(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 3 094 118 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
16.11.2016 Bulletin 2016/46

(21) Application number: **16176396.6**

(22) Date of filing: **20.03.2012**

(51) Int Cl.:
H04W 4/18 *(2009.01)* ***H04W 40/00*** *(2009.01)*
H04W 48/12 *(2009.01)* ***H04B 7/02*** *(2006.01)*
H04B 7/04 *(2006.01)* ***H04J 3/12*** *(2006.01)*
H04L 1/00 *(2006.01)* ***H04L 5/00*** *(2006.01)*
H04L 5/14 *(2006.01)* ***H04L 25/02*** *(2006.01)*
H04L 25/03 *(2006.01)* ***H04W 4/00*** *(2009.01)*
H04W 4/06 *(2009.01)* ***H04W 24/02*** *(2009.01)*
H04W 52/14 *(2009.01)* ***H04W 52/24*** *(2009.01)*
H04W 52/34 *(2009.01)* ***H04W 68/02*** *(2009.01)*
H04W 72/04 *(2009.01)* ***H04W 72/08*** *(2009.01)*

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR

(30) Priority: **04.11.2011 US 201161556109 P**

(62) Document number(s) of the earlier application(s) in accordance with Art. 76 EPC:
12845315.6 / 2 774 404

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Remarks:
This application was filed on 27-06-2016 as a divisional application to the application mentioned under INID code 62.

(54) COORDINATION OF SELF-OPTIMIZATION OPERATIONS IN A SELF ORGANIZING NETWORK

(57) Embodiments of the present disclosure describe device, methods, computer-readable media and system configurations for coordinating a plurality of self-optimization operations, such as an energy-saving management operation and a capacity and coverage optimization operation, to reduce conflicts between changes to configuration parameters of a wireless network access node caused by the self-optimization operations. Other embodiments may be described and/or claimed.

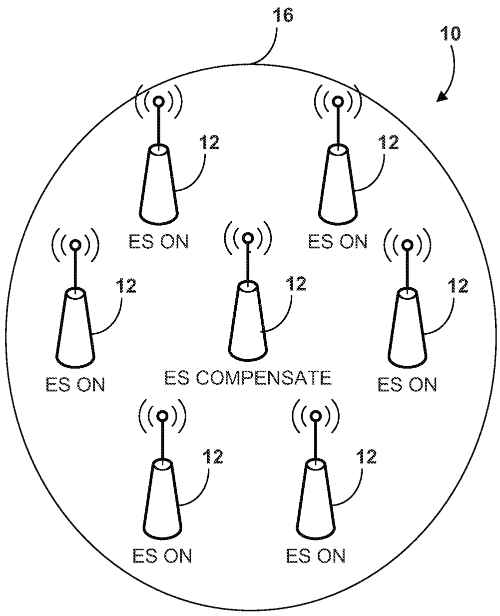

Fig. 2

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Description

Cross Reference to Related Applications

[0001] The present application claims priority to U.S. Provisional Patent Application No. 61/556,109, filed November 4, 2011, entitled "Advanced Wireless Communication Systems and Techniques," the entire disclosure of which is hereby incorporated by reference in its entirety.

Field

[0002] Embodiments of the present invention relate generally to the field of communications, and more particularly, to coordination of self-optimization operations in a self-organizing network ("SON").

Background

[0003] The background description provided herein is for the purpose of generally presenting the context of the disclosure. Work of the presently named inventors, to the extent it is described in this background section, as well as aspects of the description that may not otherwise qualify as prior art at the time of filing, are neither expressly nor impliedly admitted as prior art against the present disclosure. Unless otherwise indicated herein, the approaches described in this section are not prior art to the claims in the present disclosure and are not admitted to be prior art by inclusion in this section.

[0004] Wireless network access nodes ("WNANs"), such as base stations configured to operate pursuant to the IEEE 802.16 standard, IEEE Std. 802.16-2009, published May 29, 2009 ("WiMAX"), or evolved Node Bs ("eNBs") configured to operate under the 3GPP Long Term Evolution ("LTE") Release 10 (March 2011) ("LTE"), may be configured to cooperate with other WNANs to form a self-organizing network ("SON").

[0005] WNANs may be configured to perform self optimization operations. These self optimization operations may address issues such as coverage holes, weak coverage, uplink and downlink channel coverage mismatch, and so forth. WNANs may obtain data (e.g., user equipment measurements, performance measurements, trace data, etc.) from various sources such as wireless devices (e.g., user equipment in LTE). This data may be analyzed, and configuration parameters associated with one or more WNANs may be adjusted automatically to improve network performance, coverage and/or capacity, and/or to mitigate the aforementioned issues.

[0006] Self-optimization operations may include but are not limited to load balancing, handover performance optimization, coverage and capacity optimization ("CCO"), inter-cell interference mitigation, radio/transport parameter optimization, energy-saving management ("ESM"), and so forth. ESM operations, for example, may be performed to cause certain WNANs providing cells in a SON to shut down during off-peak traffic time intervals (e.g., middle of the night), e.g., to conserve energy, and may cause other WNANs in the multi-cell network to compensate for the shut down WNANs. Self-optimization functions may be executed independently by WNANs or other network devices. However, conflicts may arise when two or more self-optimization operations attempt to tune a configuration parameter of a WNAN in a conflicting manner.

Brief Description of the Drawings

[0007] Embodiments will be readily understood by the following detailed description in conjunction with the accompanying drawings. To facilitate this description, like reference numerals designate like structural elements. Embodiments are illustrated by way of example and not by way of limitation in the figures of the accompanying drawings.

Fig. 1 schematically illustrates an example self-organizing network ("SON") of wireless network access nodes ("WNANs") operating during peak traffic, in accordance with various embodiments.

Fig. 2 schematically illustrates the example SON of WNANs of Fig. 1, operating during off-peak traffic, in accordance with various embodiments.

Fig. 3 schematically depicts an example method that may be performed by a WNAN, in accordance with various embodiments.

Fig. 4 schematically depicts a computing device that may be configured to implement disclosed techniques, in accordance with various embodiments.

Detailed Description

[0008] In the following detailed description, reference is made to the accompanying drawings which form a part hereof wherein like numerals designate like parts throughout, and in which is shown by way of illustration embodiments that may be practiced. It is to be understood that other embodiments may be utilized and structural or logical changes may be implemented. Therefore, the following detailed description is not to be taken in a limiting sense.

[0009] Various operations may be described as multiple discrete actions or operations in turn, in a manner that is most helpful in understanding the claimed subject matter. However, the order of description should not be construed as to imply that these operations are necessarily order dependent. In particular, these operations may not be performed in the order of presentation. Operations described may be performed in a different order than the described embodiment. Various additional operations may be performed and/or described operations may be omitted in additional embodiments.

[0010] For the purposes of the present disclosure, the phrase "A and/or B" means (A), (B), or (A and B). For the purposes of the present disclosure, the phrase "A, B, and/or C" means (A), (B), (C), (A and B), (A and C), (B and C), or (A, B and C).

[0011] The description may use the phrases "in an embodiment," or "in embodiments," which may each refer to one or more of the same or different embodiments. Furthermore, the terms "comprising," "including," "having," and the like, as used with respect to embodiments of the present disclosure, are synonymous.

[0012] As used herein, the term "module" may refer to, be part of, or include an Application Specific Integrated Circuit ("ASIC"), an electronic circuit, a processor (shared, dedicated, or group) and/or memory (shared, dedicated, or group) that execute one or more software or firmware programs, a combinational logic circuit, and/or other suitable components that provide the described functionality. As used herein, "computer-implemented method" may refer to any method executed by one or more processors, a computer system having one or more processors, a mobile device such as a smart phone (which may include one or more processors), a tablet computer, laptop computer, a set-top box, a gaming console, and so forth. As used herein, the term "self-optimization" refers to any successful or unsuccessful attempt at improvement in performance, including both relative and absolute optimization.

[0013] An example self-organizing network ("SON") 10 of wireless network access nodes ("WNANs") 12 is shown in Fig. 1 operating during a peak traffic situation. Each WNAN 12 of SON 10 provides a cell 14 to which one or more wireless devices (not shown), such as mobile subscribers ("MS") or user equipment ("UE") devices, may connect wirelessly. The cells 14 provided by the WNANs 12 together form a multi-cell network. In various embodiments, a WNAN may be a base station ("BS") configured to operate pursuant to WiMAX. In various embodiments, WNAN 12 may be an evolved Node B ("eNB") configured to operate in an evolved universal terrestrial radio access network ("E-UTRAN") pursuant to LTE, or other types of WNANs. In Fig. 1, traffic may be at or close to peak, and so each of the WNANs 12 shown in Fig. 1 may be operating in non-energy-saving state ("NO ES") to provide cells 14 to which a high volume of wireless devices may connect.

[0014] However, during non-peak hours, a lower volume of wireless devices may connect to the multi-cell network 14. Accordingly, as shown in Fig. 2, the WNANs 12 may perform various energy-saving management ("ESM") operations, e.g., in cooperation, to collectively conserve power. For instance, ESM operations performed by the WNANs 12 on the perimeter may include transitioning to an energy-saving state (designated as "ES ON" in Fig. 2). In various embodiments, a WNAN 12 in an energy-saving state may no longer provide a cell 14, and may be powered down or in some other type of reduced-power state.

[0015] The center WNAN 12 may perform other ESM operations to adjust its configuration parameters to provide coverage for neighboring cells 14 to accommodate powering down of the perimeter WNANs 12. For example, the center WNAN 12 may operate in an energy-saving compensating state (designated as "ES COMPENSATE"). In this state, center WNAN 12 may provide a single cell 16 that may be used by wireless devices that would normally use one of the neighboring cells 14 during peak traffic.

[0016] Other self-optimization operations, performed for a variety of other reasons, may adjust configuration parameters of a WNAN such as center WNAN 12 in Fig. 2 in a manner that conflicts with how the configuration parameters are adjusted by an ESM operation. For example, a coverage and capacity optimization ("CCO") operation may adjust a configuration parameter in one manner to provide better coverage for wireless devices in a particular area. An ESM operation may adjust the same configuration parameter in another manner, e.g., shut it down. These configuration parameter adjustments may conflict.

[0017] Accordingly, in various embodiments, a WNAN may be configured to coordinate a plurality of self-optimization operations to reduce conflicts between changes to configuration parameters of the WNAN caused by the self-optimization operations. These self-optimization operations may include but are not limited to load balancing, handover performance optimization, CCO, inter-cell interference mitigation, radio/transport parameter optimization, ESM, and so forth. "Configuration parameters" of WNANs may include but are not limited to downlink transmission ("DL Tx") power, antenna tilt, antenna azimuth, and so forth.

[0018] Fig. 3 depicts an example method 300 that may be performed by a WNAN such as a WNAN 12 of Figs. 1 or 2 to coordinate multiple self-optimization operations to avoid conflicts. In this example, two self-optimization operations, CCO 302 and ESM 304, are depicted. However, this is not meant to be limiting, and more than two self-optimization operations may be selectively coordinated to avoid conflicts in changes to configuration parameters. Moreover, these self-optimization operations may include other types of self-optimization operations; CCO and ESM are used in Fig. 3 for illustrated purposes only.

[0019] In various embodiments, at block 306, a CCO may be triggered by various events. For example, a WNAN 12 such as an eNB or base station may analyze data received from various sources (e.g., wireless devices) and determine that capacity and/or coverage may be improved if one or more configuration parameters of the WNAN 12 are changed.

[0020] At block 308, WNAN 12 may perform an atomic test and set command on a binary semaphore 310 (e.g., stored in memory of WNAN 12), to determine whether the semaphore is in a locked state. For example, the binary semaphore may be set to a locked state, and its previous value (locked or unlocked state) may be returned as indicated by the "SEMAPHORE VALUE" arrow. At block 312, this previous value may be examined. In various embodiments, if the previous value of the binary semaphore 310 is locked, that may indicate that another self-optimization operation, such as ESM 304, has locked the semaphore, has recently adjusted, is currently adjusting or will be soon adjusting one or more configuration parameters of WNAN 12. In such case, method 300 may refrain from initiating the CCO operation until binary semaphore 310 becomes unlocked. For example, as shown by the "WAIT" arrow in Fig. 3, method 300 may go back and retest and reset binary semaphore 310 until the test and set command returns a previous value that indicates the semaphore has been unlocked (e.g., by another process).

[0021] If at block 312 the previous state of binary semaphore 310 is determined to be unlocked, then method 300 may proceed to block 314, and it may be determined whether the WNAN 12 is currently in an energy-saving compensating state (also referred to herein as an "ES COMPENSATE state). If WNAN 12 is currently in the ES COMPENSATE state, then WNAN 12 may not need to initiate CCO because it is currently extending coverage (e.g., as shown in Fig. 2) to compensate for other shutdown cells. In such case, the CCO may not be initiated and method 300 may proceed back to the beginning (e.g., waiting for CCO or ESM to be triggered). However, if WNAN 12 is not currently in the ES COMPENSATE state, then at block 316, the WNAN may initiate the CCO, and then unlock the semaphore at block 317.

[0022] Method 300 may include another track that begins at block 320 when an ESM operation is triggered. An ESM operation may be triggered by various events. For example, an ESM operation may be triggered in one or more WNANs 12 during a transition from peak traffic (e.g., shown in Fig. 1) to non-peak traffic (e.g., shown in Fig. 2). For example, an ESM operation may be triggered on the perimeter WNANs 12 to cause them to transition into energy-saving states. Similarly, an ESM operation may be triggered on the center WNAN 12, to enable it to provide coverage for the neighboring cells 14 to accommodate powering down of the perimeter WNANs 12.

[0023] At block 322, binary semaphore 310 may be tested and set, e.g., by the WNAN. Similar to block 308, the binary semaphore 310 may be set to a locked state, and its previous value (e.g., locked or unlocked state) may be returned. If at block 324 the previous value was locked, then method 300 may refrain from initiating the ESM operation until binary semaphore is unlocked (e.g., as shown by the WAIT arrow).

[0024] If the previous value of binary semaphore 310 was unlocked, then method 300 may proceed to block 326, and the ESM operation may be initiated. For example, in Fig. 3, the ESM operation at block 326 may be to cause the WNAN to enter into an energy-saving state or an ES COMPENSATE state.

[0025] At 328, it may be determined whether the WNAN is in ES COMPENSATE state. If yes, then method 300 may proceed back to the beginning (e.g., back to block 304). However, if the WNAN is determined to be in ENERGY SAVING STATE, then at block at block 330, the binary semaphore 310 may be unlocked, after which method 300 may end (e.g., because the WNAN has powered down).

[0026] Fig. 4 illustrates a computing device 400 in accordance with various embodiments. The computing device 400 houses a printed circuit board ("PCB") 402. The PCB 402 may include a number of components, including but not limited to a processor 404 and at least one communication chip 406. The processor 404 may be physically and electrically coupled to the PCB 402. In various embodiments, the at least one communication chip 406 may also be physically and electrically coupled to the PCB 402. In further implementations, the communication chip 406 may be part of the processor 404.

[0027] Depending on its applications, computing device 400 may include other components that may or may not be physically and electrically coupled to the PCB 402. These other components include, but are not limited to, volatile memory (e.g., dynamic random access memory 408, also referred to as "DRAM"), non-volatile memory (e.g., read only memory 410, also referred to as "ROM"), one or more semaphores 411 (which may in some embodiments reside in various memory), flash memory 412, a graphics processor 414, a digital signal processor (not shown), a crypto processor (not shown), a chipset 416, an antenna 418, a display (not shown), a touch screen display 420, a touch screen controller 422, a battery 424, an audio codec (not shown), a video codec (not shown), a power amplifier 426, a global positioning system ("GPS") device 428, a compass 430, an accelerometer (not shown), a gyroscope (not shown), a speaker 432, a camera 434, and a mass storage device (such as hard disk drive, a solid state drive, compact disk ("CD"), digital versatile disk ("DVD"))(not shown), and so forth.

[0028] In various embodiments, volatile memory (e.g., DRAM 408), non-volatile memory (e.g., ROM 410), flash memory 412, and the mass storage device may include programming instructions configured to enable computing device 400, in response to execution by processor(s) 404, to practice all or selected aspects of method 300.

[0029] The communication chip 406 may enable wired and/or wireless communications for the transfer of data to and from the computing device 400. The term "wireless" and its derivatives may be used to describe circuits, devices, systems, methods, techniques, communications channels, etc., that may communicate data through the use of modulated electromagnetic radiation through a non-solid medium. The term does not imply that the associated devices do not contain any wires, although in some embodiments they might not. The communication chip 406 may implement any of a number of wireless standards or protocols, including but not limited to Wi-Fi (IEEE 802.11 family), WiMAX (IEEE 802.16 family), IEEE 802.20, Long Term evolution ("LTE"), Ev-DO, HSPA+, HSDPA+, HSUPA+, EDGE, GSM, GPRS, CDMA, TDMA, DECT, Bluetooth, derivatives thereof, as well as any other wireless protocols that are designated as 3G, 4G, 5G, and beyond. The computing device 400 may include a plurality of communication chips 406. For instance, a first communication chip 406 may be dedicated to shorter range wireless communications such as Wi-Fi and Bluetooth and a second communication chip 406 may be dedicated to longer range wireless communications such as GPS, EDGE, GPRS, CDMA, WiMAX, LTE, Ev-DO, and others.

[0030] The processor 404 of the computing device 400 may include an integrated circuit die packaged within the processor 404. In various embodiments, the integrated circuit die of the processor 404 may include one or more devices, such as transistors or metal interconnects, that are formed to facilitate coordination of self-optimization operations using one or more techniques described herein. The term "processor" may refer to any device or portion of a device that processes electronic data from registers and/or memory to transform that electronic data into other electronic data that may be stored in registers and/or memory.

[0031] The communication chip 406 may also include an integrated circuit die packaged within the communication chip 406. In various embodiments, the integrated circuit die of the communication chip 406 may include one or more devices, such as transistors or metal interconnects, that are formed to facilitate coordination of self-optimization operations using one or more techniques described herein.

[0032] In various implementations, the computing device 400 may be a laptop, a netbook, a notebook, an ultrabook, a smart phone, a tablet, a personal digital assistant ("PDA"), an ultra mobile PC, a mobile phone, a desktop computer, a server, a printer, a scanner, a monitor, a set-top box, an entertainment control unit, a digital camera, a portable music player, or a digital video recorder. In further implementations, the computing device 400 may be any other electronic device that processes data.

[0033] The following paragraphs describe examples of various embodiments. In various embodiments, a plurality of self-optimization operations, including an energy-saving management operation and a capacity and coverage optimization operation, may be coordinated to reduce conflicts between changes to configuration parameters of a wireless network access node caused by the self-optimization operations.

[0034] In various embodiments, the energy-saving management operation may adjust the configuration parameters at off-peak times to provide coverage for neighboring cells to accommodate powering down of wireless network access nodes of the neighboring cells. In various embodiments, the energy-saving management operation may cause the wireless network access node to enter into an energy-saving state or energy-saving compensation state. In various embodiments, the changes to configuration parameters caused by the capacity and coverage optimization operation or other self-optimization operations may include changes to power of downlink transmissions, changes to antenna tilt, or changes to antenna azimuth.

[0035] In various embodiments, the plurality of self-optimization operations may be coordinated using a semaphore. In various embodiments, may be detected that triggers a self-optimization operation, and it may be determined whether the semaphore is in a locked or unlocked state before the self-optimization operation is initiated. In various embodiments, an atomic test and set command may be performed to determine whether the semaphore is in the locked or unlocked state. In various embodiments, where it is determined that the semaphore is in a locked state, the self-optimization algorithm may not be initiated.

[0036] Computer-readable media (including non-transitory computer-readable media), methods, systems and devices for performing the above-described techniques are illustrative examples of embodiments disclosed herein.

[0037] Although certain embodiments have been illustrated and described herein for purposes of description, a wide variety of alternate and/or equivalent embodiments or implementations calculated to achieve the same purposes may be substituted for the embodiments shown and described. This application is intended to cover any adaptations or variations of the embodiments discussed herein. Therefore, it is manifestly intended that embodiments described herein be limited only by the claims and the equivalents thereof.

[0038] The following section of the description consists of numbered paragraphs simply providing statements of the invention already described herein. The numbered paragraphs in this section are not claims. The claims are set forth below in the later section headed "claims".

1. A system, comprising: a processor; memory operably coupled to the processor; and a control module to be operated by the processor and configured to coordinate a plurality of self-optimization operations, including an energy-saving management operation and a capacity and coverage optimization operation, to reduce conflicts between changes to configuration parameters of a wireless network access node caused by the self-optimization operations.

2. The system of clause 1, further comprising one or more antennas.

3. The system of clause 2, wherein the energy-saving management operation adjusts the configuration parameters at off-peak times to provide coverage for neighboring cells to accommodate powering down of wireless network access nodes of the neighboring cells.

4. The system of clause 2, wherein the energy-saving management operation causes the wireless network access node to enter into an energy-saving state or energy-saving compensation state.

5. The system of clause 1, wherein the changes to configuration parameters caused by the capacity and coverage optimization operation include changes to power of downlink transmissions, changes to antenna tilt, or changes to antenna azimuth.

6. The system of any one of clauses 1-5, wherein the memory comprises a semaphore, and the control module is further configured coordinate the plurality of self-optimization operations using the semaphore.

7. The system of clause 6, wherein the control module is further configured to detect an event that triggers a self-optimization operation, and to determine whether the semaphore is in a locked or unlocked state before initiating the self-optimization operation.

8. The system of clause 7, wherein the control module is further configured to perform an atomic test and set command to determine whether the semaphore is in the locked or unlocked state.

9. The system of clause 7, wherein the control module is further configured to refrain from initiating the self-optimization algorithm where it is determined that the semaphore is in a locked state.

10. The system of any one of clauses 1-5, wherein the wireless network access node is an evolved Node B configured to operate in an evolved universal terrestrial radio access network ("E-UTRAN").

11. The system of any one of clauses 1-5, wherein the wireless network access node is a base station configured to operate in a network providing WiMAX services.

12. A computer-implemented method, comprising: determining, by a wireless network access node, that a capacity and coverage optimization operation has been triggered; determining, by the wireless network access node, whether the wireless network access node is performing an energy-saving management operation; and initiating, by the wireless network access node, the capacity and coverage operation where it is determined that the wireless network access node is not performing the energy-saving management operation.

13. The computer-implemented method of clause 12, wherein determining whether the wireless network access node is performing an energy-saving management operation comprises: testing, by the wireless network access node, a semaphore to determine whether the semaphore is in a locked state; and setting, by the wireless network access node, the semaphore to the locked state where it is determined that the semaphore is not in a locked state.

14. The computer-implemented method of clause 12, further comprising: determining, by the wireless network access node, that the energy-saving management operation has been triggered; determining, by the wireless network access node, whether the wireless network access node is performing the coverage and capacity optimization operation; and initiating, by the wireless network access node, the energy-saving management operation where it is determined that the wireless network access node is not performing the coverage and capacity optimization operation.

15. The computer-implemented method of clause 14, wherein determining whether the wireless network access node is performing the coverage and capacity optimization operation comprises: testing, by the wireless network access node, a semaphore to determine whether the semaphore is in a locked state; and setting, by the wireless network access node, the semaphore to the locked state where it is determined that the semaphore is not in a locked state.

16. The computer-implemented method of clause 12, wherein the coverage and capacity optimization operation comprises making changes to configuration parameters of the wireless network access node.

17. The computer-implemented method of clause 16, wherein the changes to configuration parameters comprise changes to power of downlink transmissions, changes to antenna tilt, or changes to antenna azimuth.

18. The computer-implemented method of clause 12, wherein the energy-saving management operation comprises making changes to configuration parameters of the wireless network access node.

19. The computer-implemented method of clause 18, wherein the changes to configuration parameters comprise changes to power of downlink transmissions, changes to antenna tilt, or changes to antenna azimuth.

20. The computer-implemented method of clause 12, further comprising refraining from initiating the capacity and coverage optimization operation where it is determined that the semaphore is in a locked state.

21. The computer-implemented method of clause 13, further comprising refraining from initiating the energy-saving management operation where it is determined that the semaphore is in a locked state.

22. At least one machine-readable medium comprising a plurality of instructions that, in response to being executed on a computing device, cause the computing device to carry out a method according to any one of clauses 12-21.

23. An apparatus configured to perform the method of any one of clauses 12-21.

24. At least one machine-readable medium comprising a plurality of instructions that, in response to being executed on an evolved Node B ("eNB"), enable the eNB to coordinate a plurality of self-optimization operations, including an energy-saving management operation, to reduce conflicts between changes to configuration parameters of the eNB caused by the self-optimization operations.

25. The at least one machine-readable medium of

clause 24, wherein the plurality of self-optimization operations further include one or more of load balancing, handover performance optimization, coverage and capacity optimization, inter-cell interference mitigation, and radio/transport parameter optimization.

26. The at least one machine-readable medium of clause 24, wherein the energy-saving management operation adjusts the configuration parameters at off-peak times to provide coverage for neighboring cells to accommodate powering down of eNBs of the neighboring cells.

27. The at least one machine-readable medium of clause 26, wherein the changes to configuration parameters caused by the self-optimization operations include changes to power of downlink transmissions, changes to antenna tilt, or changes to antenna azimuth.

28. The at least one machine-readable medium of any one of clauses 24-27, wherein the plurality of self-optimization operations are coordinated using a semaphore.

Claims

1. An apparatus to implement self-organizing network (SON) function coordination, the apparatus comprising:

one or more processors operably coupled with one or more computer readable media, the one or more processors are to execute instructions to:

identify a trigger for an evolved nodeB (eNB) to compensate for a cell that is to enter an energy saving (ES) state;
determine whether one or more configuration parameters are being changed for the eNB; and
instruct the eNB to initiate an ES compensate state when the one or more configuration parameters are not being changed, wherein the eNB in the ES compensate state is to compensate for the cell that is to enter the ES state.

2. The apparatus of claim 1, wherein the one or more processors are to execute the instructions to:

instruct the eNB to not initiate the ES compensate state based on a determination that the one or more configuration parameters are being changed.

3. The apparatus of claim 1, wherein, to instruct the eNB to initiate the ES compensate state, the one or more processors are to execute the instructions to:

instruct the eNB to adjust at least one configuration parameter of the one or more configuration parameters.

4. The apparatus of claim 1, wherein the eNB is to be triggered by an ES function to compensate the cell that is to enter ES state.

5. The apparatus of claim 1, wherein the one or more processors are to execute the instructions to determine whether the one or more configuration parameters are being changed by a capacity and coverage optimization (CCO) function.

6. The apparatus of claim 1, wherein the one or more configuration parameters include one or more of a downlink transmission power, an antenna tilt, or an antenna azimuth.

7. The apparatus of claims 1-6, wherein the apparatus is to be implemented in the eNB or another eNB.

8. A computer-implemented method comprising:

determining whether an evolved nodeB (eNB) is to be activated to compensate for a cell that is to enter an energy saving (ES) state;
determining whether one or more configuration parameters are being changed for the eNB by a capacity and coverage optimization (CCO) function;
instructing the eNB to not initiate an ES compensate state when it is determined that the one or more configuration parameters are being changed by the CCO function such that the eNB will not compensate for the cell that is to enter the ES state.

9. The computer-implemented method of claim 8, further comprising:

instructing the eNB to initiate the ES compensate state when it is determined that the one or more configuration parameters are not being changed by the CCO function such that the eNB will compensate for the cell after the cell enters the ES state.

10. The computer-implemented method of claim 9, wherein instructing the eNB to initiate the ES compensate state comprises:

instructing the eNB to adjust at least one configuration parameter of the one or more configuration parameters.

11. The computer-implemented method of claim 8, wherein the eNB is to be activated to compensate the cell that is to enter ES state by an ES function, and the method further comprises:

determining whether the eNB is currently in an ES state; and
refraining from instructing the eNB to initiate the ES compensate state when it is determined that the eNB is currently in the ES state.

12. The computer-implemented method of claim 8, wherein the one or more configuration parameters include one or more of a downlink transmission power, an antenna tilt, or an antenna azimuth.

13. The computer-implemented method of claim 8, wherein determining whether the one or more configuration parameters are being changed by the CCO function comprises:

testing a semaphore to determine whether the semaphore is in a locked state; and
setting the semaphore to the locked state when it is determined that the semaphore is not in the locked state.

14. An apparatus to implement self-organizing network (SON) function coordination, the apparatus comprising:

means for detecting an event that triggers an evolved nodeB (eNB) to compensate for another eNB that is to enter an energy saving (ES) state;
means for determining whether one or more configuration parameters are currently being changed for the eNB in response to the detection; and
means for instructing the eNB to initiate an ES compensate state based on a determination that the one or more configuration parameters are not currently being changed or for instructing the eNB to not initiate the ES compensate state based on a determination that the one or more configuration parameters are currently being changed,

wherein the eNB in the ES compensate state is to compensate for the other eNB that is to enter the ES state, and wherein instructing the eNB to initiate an ES compensate state includes instructing the eNB to adjust at least one configuration parameter of the one or more configuration parameters.

15. The apparatus of claim 14, wherein the one or more configuration parameters include one or more of a downlink transmission power, an antenna tilt, or an antenna azimuth, and wherein the means for determining is further for determining whether the one or more configuration parameters are currently being changed by a capacity and coverage optimization (CCO) function.

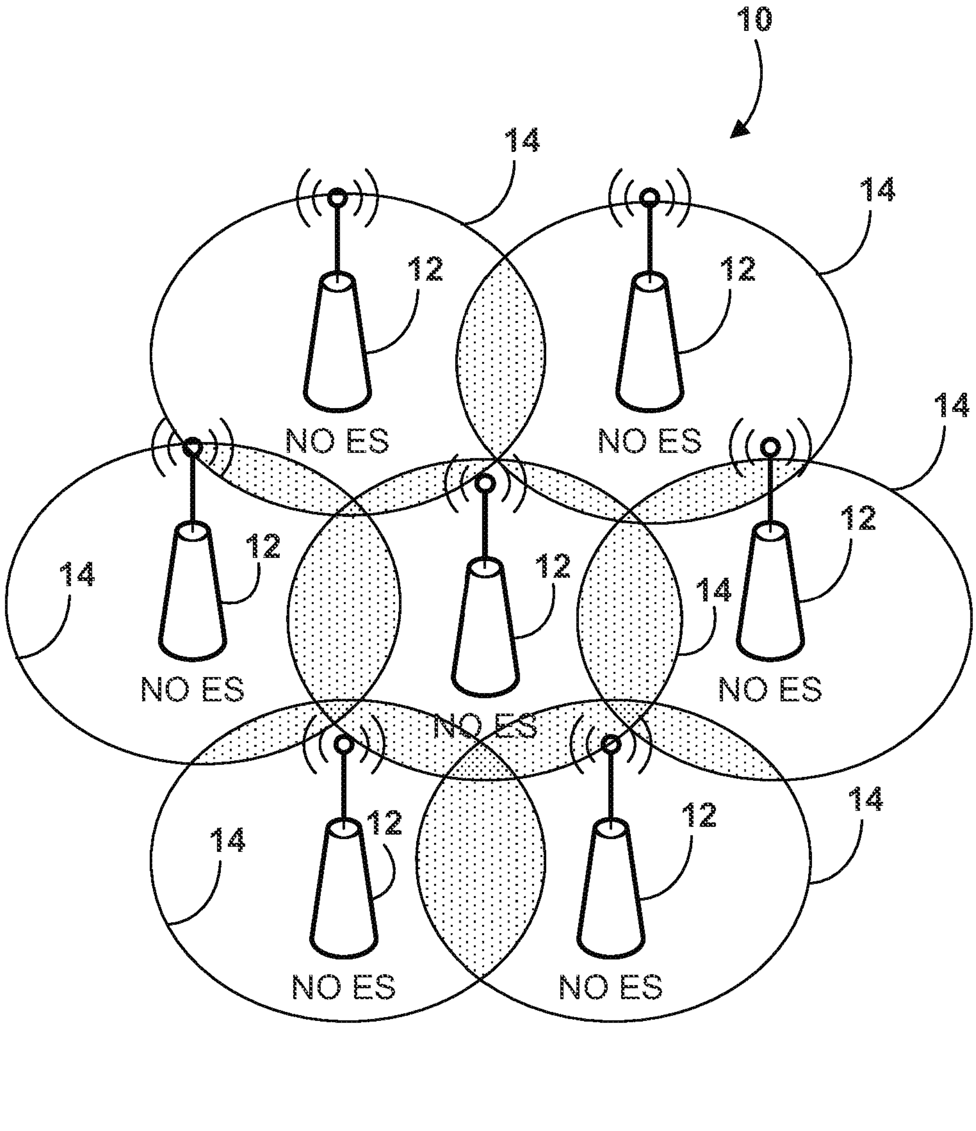

10
14
14
14
14
14
14
14
14
12
12
12
12
12
12
12
NO ES
NO ES
NO ES
NO ES
NO ES
NO ES
NO ES

Fig. 1

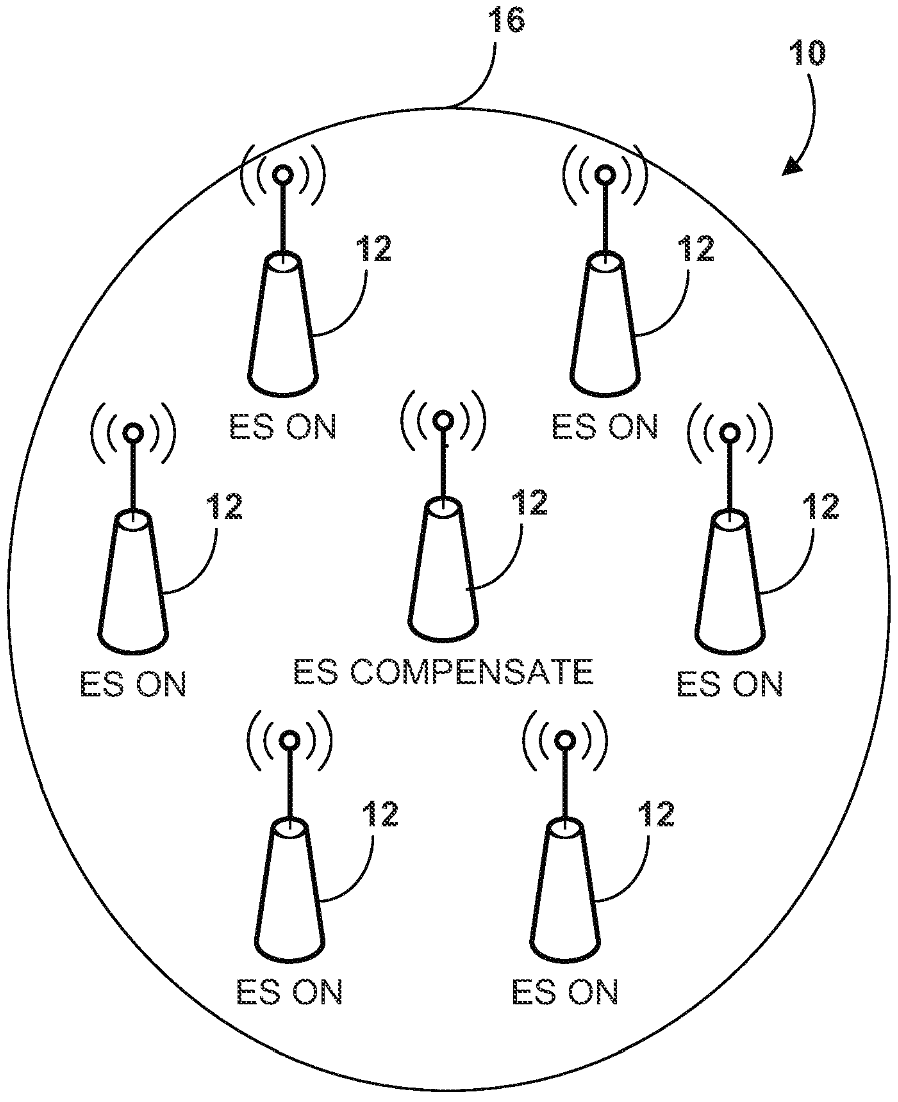
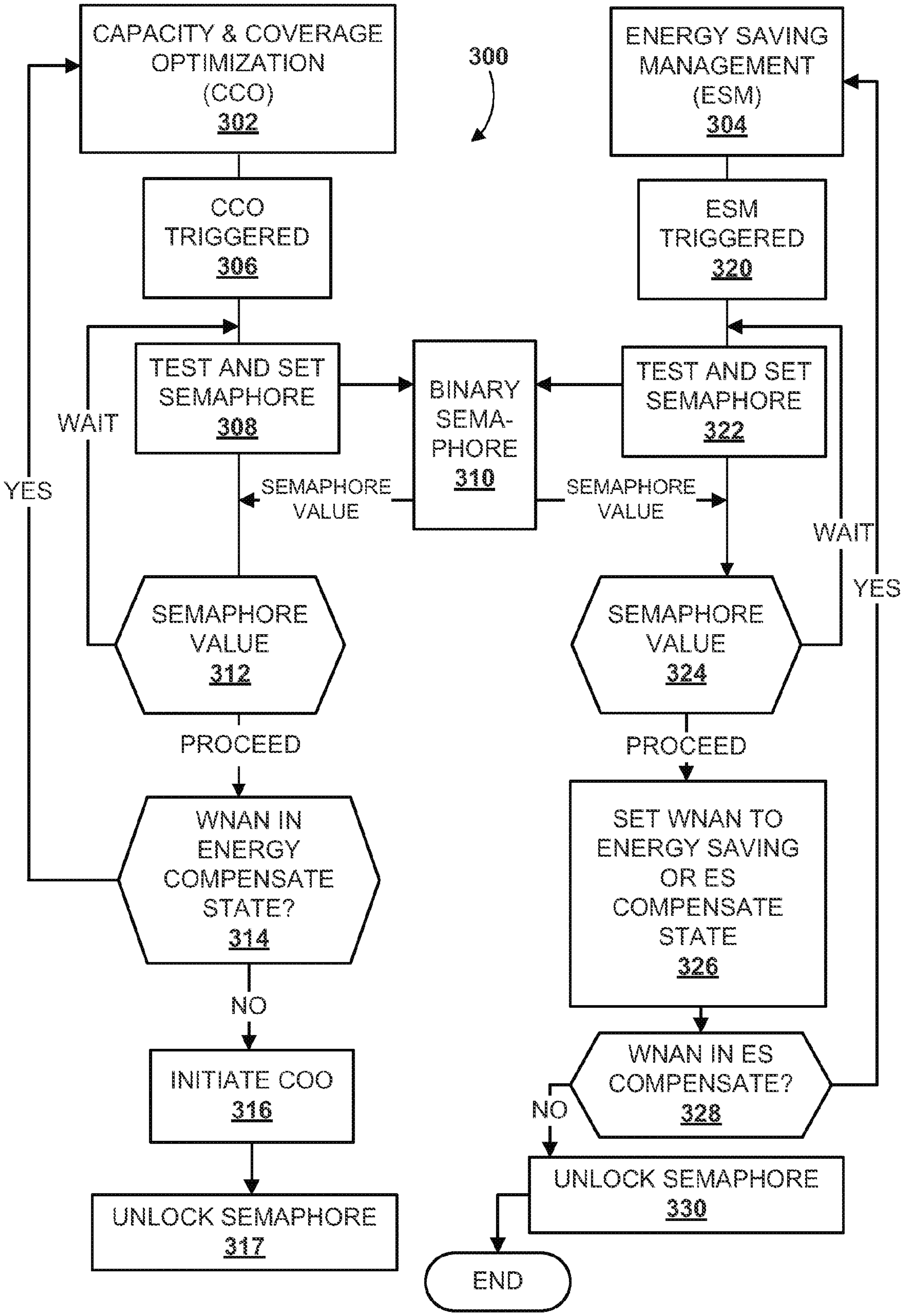
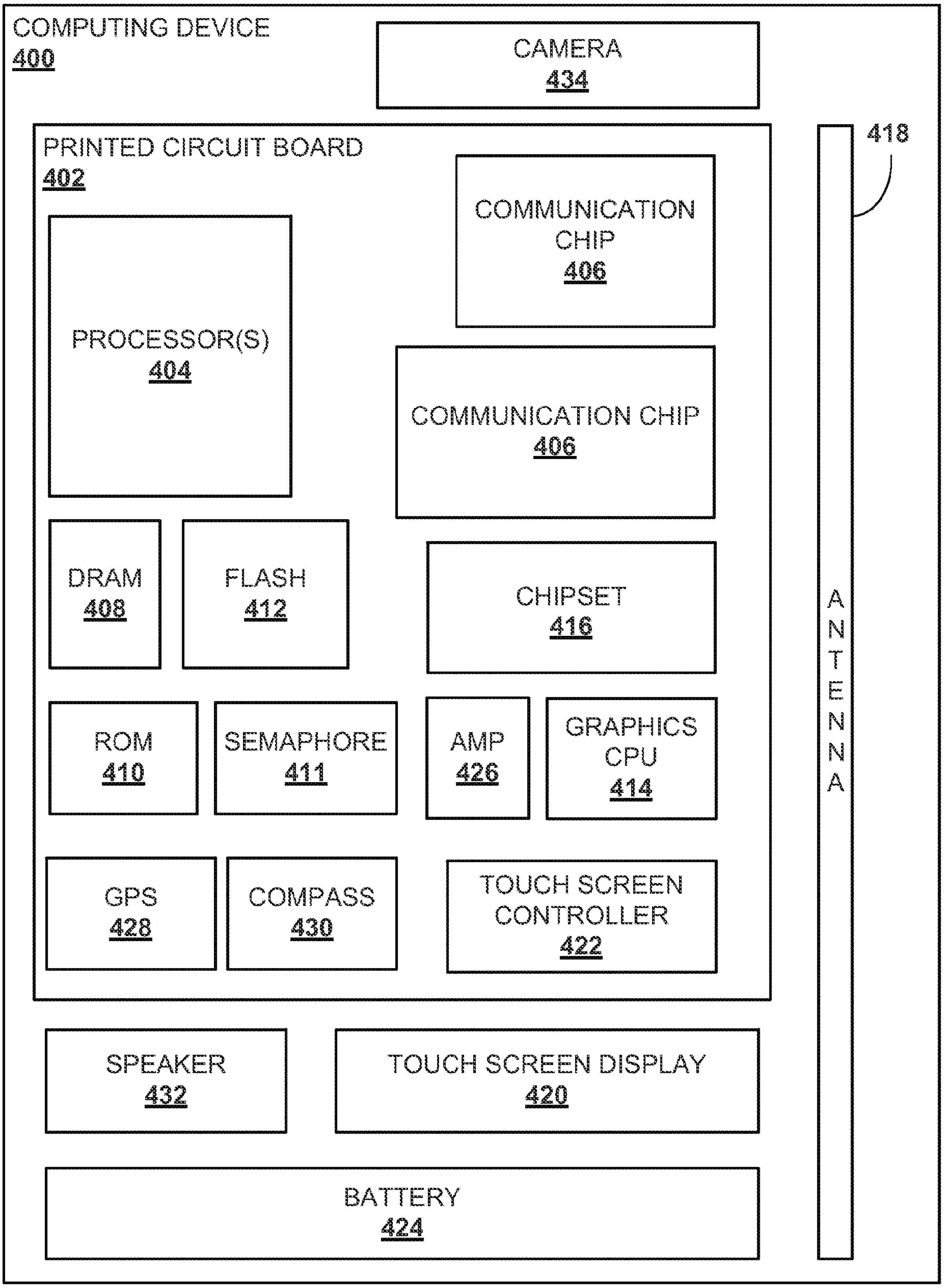

16
10
12
ES ON
12
ES ON
12
ES ON
12
ES COMPENSATE
12
ES ON
12
ES ON
12
ES ON

Fig. 2



CAPACITY & COVERAGE OPTIMIZATION (CCO) 302
300
ENERGY SAVING MANAGEMENT (ESM) 304
CCO TRIGGERED 306
ESM TRIGGERED 320
TEST AND SET SEMAPHORE 308
BINARY SEMA-PHORE 310
TEST AND SET SEMAPHORE 322
WAIT
YES
SEMAPHORE VALUE
SEMAPHORE VALUE
WAIT
YES
SEMAPHORE VALUE 312
SEMAPHORE VALUE 324
PROCEED
PROCEED
WNAN IN ENERGY COMPENSATE STATE? 314
SET WNAN TO ENERGY SAVING OR ES COMPENSATE STATE 326
NO
WNAN IN ES COMPENSATE? 328
NO
INITIATE COO 316
UNLOCK SEMAPHORE 330
UNLOCK SEMAPHORE 317
END

Fig. 3


COMPUTING DEVICE
400
CAMERA
434
PRINTED CIRCUIT BOARD
402
418
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406
PROCESSOR(S)
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406
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BATTERY
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Fig. 4

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EUROPEAN SEARCH REPORT

Application Number
EP 16 17 6396

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A	WO 2011/050753 A1 (HUAWEI TECHNOLOGIES CO LTD) 5 May 2011 (2011-05-05) * the whole document * & EP 2 487 951 A1 (HUAWEI TECH CO LTD [CN]) 15 August 2012 (2012-08-15) * paragraphs [0049] - [0051] * -----	1-15	
A	NOKIA SIEMENS NETWORKS: "SON conflict resolution", 3GPP DRAFT; S5-093241 NSN SONCOORDINATIONFUNCTION, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE, no. Vancouver, Canada; 20090904, 4 September 2009 (2009-09-04), XP050399222, [retrieved on 2009-08-23] * Section 3; pages 1, 2 * -----	1-15	TECHNICAL FIELDS SEARCHED (IPC) H04L H04B H04W
A	CMCC: "Dependencies among SON use cases and CCO priority", 3GPP DRAFT; R3-091032 DEPENDENCIES AMONG SON USE CASES AND CCO PRIORITY, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE, no. San Francisco, USA; 20090429, 29 April 2009 (2009-04-29), XP050341416, [retrieved on 2009-04-29] * page 1, line 8 - page 2, line 30 * -----	1-15	

The present search report has been drawn up for all claims

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Place of search	Date of completion of the search	Examiner
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			TECHNICAL FIELDS SEARCHED (IPC)

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	9 September 2016	Cantagallo, Marco

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