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(54) **INTERFERENCE REDUCTION FOR A WIRELESS COMMUNICATIONS NETWORK**

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(57) **ABSTRACT**

An apparatus, method and program reduce interference in interfered cell sites of a wireless communications network. A cell site is a region in which wireless communications are provided to mobile devices, and the interfered cell sites being cell sites where mobile devices are subject to interference signals from at least one interfering transmitter. A transmitter is selected from a list of interfering transmitters in need of adjustment and corresponding antennas. A critical zone is determined with respect to the selected transmitter. Parameters of the selected transmitter and the corresponding antenna are altered and performance of the wireless network in the critical zone around the problem transmitter and interference in the cell sites interfered by the problem transmitter are monitored. Altering of the parameters of the transmitter and the corresponding antenna is performed continuously until a desired interference reduction is achieved in the cell sites interfered by the selected transmitter.

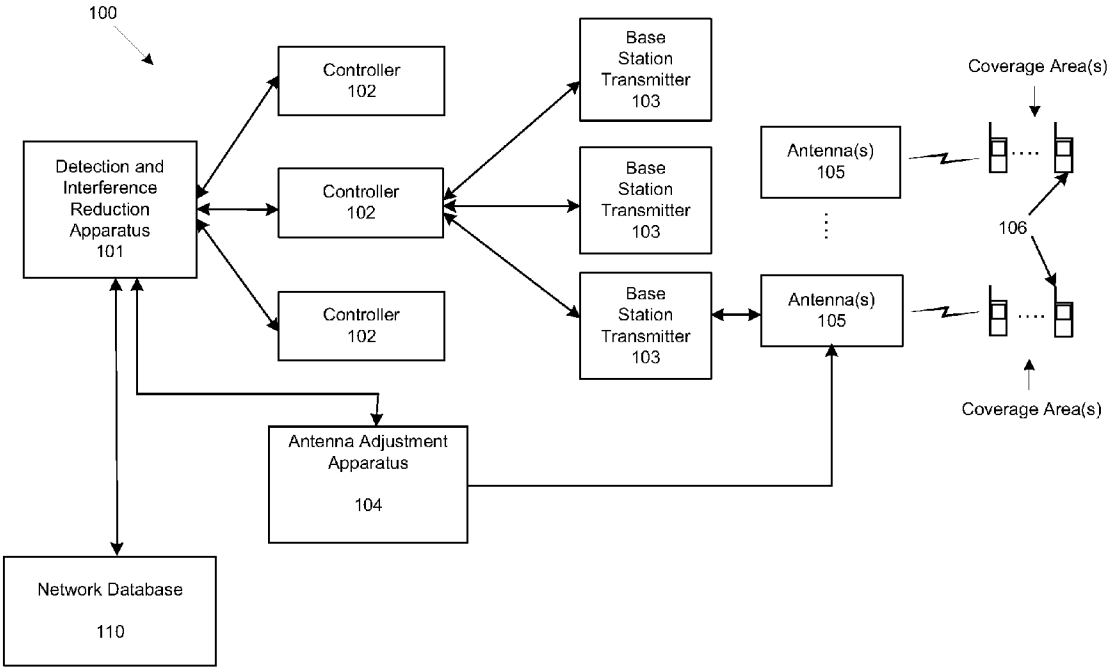


FIG. 1

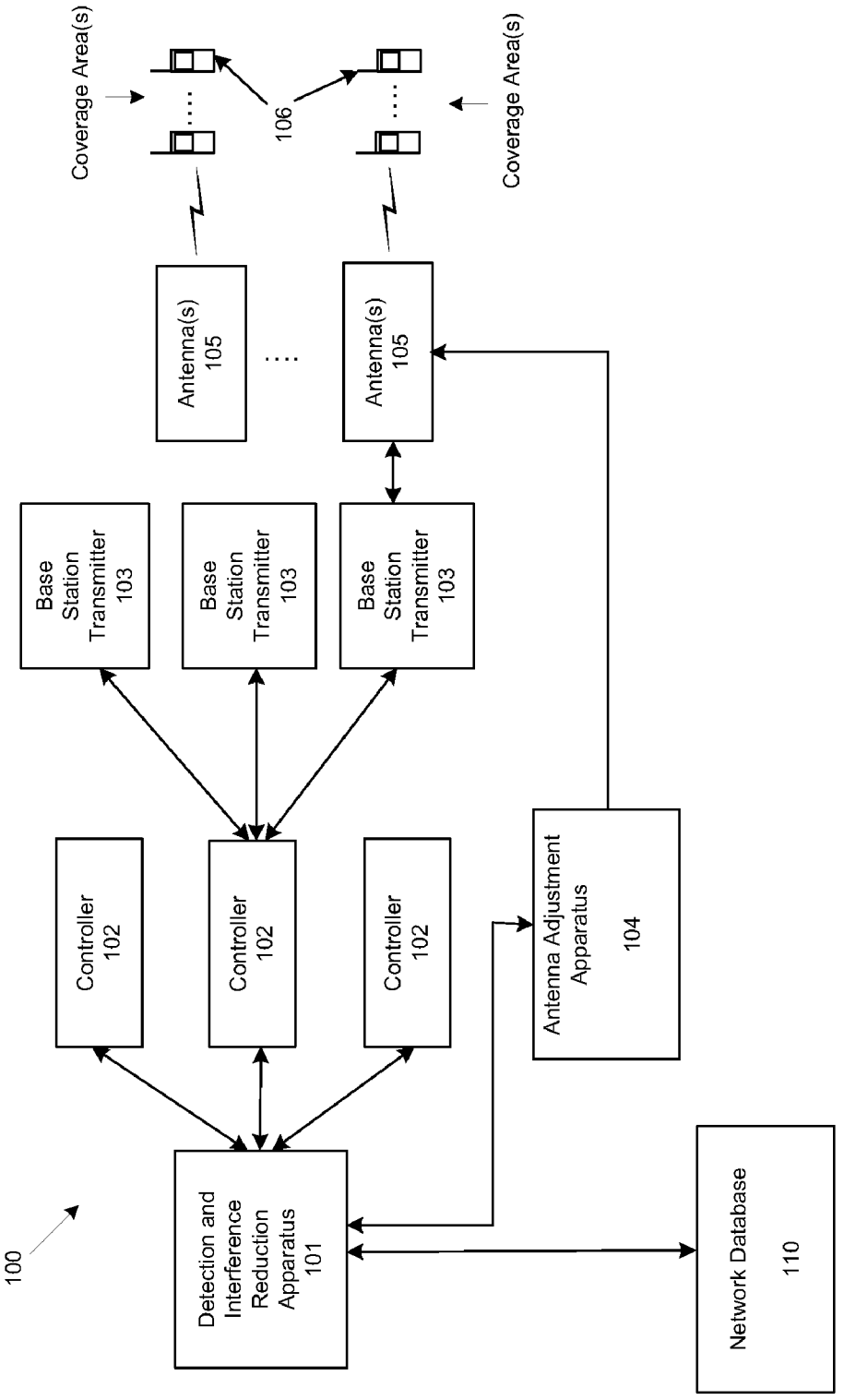

Coverage Area(s)
106
Coverage Area(s)
Antenna(s) 105
Antenna(s) 105
Base Station Transmitter 103
Base Station Transmitter 103
Base Station Transmitter 103
Controller 102
Controller 102
Controller 102
Antenna Adjustment Apparatus 104
100
Detection and Interference Reduction Apparatus 101
Network Database 110

FIG. 2

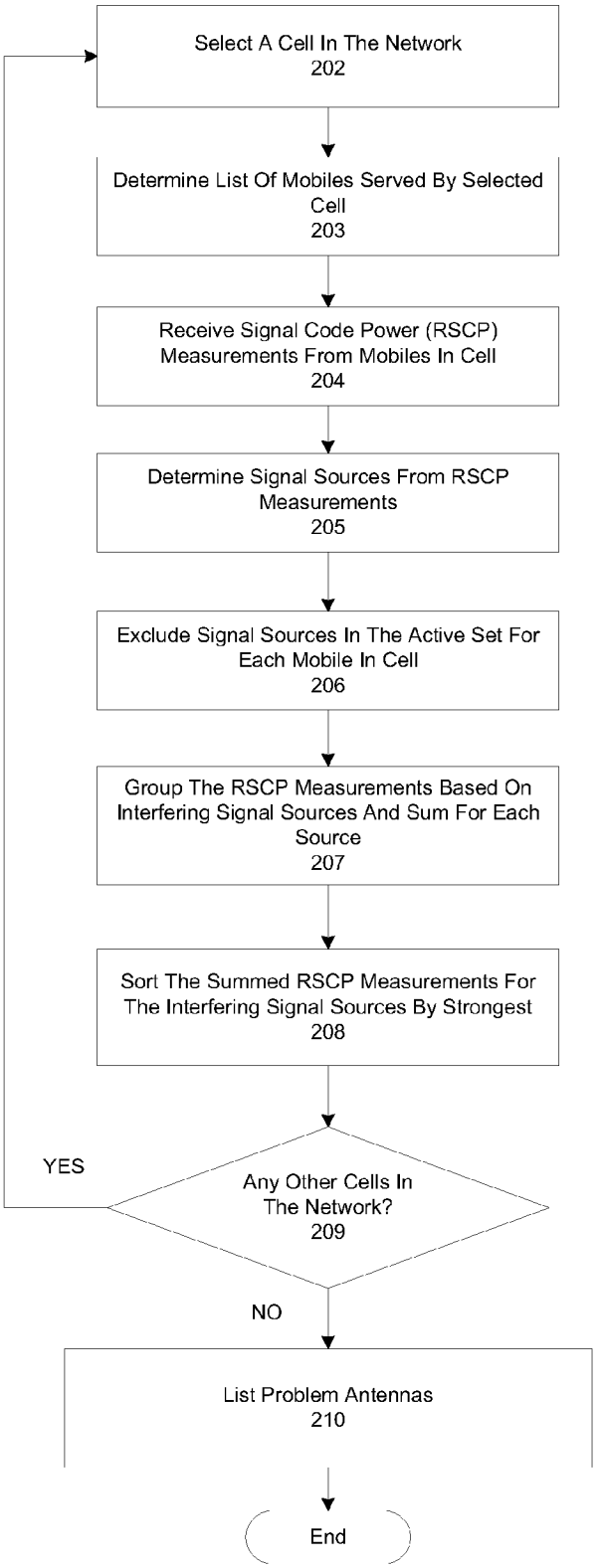

Select A Cell In The Network
202
Determine List Of Mobiles Served By Selected Cell
203
Receive Signal Code Power (RSCP) Measurements From Mobiles In Cell
204
Determine Signal Sources From RSCP Measurements
205
Exclude Signal Sources In The Active Set For Each Mobile In Cell
206
Group The RSCP Measurements Based On Interfering Signal Sources And Sum For Each Source
207
Sort The Summed RSCP Measurements For The Interfering Signal Sources By Strongest
208
Any Other Cells In The Network?
209
YES
NO
List Problem Antennas
210
End

FIG. 3

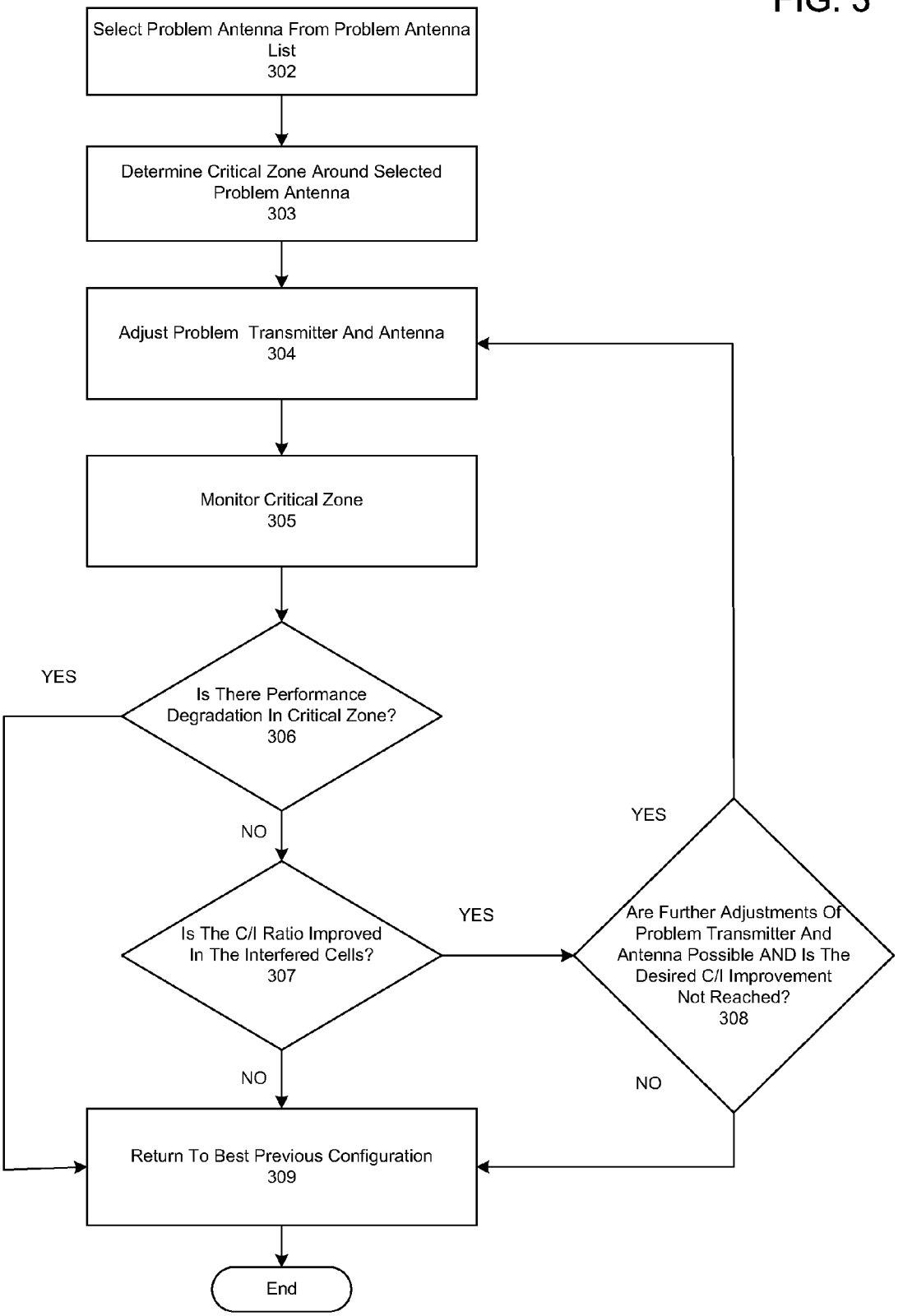
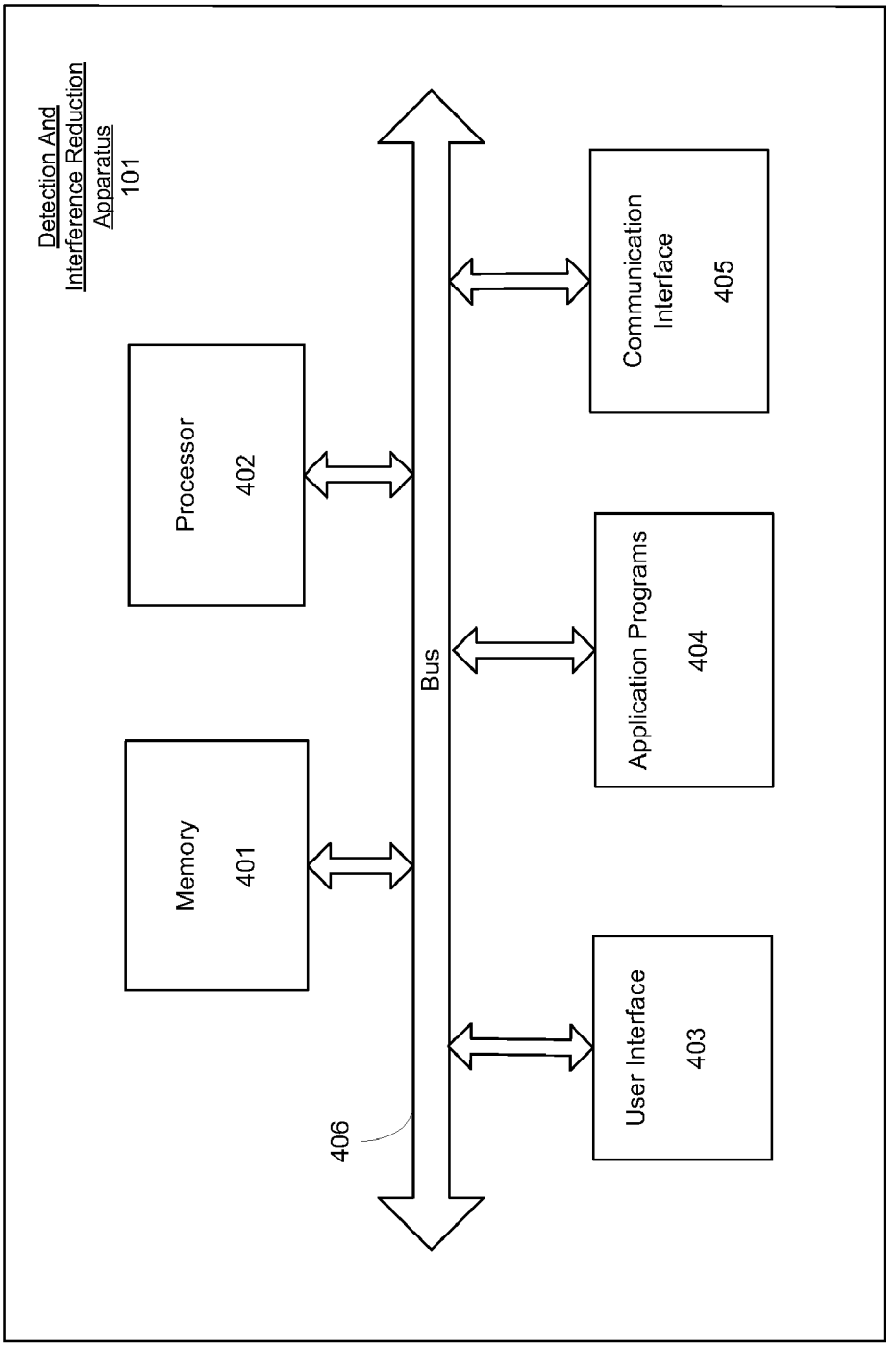

Select Problem Antenna From Problem Antenna List
302
Determine Critical Zone Around Selected Problem Antenna
303
Adjust Problem Transmitter And Antenna
304
Monitor Critical Zone
305
Is There Performance Degradation In Critical Zone?
306
YES
NO
Is The C/I Ratio Improved In The Interfered Cells?
307
YES
Are Further Adjustments Of Problem Transmitter And Antenna Possible AND Is The Desired C/I Improvement Not Reached?
308
YES
NO
NO
Return To Best Previous Configuration
309
End

FIG. 4


Detection And Interference Reduction Apparatus 101
Processor 402
Memory 401
Bus
406
Communication Interface 405
Application Programs 404
User Interface 403

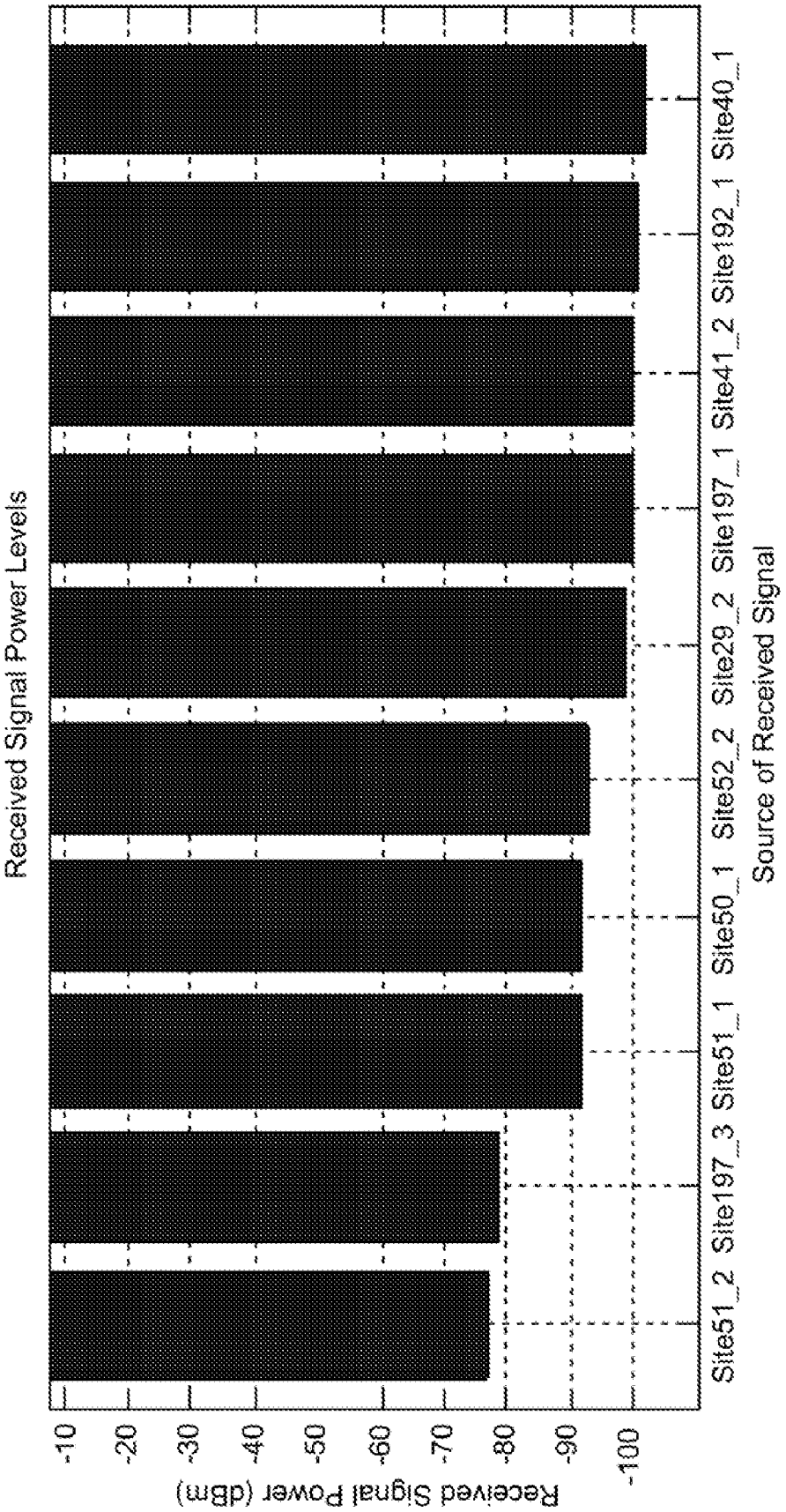

Received Signal Power Levels
Received Signal Power (dBm)
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
Site51_2
Site197_3
Site51_1
Site50_1
Site52_2
Site29_2
Site197_1
Site41_2
Site192_1
Site40_1
Source of Received Signal

FIG. 5

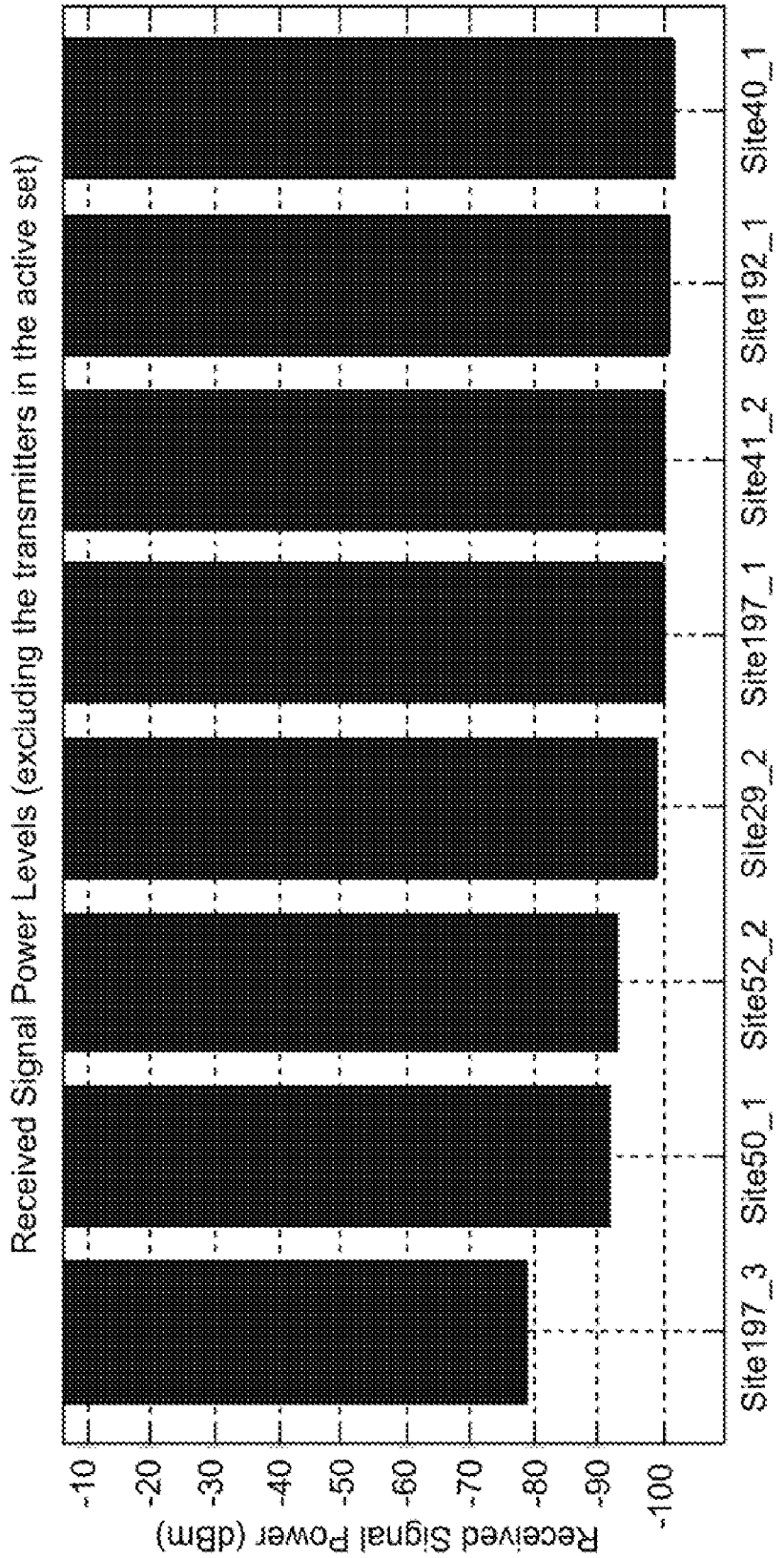

Received Signal Power Levels (excluding the transmitters in the active set)
Received Signal Power (dBm)
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
Site197_3
Site50_1
Site52_2
Site29_2
Site197_1
Site41_2
Site192_1
Site40_1
Source of Received Signal

FIG. 6

INTERFERENCE REDUCTION FOR A WIRELESS COMMUNICATIONS NETWORK

[0001] This is a continuation application of U.S. patent application Ser. No. 13/110,205, filed on May 18, 2011.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The present invention generally relates to planning and optimization of a universal mobile telecommunication system (UMTS) based network. In particular, the present invention relates to detecting and reducing interference from several transmitters in a UMTS network.

[0004] 2. Description of the Related Art

[0005] Traditional network planning and optimization of a wireless network relies on static methodologies for finding site locations, dimensioning and configuring the radio resources to meet specified traffic demand. Traditional network optimization methods find the best configuration(s) of the wireless network to maximize the performance, which typically starts with an already working wireless network, followed by analysis and calculations done by engineers using software and hardware tools with extensive simulations of the network. Once a better configuration is determined, the new configuration is manually implemented.

[0006] However, manual network optimization consumes a large amount of human resources and is a lengthy process that is performed only when needed or periodically. Therefore, usage of network resource is not maximized, quality of service is degraded and end users or customer satisfaction is reduced.

[0007] Additionally, UMTS based wireless networks offer soft handover features that allow a mobile station (MS) to be served by multiple transmitters. The transmitters that serve the MS simultaneously constitute the active set for that MS. However, signals received by the MS that are not sent by the transmitters in the active set are considered interference signals.

[0008] Existence of interfering transmitters may lead to reduced network performance by reducing the number useful signals received by mobile stations. Moreover, interfering transmitters may cause pilot pollution, which is a phenomenon that occurs when there are too many potential serving cells to choose from.

[0009] Therefore, it would be useful to implement an automated device for reducing interference and maximizing overall network performance.

SUMMARY OF THE INVENTION

[0010] An embodiment of the invention is directed to a method for reducing interference in interfered cell sites of a wireless communications network, a cell site being a region in which wireless communications are provided to mobile users, and the interfered cell sites being cell sites where mobile users are subject to interference signals from at least one interfering transmitter. Further, the method includes selecting a transmitter from a list of interfering transmitters in need of adjustment and corresponding antennas; and determining a critical zone with respect to the selected transmitter. According to the method, once the transmitter is selected, parameters of the selected transmitter and the associated antenna are altered, and performance of the wireless network in the critical zone and interference by signals being transmitted to the interfered cell sites from the transmitter are monitored.

[0011] Moreover, according to the method, the altered parameters may include antenna tilt and transmit power of the transmitter. Altering of the parameters of the transmitter and the antenna can be performed continuously until a desired interference reduction is achieved in the interfered cell sites of the wireless communications network. Additionally, altering of the transmitter parameters can be performed for all the transmitters on the list of interfering transmitters.

[0012] An embodiment of the invention is directed to at least one program recorded on a non-transitory computer-readable storage medium for reducing interference in cell sites of a wireless network, wherein the at least one program causes a computer to perform an interference reduction method as described in the previous embodiment.

[0013] An embodiment of the invention is directed to an interference reduction apparatus for reducing interference in interfered cell sites of a wireless network including at least one processor and a memory. The memory stores at least one interference reduction program for reducing interference in interfered cell sites of a wireless network, wherein the at least one interference reduction program causes the interference apparatus to perform the interference reduction method discussed above in the previous embodiment.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] In the drawings, like reference numbers generally indicate identical, functionally similar and/or structurally similar elements. Embodiments of the invention will be described with reference to the accompanying drawings, wherein:

[0015] FIG. **1** illustrates a system for detecting and reducing interference in cell sites of a wireless communications network in accordance with an embodiment of the invention;

[0016] FIGS. **2** and **3** illustrate a method for detecting and reducing interference in cell sites of a wireless communications network in accordance with an embodiment of the invention; and

[0017] FIG. **4** illustrates an apparatus for detecting and reducing interference in cell sites of a wireless communications network in accordance with an embodiment of the invention.

[0018] FIG. **5** is a graph illustrating exemplary RSCP values measured by a mobile device, according to an embodiment.

[0019] FIG. **6** is a graph illustrating exemplary received signal power levels excluding transmitters in an active set, according to an embodiment.

[0020] Additional features are described herein, and will be apparent from the following description of the figures.

DETAILED DESCRIPTION OF THE INVENTION

[0021] In the description that follows, numerous details are set forth in order to provide a thorough understanding of the invention. It will be appreciated by those skilled in the art that variations of these specific details are possible while still achieving the results of the invention. Well-known elements and processing steps are generally not described in detail in order to avoid unnecessarily obscuring the description of the invention.

[0022] In the drawings accompanying the description that follows, often both reference numerals and legends (labels, text descriptions) may be used to identify elements. If legends are provided, they are intended merely as an aid to the reader, and should not in any way be interpreted as limiting.

[0023] FIG. **1** is a system for detecting and reducing interference in cell sites of a wireless communications network in accordance with an embodiment of the invention. The wireless network **100** illustrated in FIG. **1** includes a detection and interference apparatus **101** And, the wireless network **100** refers to any type of computer network that is wireless, and is commonly associated with a telecommunications network whose interconnections are implemented without the use of wires such as with electromagnetic waves, such as radio waves or the like as a carrier. The basic components of the wireless network **100** include the detection and interference reduction apparatus **101**; one or more controllers **102**; one or more base station transmitters **103** (hereafter "transmitters **103**") for supporting data communications between mobile devices **106** distributed throughout coverage areas (e.g., cell sites) provided by the wireless network **100** via antennas **105**; a network database **110**; and an antenna adjustment apparatus **104**.

[0024] It should be understood by one of ordinary skill in the art that the connections between the detection and interference reduction apparatus **101** and the one or more network controllers **102**, the antenna adjustment apparatus **104** and the network database **110** can be wireless, wired or a combination of wireless and wired. Similarly, it should be understood by one of ordinary skill in the art that the connections between the one or more controllers **102** and the one or more transmitters **103** can be wireless, wired or a combination of wireless and wired.

[0025] As seen in FIG. **1**, the detection and interference reduction apparatus **101** receives network statistics and the current network configurations from the network database **110** related to the wireless communication system **100** for assisting in the monitoring and optimization performed. The network statistics may include, but are not limited to, key performance Indicators (KPIs). An example of KPIs include an interference power, successful call rate, call traffic and dropped calls rate, which is the ratio between the failed calls and the total number of calls requested. Another network statistic is the capacity of the network. Capacity can be measured by the total number of calls and/or the amount of delivered data in bits or the throughput (overall data rate) in case of data calls. Additionally, the detection and interference reduction apparatus **101** also receives information regarding the transmitters **103** and the antennas **105** from the antenna adjustment apparatus **104**.

[0026] The wireless network **100** offers a soft handover feature that allows a mobile device **106** to be served by multiple transmitters **103**. The transmitters **103** that serve mobile device **106** simultaneously constitute the active set for a mobile device **106**, and there might be up to, for example, 3 transmitters **103** in an active set with one of the transmitters being the best server to the mobile device **106**. Signals received by a mobile device **106** from a transmitter **103** that is not in the active set are considered interference signals from an interfering transmitter **103**.

[0027] The detection and interference reduction apparatus **101** can be a server or other similar computer device capable of executing one or more algorithms for performing the detection and interference reduction in wireless network **100**. A more detailed discussion of the structure of the detection and interference reduction apparatus **101** is noted below with reference to FIG. **4**.

[0028] The controllers **102** illustrated in FIG. **1** control one or more of the transmitters **103** to affect performance in the corresponding coverage areas or cell sites provided by the transmitters **103** and antennas **105**. Mobile devices **106** are distributed within the coverage areas or cell sites for participating in wireless data communications provided by the wireless network **100** via the transmitters **103** and the antennas **105**. The mobile devices **106** include user equipment of various types such as fixed, mobile, and portable two way radios, cellular telephones, personal digital assistants (PDAs), or other wireless networking devices.

[0029] Each coverage area behaves as an independent cell site serving its own set of mobile devices **106**. For fixed wireless systems, such as IEEE802.16-2004, each coverage area can be used by a single transmitter **103** or plurality of transmitters **103** operating each on a different frequency channel. For mobile systems, subscribers of a single coverage area are served by a single transmitter **103** that can be a single frequency channel for IEEE802.16e-2005 (or UMTS or 1x-EVDO Rev. B and C) or multiple frequency channels that can be supported by IEEE802.16m (or UMTS or 1xEVDO Rev. B and C).

[0030] As illustrated in FIG. **1**, the antenna adjustment apparatus **104** is in direct communication with the detection and interference reduction apparatus **101** for sending information to and receiving information from the detection and interference reduction apparatus **101**, which makes adjustments to the transmitters **103** and the antennas **105**. The antenna adjustment apparatus **104** includes an algorithm that analyzes information received from the detection and interference reduction apparatus **101** and sends control signals to the antennas **105** for altering antenna parameters. The antenna adjustment apparatus **104** also sends information regarding the transmitters **103** and the antennas **105** to the detection and interference reduction apparatus **101**. The detection and interference reduction apparatus **101** makes adjustments to the transmitters **103** via the controllers **102**.

[0031] FIGS. **2** and **3** illustrate a method for detecting and reducing interference in cell sites of a wireless communications network in accordance with an embodiment of the invention. By way of example, the detection and interference reduction apparatus **101** can execute two separate algorithms; one for detecting interference caused by transmitters **103** and one algorithm for making modifications to parameters of interfering transmitters **103** and the antennas **105**. However, the detection and interference reduction apparatus **101** can also execute one algorithm for detecting and reducing interference in cell sites of the wireless network **100** caused by the transmitters **103**.

[0032] Referring now to FIG. **2**, in step **202**, the detection and interference reduction apparatus **101** selects a cell site in the wireless network **100** for detecting interference. The initial selection of the cell site may be based on network parameters received from the network database **110** or the antenna adjustment apparatus **104**, or both. In step **203**, the detection and interference reduction apparatus **101** determines a list mobile devices **106** served by the selected (interfered) cell site. The list of mobile devices **106** in the cell site can be based on information regarding the cell site received from the network database **110** or the antenna adjustment apparatus **104**. In step **204**, the detection and interference reduction appara-

tus **101** acquires received signal code power (RSCP) values that are measured by the corresponding mobile devices **106** in the cell site. In step **205**, the detection and interference reduction apparatus **101** determines the signal sources from the RSCP values measured. Exemplary RSCP values measured by a mobile device **106** are shown in FIG. **5**.

[0033] In steps **206**, the detection and interference reduction apparatus **101** excludes from the signal sources determined in step **205**, the signal sources included in the active set for each mobile device **106** in the cell site. By excluding the signal sources in the active set, only the interfering signal sources or interfering power remain on a list of signal sources. An active set of signal sources are a set of sources assigned to provide source signals to a mobile device **106** in the cell site, whereas the interfering sources are sources not assigned to provide wireless communication services to a mobile device **106** in the cell site, but whose source signal is still being received by the mobile device **106** (i.e., interfering power).

[0034] The list of interfering signal sources may include transmitters **103** that have the highest interference power as measured by the mobile devices **106**, transmitters **103** that cause interference in the highest number of mobile devices **106**, transmitters **103** that cause interference in the highest number of cells, or transmitters **103** with a highest weight metric assigned. A list of exemplary signals interfering signal sources (i.e., excluding signal sources in an active set) are provided in FIG. **6**.

[0035] In step **207**, the RSCP measurements for the interfering signal sources are grouped and summed for each of the signal sources. In step **208**, the summed RSCP measurements are sorted for the interfering source signals by the strongest. The strongest signals are determined by the signal strength received by the mobile devices **106**. In step **209**, it is determined if there are any other cell sites in the network and, if not, a list of transmitters **103** associated with the list of interfering signal sources is generated. The list of transmitters **103** may be based on network configuration information received from the network database **110** or the antenna adjustment apparatus **104**. The list of transmitters is considered to include transmitters **103** in need of adjustment by the detection and interference reduction apparatus **101** and the antenna adjustment apparatus **104**. In step **209**, if it is determined that there are other cells sites on the network, then another cell site is selected in step **202**, and the process in steps **203-209** are repeated.

Exemplary Implementation

[0036] The following is an exemplary implementation of the selection of a problem transmitter **103** causing interference in the wireless network **100** with respect to seven mobile devices **106** (also referred to here as user equipment (UE)). After collecting the interfering source signals (as noted above in steps **202-206**), the first five significant interfering signal sources are listed for all mobile devices **106** (e.g., UE1-UE7) in the currently selected cell. That is, the first five significant signal sources are generated by excluding the signal sources in the active set, so that only the interfering signal sources remain. As noted above, an active set of signal sources are a set of sources assigned to provide source signals to a mobile device **106** in the cell site, whereas the interfering sources are sources not assigned to provide wireless communication services to a mobile device **106** in the cell site, but whose source signals are still being received. For the purpose of this example, the interferers (e.g., Interferers I-V) refer to the interfering source signals. Table 1 below contains the interferers for seven mobile devices **106**, and in Table 2, the corresponding interference powers are listed.

TABLE 1

Sources Of Interference For User Equipments (UE)

	UE1	UE2	UE3	UE4	UE5	UE6	UE7
Interferer I	'Site161_3'	'Site73_3'	'Site73_3'	'Site63_1'	'Site161_3'	'Site161_3'	'Site73_3'
Interferer II	'Site151_3'	'Site161_3'	'Site63_1'	'Site64_2'	'Site73_3'	'Site63_1'	'Site63_1'
Interferer III	'Site73_3'	'Site63_1'	'Site172_2'	'Site73_3'	'Site63_1'	'Site172_2'	'Site64_2'
Interferer IV	'Site75_3'	'Site172_2'	'Site161_3'	'Site189_2'	'Site73_1'	'Site84_1'	'Site172_2'
Interferer V	'Site63_1'	'Site64_2'	'Site64_2'	'Site151_3'	'Site84_1'	'Site64_2'	'Site161_3'

TABLE 2

Interference Levels (in dBm) For UEs

	UE1	UE2	UE3	UE4	UE5	UE6	UE7
Interferer I Power (dBm)	−90	−87	−80	−87	−89	−90	−91
Interferer II Power (dBm)	−93	−91	−87	−89	−91	−94	−91
Interferer III Power (dBm)	−96	−93	−92	−91	−95	−95	−91
Interferer IV Power (dBm)	−96	−94	−96	−98	−96	−97	−91
Interferer V Power (dBm)	−96	−96	−97	−101	−96	−97	−95

[0037] For the current cell, all sources of interference are identified using the table exemplified in Table 1. Then, the accumulated interference power is found for each of these interferers by simply adding the numbers (in mW) that belong to a specific interferer. These total interference values are sorted and the strongest three interferers, for example, are determined along with the corresponding values. In this example, the interferers that cause interference the most frequently are determined as being transmitted from a problem transmitter **103**. However, the interferers can be determined based on interferers that have the highest interference power as measured by the mobile devices **106**, interferers that cause interference in the highest number of mobile devices **106**, interferers that cause interference in the highest number of cells, or interferers with the highest weight metric assigned. A list of transmitters corresponding to the list of problem interferers is generated. The list of transmitters is generated based on network configuration information received from the network database **110** or the antenna adjustment apparatus **104**. The list of transmitters is considered to include transmitters

103 in need of adjustment by the detection and interference reduction apparatus **101** and the antenna adjustment apparatus **104**.

[0038] Now referring to FIG. **3**, in step **302**, a problem transmitter **103** is selected for the list of transmitters generated (i.e., in step **209**) as a transmitter **103** in need for adjustment. In step **303**, a critical zone is determined with respect to the selected cell site and the problem transmitter **103**. The critical zone refers to a set of the neighbor cell sites in the vicinity of the selected cell site whose performance can be affected by performance in the selected cell site. The critical zone may contain direct neighbor cells sites of the selected cell site or additional levels of neighbor cell sites (i.e., indirect neighbor cell sites) with regard to the selected cell.

[0039] In step **304**, the detection and interference reduction apparatus **101** makes adjustments to the selected problem transmitter **103** and the corresponding antenna **105** via the controller **102** and antenna adjustment apparatus **104**, respectively. Adjustments can be made by altering the antenna parameters such as antenna tilt and transmit power of the transmitter **103**. In step **305**, after adjustments to the transmitter **103** and the corresponding antenna **105** are made, the performance in the critical zone is monitored by considered performance metrics in the critical zone. For example, the performance metrics can be based on dropped call rate (DCR), which has exceeded certain dropped call rate threshold over a certain observation window of time. An observation window is simply a specified time period such a number or days. The performance metric can also be calculated across specific time slots in different time frames. For example, Mondays to Fridays, Mondays only or Mondays to Fridays morning hours.

[0040] In step **306**, if performance in the critical zone has degraded, then in step **309**, the detection and interference reduction apparatus **101** returns to the best previous configuration of the transmitter **103** and the process ends. In step **306**, if performance in the critical zone is not degraded, then in step **307**, the average ratio of best server power to the interferer power (the average C/I ratio) measured by interfered mobile devices in the interfered cell sites is determined, where the best server power is the signal power of the best server and the interferer power is the signal power from the transmitter **103**. In step **307**, if it is determined that the average C/I ratio is improved, then in step **308** it is determined if further adjustments of the transmitter **103** and the antenna **105** are possible and if the improvement in the average C/I ratio has reached the desired level. If further adjustments of the transmitter **103** and the antenna **105** are possible and improvement in the average C/I ratio has not reached the desired level, then further adjustments are made to the transmitter parameters and the antenna parameters as in step **304**. As noted above, adjustments are made by altering parameters such as antenna tilt and transmit power of the transmitter **103**. However, in step **308**, if it is determined that no further adjustments of the transmitter **103** and antenna **105** are possible or the improvement in the average C/I ratio has already reached the desired level, then the detection and interference reduction apparatus **101** returns to the best previous configuration of the transmitter **103** and the process ends. Similarly, in step **307**, if it is determined that interference in the cell site is increased as a result of the initial adjustments to the transmitter **103**, then the detection and interference reduction apparatus **101** returns to the best previous configuration of the transmitter **103** and the process ends.

[0041] As noted above, optimization of the wireless network **100** is performed by utilizing certain metrics considered during monitoring the performance of the wireless network (e.g., in steps **305-309**) after making adjustments to a transmitter **103** and an antenna **105** (e.g., in step **304**)

[0042] Exemplary metrics considered are as follows:

[0043] Change in the average best server power to the interferer power ratio (C/I)

[0044] Critical Zone average Successful Call Rate (SCR)

[0045] Critical Zone average traffic increase for all hours.

[0046] The change in the average C/I perceived by the mobiles in the interfered cells is calculated as follows:

$$C/I\_\text{Change}=\text{Avg}\_I/C\_\text{Initial}-\text{Avg}\_I/C$$

where

[0047] Avg_I/C=the mean of best server power to the interferer power ratio measured by the mobile devices in the interfered cells during the last n days (converted to dB)

[0048] Avg_I/C_Initial=the mean of best server power to the interferer power ratio measured by the mobile devices in the interfered cells during the initial n days (converted to dB).

[0049] The average SCR is calculated for the sum of all the services including voice, data and HSDPA calls as follows:

$$SCR = \frac{\text{Number of successful calls in the zone for the last } n \text{ days}}{\text{Number of total seizures in the zone for the last } n \text{ days}}$$

[0050] The average increase in the traffic of the critical zone over all hours is calculated as follows:

$$TrafficIncAllHours = \frac{\text{Traffic\_TotWin} - \text{Traffic\_IniTotWin}}{\text{Traffic\_IniTotWin}}$$

where,

Traffic_TotWin=Total zone traffic for the last observation window for all hours; and

Traffic_IniTotWin=Total zone traffic for the initial window for all hours.

[0051] As noted above, the interference reduction method described above with reference, in particular, to FIG. **3** will terminate in the following situations:

[0052] The average C/I ratio in the interfered cell sites decreases

[0053] Significant performance degradation is observed in the critical zone

[0054] The desired improvement in the average C/I ratio is obtained

[0055] Further downtilting of the problem antenna is not possible.

[0056] Optimization of the wireless network **100** is achieved by detecting and reducing interference from problem transmitters **103** and continually searching for better performance even if the performance is only slightly degraded. As a result, the best performance may occur anytime during the interference reduction process (e.g., in FIGS. **2** and **3**). Performance values are recorded in the network database **110** after each modification to transmitter parameters. Additionally, modifications are made to the transmitter

parameters to yield the best performance, even if the best performance is a previous operating condition of the wireless network **100**.

[0057] FIG. **4** is a more detailed description of the detection and interference reduction apparatus **101** for performing the method of detecting and reducing interference in a selected cell site as described with reference to FIGS. **2** and **3**. In FIG. **4**, the detection and interference reduction apparatus **101** includes a memory **401**, a processor **402**, user interface **403**, application programs **404**, communication interface **405**, and bus **406**.

[0058] The memory **401** can be computer-readable storage medium used to store executable instructions, or computer program thereon. The memory **401** may include a read-only memory (ROM), random access memory (RAM), programmable read-only memory (PROM), erasable programmable read-only memory (EPROM), a smart card, a subscriber identity module (SIM), or any other medium from which a computing device can read executable instructions or a computer program. The term "computer program" is intended to encompass an executable program that exists permanently or temporarily on any computer-readable storage medium as described above.

[0059] The computer program is also intended to include an algorithm that includes executable instructions stored in the memory **401** that are executable by one or more processors **402**, which may be facilitated by one or more of the application programs **404**. The application programs **404** may also include, but are not limited to, an operating system or any special computer program that manages the relationship between application software and any suitable variety of hardware that helps to make-up a computer system or computing environment of the detection and interference reduction apparatus **101**. Additionally, the application programs **404** also include one or more interferer detection and interference reduction algorithms for performing the detecting and interference reduction method described with reference to FIGS. **2** and **3**. The one or more interferer detection and interference reduction algorithms for performing the detecting and interference reduction method described with reference to FIGS. **2** and **3** can also be stored in memory **401**. General communication between the components in the detection and interference reduction apparatus **101** is provided via the bus **406**

[0060] The user interface **403** allows for interaction between a user and the detection and interference reduction apparatus **101**. The user interface **403** may include a keypad, a keyboard, microphone, and/or speakers. The communication interface **405** provides for two-way data communications from the detection and interference reduction apparatus **101**. By way of example, the communication interface **405** may be a digital subscriber line (DSL) card or modem, an integrated services digital network (ISDN) card, a cable modem, or a telephone modem to provide a data communication connection to a corresponding type of telephone line. As another example, communication interface **405** may be a local area network (LAN) card (e.g., for Ethernet™ or an Asynchronous Transfer Model (ATM) network) to provide a data communication connection to a compatible LAN.

[0061] Further, the communication interface **405** may also include peripheral interface devices, such as a Universal Serial Bus (USB) interface, a Personal Computer Memory Card International Association (PCMCIA) interface, and the like. The communication interface **405** also allows the exchange of information across one or more wireless communication networks. Such networks may include cellular or short-range, such as IEEE 802.11 wireless local area networks (WLANS). And, the exchange of information may involve the transmission of radio frequency (RF) signals through an antenna (not shown).

[0062] From the description provided herein, those skilled in the art are readily able to combine software created as described with the appropriate general purpose or special purpose computer hardware for carrying out the features of the invention.

[0063] Additionally, it should be understood that various changes and modifications to the presently preferred embodiments described herein will be apparent to those skilled in the art. Such changes and modifications can be made without departing from the spirit and scope of the present subject matter and without diminishing its intended advantages. It is therefore intended that such changes and modifications be covered by the appended claim.

1. A method for reducing interference in interfered cell sites of a wireless communications network, a cell site being a region in which wireless communications are provided to mobile devices, and the interfered cell sites being cell sites where mobile devices are subject to interference signals from at least one interfering transmitter, the method comprising:

selecting a transmitter from a list of interfering transmitters in need of adjustment and corresponding antennas;

determining a critical zone with respect to the selected transmitter;

altering parameters of the selected transmitter and a corresponding antenna; and

monitoring performance of the wireless communications network in the critical zone and interference by signals being transmitted to any interfered cell sites from the selected transmitter,

wherein the altering of the parameters of the selected transmitter and the corresponding antenna is performed continuously until a desired interference reduction is achieved in the interfered cell sites of the wireless communications network.

2. The method of claim **1**, wherein the list of interfering transmitters includes the transmitters in need of adjustment and the corresponding antennas in association with ranked signal code measurements for sources included in a list of interfering sources.

3. The method of claim **1**, wherein the monitoring of the performance in the critical zone and the monitoring of the interference by signals being transmitted to the interfered cell sites from the selected transmitter are performed during a critical time period.

4. The method of claim **1**, further comprising:

returning to best previous transmitter parameters when it is determined that performance in the critical zone has degraded or based on an amount of interference detected by an interfering transmitter in the interfered cell sites.

5. The method of claim **1**, wherein the list of interfering transmitters includes transmitters that have a highest interference power as measured by the mobile devices, transmitters that cause interference in a highest number of mobile devices, transmitters that cause interference in a highest number of cells, or transmitters with a highest weight metric assigned.

6. The method of claim **1**, wherein the parameters altered by the altering of the parameters include antenna tilt and transmit power of the selected transmitter.

7. The method of claim 1, wherein performance in the critical zone is based on key performance indicators (KPIs).

8. The method of claim 7, wherein in the KPIs include change in interference power, successful call rate or call traffic increases during a critical time period.

9. The method of claim 1, further comprising:

determining whether to alter a parameter of the selected transmitter based on a change in the average ratio of best server power to interferer power (C/I).

10. The method of claim 1, wherein the altering of the parameters for the selected transmitter is performed for all transmitters on the list of interfering transmitters until a desired interference reduction is achieved in the interfered cell sites of the wireless network.

11. At least one program recorded on a non-transitory computer-readable storage medium for reducing interference in interfered cell sites of a wireless communications network, a cell site being a region in which wireless communications are provided to mobile devices, and the interfered cell sites being cell sites where mobile devices are subject to interference signals from at least one interfering transmitter, the at least one program causing a computer to perform steps comprising:

selecting a transmitter from a list of interfering transmitters in need of adjustment and corresponding antennas;

determining a critical zone with respect to the selected transmitter;

altering parameters of the selected transmitter and a corresponding antenna; and

monitoring performance of the wireless network in the critical zone and interference by signals being transmitted to any interfered cell sites from the selected transmitter,

wherein the altering of the parameters of the selected transmitter and the corresponding antenna is performed continuously until a desired interference reduction is achieved in the interfered cell sites of the wireless communications network.

12. The at least one program of claim 11, wherein the list of interfering transmitters includes the transmitters in need of adjustment and the corresponding antennas in association with ranked signal code measurements for sources included in a list of interfering sources.

13. The at least one program of claim 11, wherein the monitoring of the performance in the critical zone and the monitoring of the interference by signals being transmitted to the interfered cell sites from the selected transmitter are performed during a critical time period.

14. The at least one program of claim 11, further comprising:

returning to best previous transmitter parameters when it is determined that performance in the critical zone has degraded or based on an amount of interference in the interfered cell sites.

15. The at least one program of claim 11, wherein the list of interfering transmitters includes transmitters that have a highest interference power as measured by the mobile devices, transmitters that cause interference in a highest number of mobile devices, transmitters that cause interference in a highest number of cells, or transmitters with a highest weight metric assigned.

16. The at least one program of claim 11, wherein the parameters altered by the altering of the parameters include antenna tilt and transmit power corresponding to the selected transmitter.

17. The at least one program of claim 11, wherein performance in the critical zone is based on key performance indicators (KPIs).

18. The at least one program of claim 17, wherein the KPIs include change in interference power, successful call rate or call traffic increases during a critical time period.

19. The at least one program of claim 11, further comprising:

determining whether to alter a parameter of the selected transmitter based on a change in the average ratio of best server power to interferer power (C/I).

20. The at least one program of claim 11, wherein the altering of the parameters for the selected transmitter is performed for all transmitters on the list of interfering transmitters until a desired interference reduction is achieved in the interfered cell sites of the wireless network.

21. An antenna adjustment apparatus for making adjustments to at least one antenna transmitting signals to interfered cell sites of a wireless communications network, a cell site being a region in which wireless communications are provided to mobile devices, and the interfered cell sites being cell sites where mobile devices are subject to interference signals from at least one interfering transmitter, the apparatus comprising:

at least one processor; and

a memory, the memory storing at least one interference reduction program for reducing interference in interfered cell sites of a wireless network, wherein at least one transmitter and antenna performs data communication with mobile devices distributed in any of the interfered cell sites, the at least one interference reduction program causing the antenna adjustment apparatus to perform steps comprising:

selecting a transmitter from a list of interfering transmitters in need of adjustment and corresponding antennas;

determining a critical zone with respect to the selected transmitter;

altering parameters of the selected transmitter and a corresponding antenna; and

monitoring performance of the wireless network in the critical zone and interference by signals being transmitted to any of the interfered cell sites from the selected transmitter,

wherein the altering of the parameters of the selected transmitter and the corresponding antenna is performed continuously until a desired interference reduction is achieved in the interfered cell sites of the wireless communications network.

22. The apparatus of claim 21, wherein the list of interfering transmitters includes the transmitters in need of adjustment and the corresponding antennas in association with ranked signal code measurements for sources included in a list of interfering sources.

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