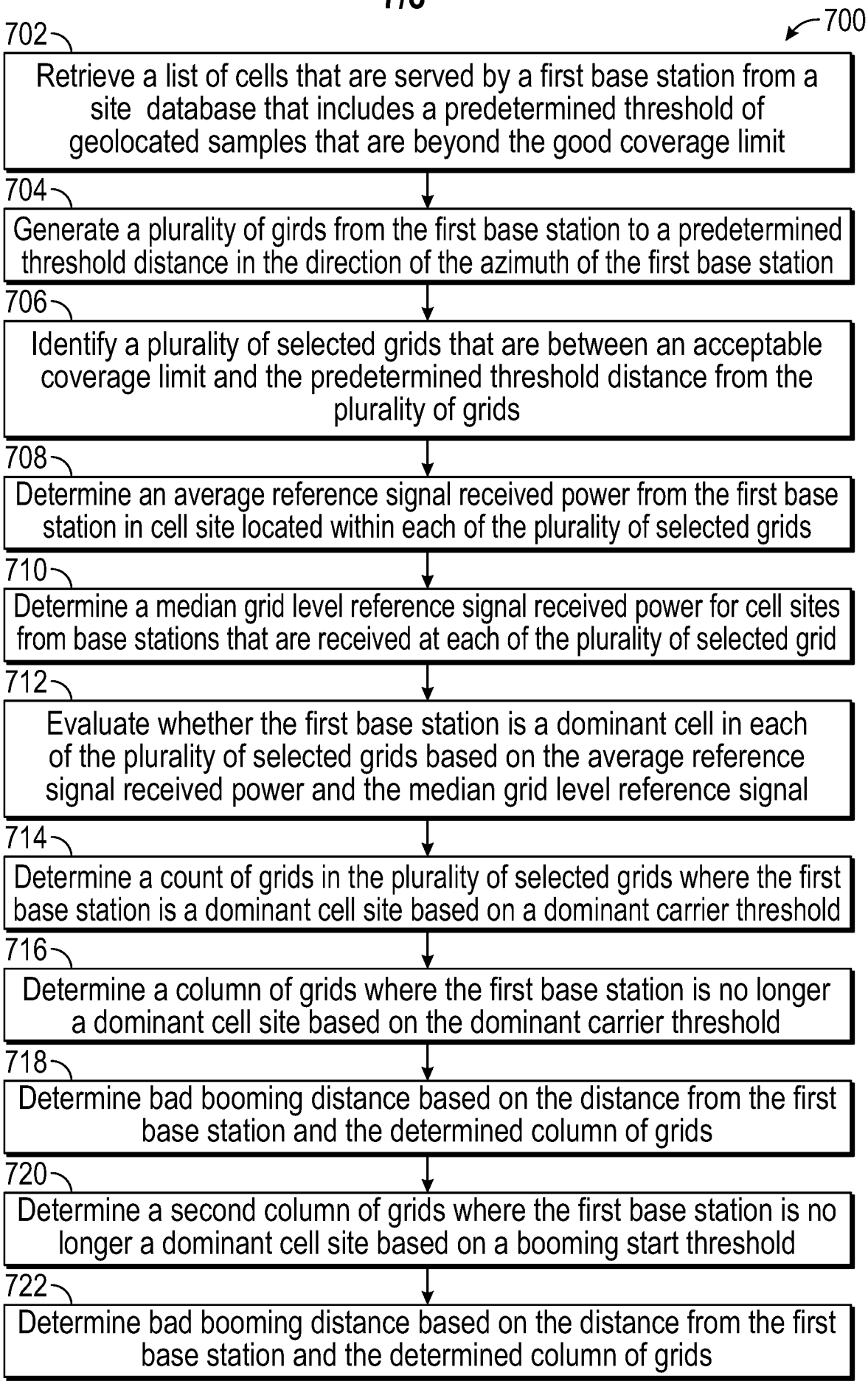

700
702
Retrieve a list of cells that are served by a first base station from a site database that includes a predetermined threshold of geolocated samples that are beyond the good coverage limit
704
Generate a plurality of girds from the first base station to a predetermined threshold distance in the direction of the azimuth of the first base station
706
Identify a plurality of selected grids that are between an acceptable coverage limit and the predetermined threshold distance from the plurality of grids
708
Determine an average reference signal received power from the first base station in cell site located within each of the plurality of selected grids
710
Determine a median grid level reference signal received power for cell sites from base stations that are received at each of the plurality of selected grid
712
Evaluate whether the first base station is a dominant cell in each of the plurality of selected grids based on the average reference signal received power and the median grid level reference signal
714
Determine a count of grids in the plurality of selected grids where the first base station is a dominant cell site based on a dominant carrier threshold
716
Determine a column of grids where the first base station is no longer a dominant cell site based on the dominant carrier threshold
718
Determine bad booming distance based on the distance from the first base station and the determined column of grids
720
Determine a second column of grids where the first base station is no longer a dominant cell site based on a booming start threshold
722
Determine bad booming distance based on the distance from the first base station and the determined column of grids

FIG. 7

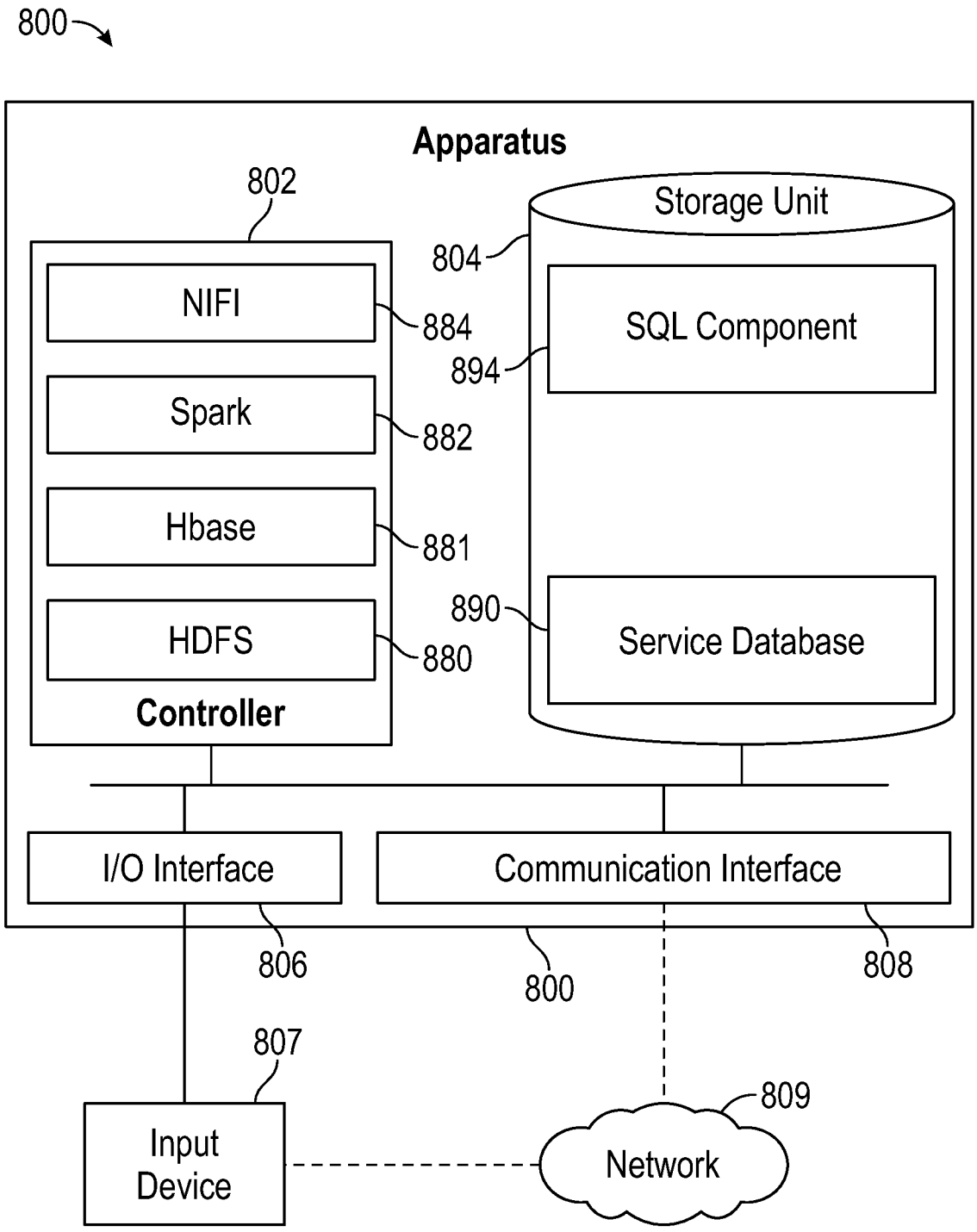

800
Apparatus
802
Storage Unit
804
NIFI
884
SQL Component
894
Spark
882
Hbase
881
890
HDFS
880
Service Database
Controller
I/O Interface
Communication Interface
806
800
808
807
809
Input Device
Network

FIG. 8

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2022/027373

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - H04B 1/38; H04Q 7/20; H04W 40/00 (2022.01)
CPC - H01Q 3/08; H04B 17/16; H04B 17/20; H04W 24/00; H04W 36/0061 (2022.05)

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)
see Search History document

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2002/0107025 A1 (OLIVEIRA) 08 August 2002 (08.08.2002) entire document	1-19
A	US 2008/0188242 A1 (CARLSON et al) 07 August 2008 (07.08.2008) entire document	1-19
A	US 2013/0273912 A1 (XU et al) 17 October 2013 (17.10.2013) entire document	1-19
A	US 7,085,592 B1 (DAVIES) 01 August 2006 (01.08.2006) entire document	1-19
A	GUNNARSSON et al. "Downtilted base station antennas-a simulation model proposal and impact on HSPA and LTE performance." 2008 IEEE 68th Vehicular Technology Conference. IEEE, 2008. 24 September 2008 (24.09.2008) Retrieved on 27 June 2022 (27.06.2022) from <https://ieeexplore.ieee.org/abstract/document/4656881> entire document	1-19
A	US 8,649,791 B1 (WOHLD) 11 February 2014 (11.02.2014) entire document	1-19

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
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"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
28 June 2022	JUL 19 2022
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