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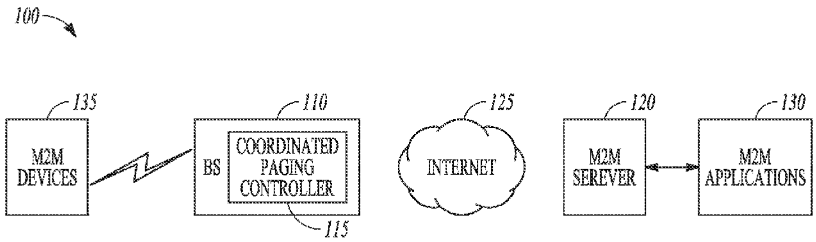

FIG. 1

(57) Abstract: A base station and method include dividing machine to machine devices into a plurality of groups and paging each group during paging listening windows corresponding to each paging group during a coordinated paging cycle. A machine to machine device wakes up at a coordinated paging cycle selected from a number of coordinated paging cycles and sends uplink data following receipt of the number of coordinated paging cycles corresponding to the reporting period.

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BASE STATION AND COMMUNICATION METHOD FOR MACHINE TO MACHINE COMMUNICATIONS

Related Application

[0001] This application claims priority to United States Provisional Application serial number 61/450,716, filed March 9, 2011, entitled "ADVANCED WIRELESS COMMUNICATION SYSTEMS AND TECHNIQUES", which is incorporated herein by reference.

Background

[0002] Cellular systems employ a random access mechanism to arbitrate the network entry or network reentry of mobile stations (MS). Base stations (BS) have a limited resource of random access channels based on the assumption that not all mobile stations will enter the network at the same time. With the addition of thousands of machine to machine (M2M) devices to an overlaid base station that is serving large number of mobile stations, there is a great concern that the random access channels will be congested. Currently, M2M devices can send data at any interval that they want. When a large number of M2M devices are deployed in a single cell, it can result in network entry congestion.

Brief Description of the Drawings

[0003] FIG. 1 is a block diagram illustrating a coordinated paging architecture according to an example embodiment.

[0004] FIG. 2 is a timing diagram illustrating coordinated paging for multiple M2M devices according to an example embodiment.

[0005] FIG. 3 is a flow diagram illustrating a method of grouping devices for uplink communications in a cell according to an example embodiment.

[0006] FIG. 4 is a flow diagram illustrating a method executed by a coordinated paging controller to poll devices according to an example embodiment.

[0007] FIG. 5 is a flow diagram illustrating a method executed by a device responding to polls according to an example embodiment.

[0008] FIG. 6 is a timing diagram illustrating hybrid paging of devices according to an example embodiment.

[0009] FIG. 7 is a block diagram of a machine that maybe specifically programmed to execute one or more methods according to an example embodiment.

Detailed Description

[0010] In the following description, reference is made to the accompanying drawings that form a part hereof, and in which is shown by way of illustration specific embodiments which may be practiced. These embodiments are described in sufficient detail to enable those skilled in the art to practice the invention, and it is to be understood that other embodiments may be utilized and that structural, logical and electrical changes may be made without departing from the scope of the present invention. The following description of example embodiments is, therefore, not to be taken in a limited sense, and the scope of the present invention is defined by the appended claims.

[0011] The functions or algorithms described herein may be implemented in software or a combination of software and human implemented procedures in one embodiment. The software may consist of computer executable instructions stored on computer readable media such as memory or other type of storage devices. Further, such functions correspond to modules, which are software, hardware, firmware or any combination thereof. Multiple functions may be performed in one or more modules as desired, and the embodiments described are merely examples. The software may be executed on a digital signal processor, ASIC, microprocessor, or other type of processor operating on a computer system, such as a personal computer, server or other computer system.

[0012] In various embodiments, a method is used to alleviate uplink congestion issues without changing an underlying random access communication mechanism that cellular systems use to communicate with mobile stations and machine to machine (M2M) devices.

[0013] There are many different types of M2M devices currently being used in cellular systems at the same time as mobile stations that are typically used by humans for various types of communications. M2M devices may be fixed or mobile, and have a bias toward sending uplink communications as opposed to receiving large amounts of data. A smart phone may also operate as an M2M device in addition to providing typical phone functionality. Typical uplink communications consist of short messages, but some also provide video streaming. Several usage models include vehicle location tracking, healthcare, secured access and surveillance, public safety such as river and dam water level monitoring, point of sale, smart meters, digital signage, and remote sensing such as oil, gas, water, and alarm. This list of M2M devices is not exhaustive, and many more may be developed in the future with different service requirements.

[0014] Given the current mix of M2M devices used in various applications, some average attributes include a long idle time between sensing uplink data and a fairly small data payload for the uplink. Uplink transmissions have a bias toward mainly providing non-real time periodic monitoring reports and occasionally to send a real time alarm report.

[0015] Since M2M applications generally have a bias toward uplink, and most of the uplink traffic is dedicated to provide non-real time periodic monitoring reports, uplink grants to the M2M devices are scheduled in a sequential manner in one embodiment, to reduce the chance of collision in a network re-entry process.

[0016] Existing paging mechanisms in an IIEE 802.16 standard are used in one embodiment with modifications to schedule uplink transmissions for large numbers of M2M devices such as sensors. The modifications transform the paging mechanisms into coordinated paging, as opposed to idle mode paging that is used to signal pending downlink traffic.

[0017] FIG. 1 is a block diagram illustrating a coordinated paging architecture generally at 100. A base station 110 is controlled by a coordinated paging controller 115, which in one embodiment is a computer program stored and executed on the base station 110. The controller 115 is coupled to an M2M server 120 via a network 125, such as the Internet, or other type of wireless or wired network. The M2M server 120 is used in one embodiment to determine uplink requirements of various M2M applications 130. The M2M server 120 then configures the controller 115 about the interval of M2M periodic reports. Once the controller 115 is configured, the controller via a base station transceiver and antenna polls the M2M devices 135 at a paging cycle, and delivers the M2M reports to the M2M server 120.

[0018] FIG. 2 is a timing diagram illustrating coordinated paging for multiple M2M devices generally at 200. In one embodiment, 128 paging groups labeled PG1 to PG128 are illustrated on the vertical axis. Each paging group has a corresponding page listening window 210 separated in time from adjacent page listening windows 210 by a paging offset 215. The horizontal axis corresponds to time, as measured by superframe numbers, and illustrates one coordinated paging cycle.

[0019] In one embodiment, the duration of a paging cycle is equivalent to the reporting interval of an M2M application. The paging groups each have the same paging cycle of 4096 superframes, or approximately 80 seconds. Each group is separated by different paging offsets, such as zero for paging group PG1, 32 superframes for PG2, 64 superframes for PG2, etc.

[0020] In one example, there are 4096 M2M devices that need to send a measurement every 4096 superframes. While specific numbers are used to identify superframes, devices, and paging cycles, further embodiment may utilize different number of superframes, devices, and paging cycles as desired. When an M2M device de-registers from the base station 110, the base station 110 assigns the device to one of the paging groups. If each paging group contains 32 devices, then 4096 devices may be supported. Therefore, coordinated paging can reduce the number of devices entering the network in every 32 superframes interval to 32 devices. Many of the M2M devices are remote sensors or smart meters that are designed to send hourly, daily, weekly, or even monthly measurements. An M2M device may receive polls sent during a paging cycle to determine when to send a report.

[0021] Some typical paging cycles that may be used by M2M devices determine times for reporting include 4096 superframes corresponding to approximately 80 seconds, 16384 superframes (approximately 5 minutes, 27 seconds), 65536 superframes (approximately 22 minutes), 262144 superframes (approximately 87 minutes), 1048576 superframes (approximately 5 hours, 48 minutes), and 4194304 superframes (approximately 23 hours, 18 minutes).

[0022] In some embodiments, an M2M device operating as a remote sensor can report a measurement at an interval greater than its paging cycle. In one example, an M2M sensor device is assigned a paging cycle of 4194302 superframes (i.e. 23 hours, 18 minutes). If the sensor only takes a measurement once a month, the sensor will wake up at each page listening interval, but will go back to an idle mode without performing network entry responsive to the page. When it reaches a 30th paging cycle, the sensor will then send the measurement report.

[0023] In essence, a remote sensor will go into an idle mode, then wake up at the interval of its assigned paging cycle to listen to a broadcast paging message. The base station in one embodiment will send an M2M report code identifying the M2M sensor with an ID and a report code telling the device to report. In one embodiment, the report codes include "0b0" for no action required and "0b1" for send uplink report.

[0024] FIG. 3 is a flow diagram illustrating a method 300 of grouping devices for uplink communications in a cell. In one embodiment, M2M server 120 receives information at 310 from applications running on M2M devices, including the identities of devices within a cell and the reporting requirements of the devices. This information is used to assign paging groups to the M2M devices, and provide the M2M devices with an offset in a coordinated paging cycle. The M2M devices may be assigned to the paging groups as a function of their reporting intervals to minimize network reentry congestion. For example, a larger number of M2M devices with longer reporting intervals may be assigned to one group, and fewer M2M devices with shorter reporting intervals may be assigned to another group. In further embodiments, the M2M devices may be assigned randomly, or sequentially, with each new M2M device being added to the next group in sequence.

[0025] At 320, M2M devices are assigned a paging cycle as a function of the length of their individual reporting intervals. As described above, the M2M devices will wake from idle mode to listen for a page from the controller at their assigned paging cycle, and wait a selected number of paging cycles until they provide their uplink data at their reporting interval. The assigned paging cycle may be assigned to conserve battery power in the M2M device in some embodiments, ensuring that the number of times the devices need to wake up is minimized with respect to their reporting interval. Note that the functions described in method 300 may be performed in one or more different places. The assignment of M2M devices to paging groups may be performed by the controller 115 or the server 120 in various embodiments. If done by the controller 115, the server 120 will provide the controller 115 with the information obtained from the M2M devices to enable the assignment.

[0026] FIG. 4 is a flow diagram illustrating a method 400 executed by the controller 115 to poll devices according to an example embodiment. The controller 115 retrieves a list of M2M devices in the cell that identifies their group and particular assigned paging cycle and offset at 410. The controller then broadcasts a page corresponding to the first paging group at 415. It then listens for responses at 420.

[0027] Various protocols may be used for responding to pages. In one embodiment, the controller 115 sends a poll that includes the ID of the M2M device with a report code indicating whether or not the device should report. In this embodiment, the device need not keep track of the number of pages received in order to correlate the pages to the reporting interval. The controller sends the page with ID and a report code informing the device to report.

[0028] When reports are received at 420, they are forwarded on to the M2M server 120, which may further forward the reports at 425 on to various entities that are monitoring the M2M devices, such as a utility company. These steps are repeated as indicated at 430 for each of the paging groups in the coordinated paging cycle. The paging cycle is then repeated, starting at 410, updating the list of M2M devices in the cell. In some embodiments, the list of M2M devices may be updated in real time as devices are added, or periodically as desired.

[0029] FIG. 5 is a flow diagram illustrating a method 500 executed by a device responding to polls according to an example embodiment. At 510, an M2M device sends information regarding its reporting interval to the server 125. In further embodiments, the information may be sent by an installer or owner of the M2M device, or M2M operators by any convenient means, such as via a network. At 515, the M2M device receives back a coordinated paging cycle. In some embodiments, the reporting info may be controlled by an operator. In a smart meter example, the operator may determine how often, and what information is to be polled.

[0030] The coordinating paging cycle identifies when the device should wake up and listen for pages. It may include an offset into the coordinated paging cycle during which to listen for a page. In one embodiment, if the controller wants the device to send the report at the fourth paging cycles, then the controller can send the report code of no action required in the coordinated paging cycles one, two, and three. In the fourth paging cycle, the controller sends a page with a report code indicating that the device should send a report.

[0031] At 520, the M2M device may enter an idle mode while waiting for its page at the offset into the coordinated paging cycle. When The M2M device wakes up a page is received as indicated at 525 at the proper time, the M2M device determines if there is data available to send. If the data is available and the page indicates that data should be sent, the M2M device will transmit the data responsive to the page at 530. In one embodiment, the M2M device will receive a page identifying the M2M device by ID and containing a reporting code to send an uplink report. The M2M device will then enter the idle mode again at 520, waiting for the next page.

[0032] FIG. 6 at 600 illustrates a coordinated paging cycle 602 for a device that needs to receive a downlink message at an interval smaller than the paging cycle for sending an uplink message. If the M2M device needs to receive a downlink message at an interval smaller than the uplink reporting interval, then it chooses a smaller paging cycle 604, such as for example a 128 superframe cycle for downlink messages and a 4096 superframe paging cycle 602 for uplink messages. Listening windows 605 for downlink messages are shown as offset by a paging offset 610. In one embodiment, the M2M device wakes up from idle mode every 128 superframes at 605. Coordinated paging listening windows 615 are indicated near the beginning of each coordinated paging cycle, and contain a report code. The other page listening windows 605 contain an action code for the downlink data. In some IEEE 802.16 embodiments, a base station sends a downlink message, such as an AA1-PAG-ADV message with an action code of 0b0 to signal a pending downlink message.

[0033] The action code 0b0 signals the device to perform network entry. Action code 0b1 signals the device to perform a location update. For hybrid paging, a base station sends the AA1-PAG-ADV message with an action code of 0b0 if the device has a downlink message pending , and /or with a report code of 0b1 if the device is to send the uplink data.

[0034] In further embodiments, the paging control for both coordinated paging and downlink paging are separated into two one-bit codes. A one bit action code for the downlink action, and a one bit report code for coordinated paging. The report code 0b1 signals the device to send the uplink report. The report code 0b0 is reserved.

[0035] FIG. 7 is a block diagram of a machine that maybe specifically programmed to execute one or more methods according to an example embodiment. In the embodiment shown in FIG. 7, a hardware and operating environment is provided that is applicable to any of the base stations, controllers, servers, smart phones and M2M devices shown in the other Figures. Many of the components in FIG. 7 may not be needed for various implementations. The machine illustrated in FIG. 7 may be suitable for use as any of the machine to machine devices (FIG. 1), although other configuration may be suitable. The machine illustrated in FIG. 7 may also be suitable for use as base station 110 (FIG. 1) although other configurations may be suitable.

[0036] As shown in FIG. 7, one embodiment of the hardware and operating environment includes a general purpose computing device in the form of a computer 700 (e.g., a personal computer, workstation, or server), including one or more processing units 721, a system memory 722, and a system bus 723 that operatively couples various system components including the system memory 722 to the processing unit 721. There may be only one or there may be more than one processing unit 721, such that the processor of computer 700 comprises a single central-processing unit (CPU), or a plurality of processing units, commonly referred to as a multiprocessor or parallel-processor environment. In various embodiments, computer 700 is a conventional computer, a distributed computer, or any other type of computer.

[0037] The system bus 723 can be any of several types of bus structures including a memory bus or memory controller, a peripheral bus, and a local bus using any of a variety of bus architectures. The system memory can also be referred to as simply the memory, and, in some embodiments, includes read-only memory (ROM) 724 and random-access memory (RAM) 725. A basic input/output system (BIOS) program 726, containing the basic routines that help to transfer information between elements within the computer 700, such as during start-up, may be stored in ROM 724. The computer 700 further includes a hard disk drive 727 for reading from and writing to a hard disk, not shown, a magnetic disk drive 728 for reading from or writing to a removable magnetic disk 729, and an optical disk drive 730 for reading from or writing to a removable optical disk 731 such as a CD ROM or other optical media.

[0038] The hard disk drive 727, magnetic disk drive 728, and optical disk drive 730 couple with a hard disk drive interface 732, a magnetic disk drive interface 733, and an optical disk drive interface 734, respectively. The drives and their associated computer-readable media provide non volatile storage of computer-readable instructions, data structures, program modules and other data for the computer 700. It should be appreciated by those skilled in the art that any type of computer-readable media which can store data that is accessible by a computer, such as magnetic cassettes, flash memory cards, digital video disks, Bernoulli cartridges, random access memories (RAMs), read only memories

(ROMs), redundant arrays of independent disks (e.g., RAID storage devices) and the like, can be used in the exemplary operating environment.

[0039] A plurality of program modules can be stored on the hard disk, magnetic disk 729, optical disk 731, ROM 724, or RAM 725, including an operating system 735, one or more application programs 736, other program modules 737, and program data 738. Programming for implementing one or more processes or method described herein may be resident on any one or number of these computer-readable media.

[0040] A user may enter commands and information into computer 700 through input devices such as a keyboard 740 and pointing device 742. Other input devices (not shown) can include a microphone, joystick, game pad, satellite dish, scanner, or the like. These other input devices are often connected to the processing unit 721 through a serial port interface 746 that is coupled to the system bus 723, but can be connected by other interfaces, such as a parallel port, game port, or a universal serial bus (USB). A monitor 747 or other type of display device can also be connected to the system bus 723 via an interface, such as a video adapter 748. The monitor 747 can display a graphical user interface for the user. In addition to the monitor 747, computers typically include other peripheral output devices (not shown), such as speakers and printers.

[0041] The computer 700 may operate in a networked environment using logical connections to one or more remote computers or servers, such as remote computer 749. These logical connections are achieved by a communication device coupled to or a part of the computer 700; the invention is not limited to a particular type of communications device. The remote computer 749 can be another computer, a server, a router, a network PC, a client, a peer device or other common network node, and typically includes many or all of the elements described above I/0 relative to the computer 700, although only a memory storage device 750 has been illustrated. The logical connections depicted in FIG. 7 include a local area network (LAN) 751 and/or a wide area network (WAN) 752. Such networking environments are commonplace in office networks, enterprise-wide computer networks, intranets and the internet, which are all types of networks.

[0042] When used in a LAN-networking environment, the computer 700 is connected to the LAN 751 through a network interface or adapter 753, which is one type of communications device. In some embodiments, when used in a WAN-networking environment, the computer 700 typically includes a modem 754 (another type of communications device) or any other type of communications device, e.g., a wireless transceiver, for establishing communications over the wide-area network 752, such as the internet. The modem 754, which may be internal or external, is connected to the system bus 723 via the serial port interface 746. In a networked environment, program modules depicted relative to the computer 700 can be stored in the remote memory storage device 750 of remote computer, or server 749. It is appreciated that the network connections shown are exemplary and other means of, and communications devices for, establishing a communications link between the computers may be used including hybrid fiber-coax connections, T1-T3 lines, DSL's, OC-3 and/or OC-12, TCP/IP, microwave, wireless application protocol, and any other electronic media through any suitable switches, routers, outlets and power lines, as the same are known and understood by one of ordinary skill in the art.

[0043] In some embodiments, base station 110 and M2M devices may be configured to communicate orthogonal-frequency division multiplexed (OFDM) communication signals over a multicarrier communication channel. The OFDM signals may comprise a plurality of orthogonal subcarriers. In some broadband multicarrier embodiments, base station 110 may be part of a broadband wireless access (BWA) network communication station, such as a Worldwide Interoperability for Microwave Access (WiMAX) communication station. In some other broadband multicarrier embodiments, base station 110 may be a 3rd Generation Partnership Project (3GPP) Universal Terrestrial Radio Access Network (UTRAN or eNB (E-UTRAN Node B)) Long-Term-Evolution (LTE) or a Long-Term-Evolution (LTE) communication station, although the scope of the invention is not limited in this respect. In these broadband multicarrier embodiments, base station 110 and M2M devices may be configured to communicate in accordance with an orthogonal frequency division multiple access (OFDMA) technique.

[0044] For more information with respect to the IEEE 802.16 standards, please refer to "IEEE Standards for Information Technology -- Telecommunications and Information Exchange between Systems" - Metropolitan Area Networks - Specific Requirements – Part 16: "Air Interface for Fixed Broadband Wireless Access Systems," May 2005 and related amendments/versions. For more information with respect to UTRAN LTE standards, see the 3rd Generation Partnership Project (3GPP) standards for UTRAN-LTE, release 8, March 2008, including variations and evolutions thereof.

[0045] In some embodiments, the base station 110 and the M2M devices may utilize one or more antennas for transmission of RF signals to M2M devices. The antennas may comprise one or more directional or omnidirectional antennas, including, for example, dipole antennas, monopole antennas, patch antennas, loop antennas, microstrip antennas or other types of antennas suitable for transmission of RF signals. In some embodiments, instead of two or more antennas, a single antenna with multiple apertures may be used. In these embodiments, each aperture may be considered a separate antenna. In some multiple-input multiple-output (MIMO) embodiments, antennas may be effectively separated to take advantage of spatial diversity and the different channel characteristics that may result between each of antennas and the antennas of a transmitting station. In some embodiments, a M2M device may utilize a single antenna.

[0046] Several examples are now provided.

[0047] 1. A method comprising:

dividing machine to machine devices into a plurality of groups;

paging each group during paging listening windows corresponding to each paging group during a coordinated paging cycle.

[0048] 2. The method of example 1 wherein the paging is performed by a controller in a base station of a cell.

[0049] 3. The method of example 1 wherein the coordinated paging cycle includes 4096 superframes and wherein there are 128 paging groups.

[0050] 4. The method of example 1 wherein machine to machine devices are assigned to groups as a function of a machine to machine reporting interval.

[0051] 5. The method of example 1 wherein paging includes a page including an ID of a particular machine to machine device.

[0052] 6. The method of example 5 wherein the page includes a report code identifying whether or not the machine to machine device should send an uplink report.

[0053] 7. The method of example 6 wherein the page report code indicates to send an uplink report when a specified number of paging cycles has been reached corresponding to a reporting interval of the machine to machine device.

[0054] 8. The method of example 1 and further comprising:

receiving an uplink report from a machine to machine device; and

forwarding the uplink report to a machine to machine device server.

[0055] 9. The method of example 1 and further comprising paging a machine to machine device with a paging cycle less than the coordinated paging cycle to indicate a downlink message is available to the machine to machine device.

[0056] 10. A machine readable storage device having coded stored thereon to cause a machine to implement a method, the method comprising:

waking up at a coordinated paging cycle selected from a number of coordinated paging cycles; and

sending uplink data following receipt of the number of coordinated paging cycles corresponding to the reporting period.

[0057] 11. The machine readable storage device of example 10 and wherein the method further comprises receiving a page sent at a group paging offset during each coordinated paging cycle, and wherein the uplink data is sent following a paging offset within the coordinated paging cycle corresponding to one of a plurality of paging groups.

[0058] 12. The machine readable storage device of example 11 wherein the page includes a machine to machine device ID and a report code.

[0059] 13. The machine readable storage device of example 12 wherein the uplink data is sent in response to a paging report code instructing the machine to machine device to send a report.

[0060] 14. The machine readable storage device of example 10 wherein the method further comprises sending a reporting interval from which a coordinated paging cycle is selected.

[0061] 15. The machine readable storage device of example 10 wherein the method further comprises receiving pages for downlink data at a paging cycle that is shorter than the coordinated paging cycle for uplink data.

[0062] 16. The machine readable storage device of example 10 and further comprising a machine to machine device having a processor to execute the code stored on the machine readable storage device.

[0063] 17. A system comprising:

a base station comprising physical layer circuitry (or a transceiver) to communicate with mobile devices and machine to machine devices within a cell; and

a coordinated paging controller to divide machine to machine devices into a plurality of groups and page each group during paging listening windows corresponding to each paging group during a coordinated paging cycle.

[0064] 18. The system of example 17 wherein the coordinated paging cycle includes 4096 superframes and wherein there are 128 paging groups.

[0065] 19. The system of example 17 wherein paging includes a page including an ID of a particular machine to machine device and a report code identifying whether or not the machine to machine device should send an uplink report.

[0066] 20. The system of example 19 wherein the page report code indicates to send an uplink report when a specified number of paging cycles has been reached corresponding to a reporting interval of the machine to machine device.

[0067] 21. The system of example 20 wherein the page report code is a one bit code.

[0068] 22. The system of example 17 wherein the coordinated paging controller further receives an uplink report from a machine to machine device and forwards the uplink report to a machine to machine device server.

[0069] 23. The system of example 17 wherein the coordinated paging controller further pages a machine to machine device with a paging cycle less than the coordinated paging cycle to indicate a downlink message is available to the machine to machine device.

[0070] 24. The system of example 23 wherein a down link page action code is a one bit code.

[0071] 25. The system of example 17 wherein the base station is an eNB operating in accordance with a 3GPP LTE specification.

[0072] 26. The system of example 17 wherein the base station is a WiMAX base station operating in accordance with an IEEE 802.16 specification.

[0073] 27. A machine to machine device programmed to wake up at a coordinated paging cycle selected from a number of coordinated paging cycles and send uplink data following receipt of the number of coordinated paging cycles corresponding to the reporting period.

[0074] 28. The machine to machine device of example 27 wherein the machine to machine device is further programmed to receive a page sent at a group paging offset during each coordinated paging cycle and to send the uplink data following a paging offset within the coordinated paging cycle corresponding to one of a plurality of paging groups.

[0075] 29. The machine to machine device of example 28 wherein that page includes a machine to machine device ID and a report code.

[0076] 30. The machine to machine device of example 28 wherein the machine to machine device further receives pages for downlink data at a paging cycle that is shorter than the coordinated paging cycle for uplink data.

[0077] 31. A machine readable storage device having instructions to cause a machine to perform a method, the method comprising:

dividing machine to machine devices into a plurality of groups;

paging each group during paging listening windows corresponding to each paging group during a coordinated paging cycle.

[0078] 32. The machine readable storage device of example 31 wherein the coordinated paging cycle includes 4096 superframes and wherein there are 128 paging groups.

[0079] 33. The machine readable storage device of example 31 wherein paging includes a page including an ID of a particular machine to machine device and an report code identifying whether or not the machine to machine device should send an uplink report.

[0080] 34. The machine readable storage device of example 31 wherein the method further comprises:

receiving an uplink report from a machine to machine device; and

forwarding the uplink report to a machine to machine device server.

[0081] 35. The machine readable storage device of example 31 wherein the method further comprises paging a machine to machine device with a paging cycle less than the coordinated paging cycle to indicate a downlink message is available to the machine to machine device.

[0082] Although a few embodiments and examples have been described in detail above, other modifications are possible. For example, the logic flows depicted in the figures do not require the particular order shown, or sequential order, to achieve desirable results. Other steps may be provided, or steps may be eliminated, from the described flows, and other components may be added to, or removed from, the described systems. Other embodiments may be within the scope of the following claims.

CLAIMS

1. A method comprising:

dividing machine to machine devices into a plurality of groups;

paging each group during paging listening windows corresponding to each paging group during a coordinated paging cycle.

2. The method of claim 1 wherein the paging is performed by a controller in a base station of a cell.

3. The method of claim 1 wherein the coordinated paging cycle includes 4096 superframes and wherein there are 128 paging groups.

4. The method of claim 1 wherein machine to machine devices are assigned to groups as a function of a machine to machine reporting interval.

5. The method of claim 1 wherein paging includes a page including an ID of a particular machine to machine device.

6. The method of claim 5 wherein the page includes a report code identifying whether or not the machine to machine device should send an uplink report.

7. The method of claim 6 wherein the page report code indicates to send an uplink report when a specified number of paging cycles has been reached corresponding to a reporting interval of the machine to machine device.

8. The method of claim 1 and further comprising:

receiving an uplink report from a machine to machine device; and

forwarding the uplink report to a machine to machine device server.

9. The method of claim 1 and further comprising paging a machine to machine device with a paging cycle less than the coordinated paging cycle to indicate a downlink message is available to the machine to machine device.

10. A machine readable storage device having coded stored thereon to cause a machine to implement a method, the method comprising:

waking up at a coordinated paging cycle selected from a number of coordinated paging cycles; and

sending uplink data following receipt of the number of coordinated paging cycles corresponding to the reporting period.

11. The machine readable storage device of claim 10 and wherein the method further comprises receiving a page sent at a group paging offset during each coordinated paging cycle, and wherein the uplink data is sent following a paging offset within the coordinated paging cycle corresponding to one of a plurality of paging groups.

12. The machine readable storage device of claim 11 wherein the page includes a machine to machine device ID and a report code.

13. The machine readable storage device of claim 12 wherein the uplink data is sent in response to a paging report code instructing the machine to machine device to send a report.

14. The machine readable storage device of claim 10 wherein the method further comprises sending a reporting interval from which a coordinated paging cycle is selected.

15. The machine readable storage device of claim 10 wherein the method further comprises receiving pages for downlink data at a paging cycle that is shorter than the coordinated paging cycle for uplink data.

16. The machine readable storage device of claim 10 and further comprising a a machine to machine device having a processor to execute the code stored on the machine readable storage device.

17. A system comprising:

a base station comprising physical layer circuitry (or a transceiver) to communicate with mobile devices and machine to machine devices within a cell; and

a coordinated paging controller to divide machine to machine devices into a plurality of groups and page each group during paging listening windows corresponding to each paging group during a coordinated paging cycle.

18. The system of claim 17 wherein the coordinated paging cycle includes 4096 superframes and wherein there are 128 paging groups.

19. The system of claim 17 wherein paging includes a page including an ID of a particular machine to machine device and a report code identifying whether or not the machine to machine device should send an uplink report.

20. The system of claim 19 wherein the page report code indicates to send an uplink report when a specified number of paging cycles has been reached corresponding to a reporting interval of the machine to machine device.

21. The system of claim 20 wherein the page report code is a one bit code.

22. The system of claim 17 wherein the coordinated paging controller further receives an uplink report from a machine to machine device and forwards the uplink report to a machine to machine device server.

23. The system of claim 17 wherein the coordinated paging controller further pages a machine to machine device with a paging cycle less than the coordinated paging cycle to indicate a downlink message is available to the machine to machine device.

24. The system of claim 23 wherein a down link page action code is a one bit code.

25. The system of claim 17 wherein the base station is an eNB operating in accordance with a 3GPP LTE specification.

26. The system of claim 17 wherein the base station is a WiMAX base station operating in accordance with an IEEE 802.16 specification.

27. A machine to machine device programmed to wake up at a coordinated paging cycle selected from a number of coordinated paging cycles and send uplink data following receipt of the number of coordinated paging cycles corresponding to the reporting period.

28. The machine to machine device of claim 27 wherein the machine to machine device is further programmed to receive a page sent at a group paging offset during each coordinated paging cycle and to send the uplink data following a paging offset within the coordinated paging cycle corresponding to one of a plurality of paging groups.

29. The machine to machine device of claim 28 wherein that page includes a machine to machine device ID and a report code.

30. The machine to machine device of claim 28 wherein the machine to machine device further receives pages for downlink data at a paging cycle that is shorter than the coordinated paging cycle for uplink data.

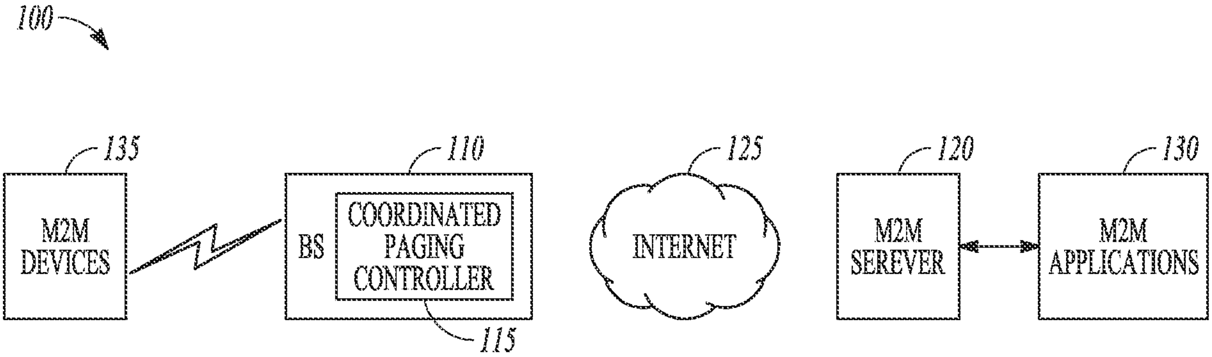
100
135
M2M
DEVICES
110
BS
COORDINATED
PAGING
CONTROLLER
115
125
INTERNET
120
M2M
SEREVER
130
M2M
APPLICATIONS

FIG. 1

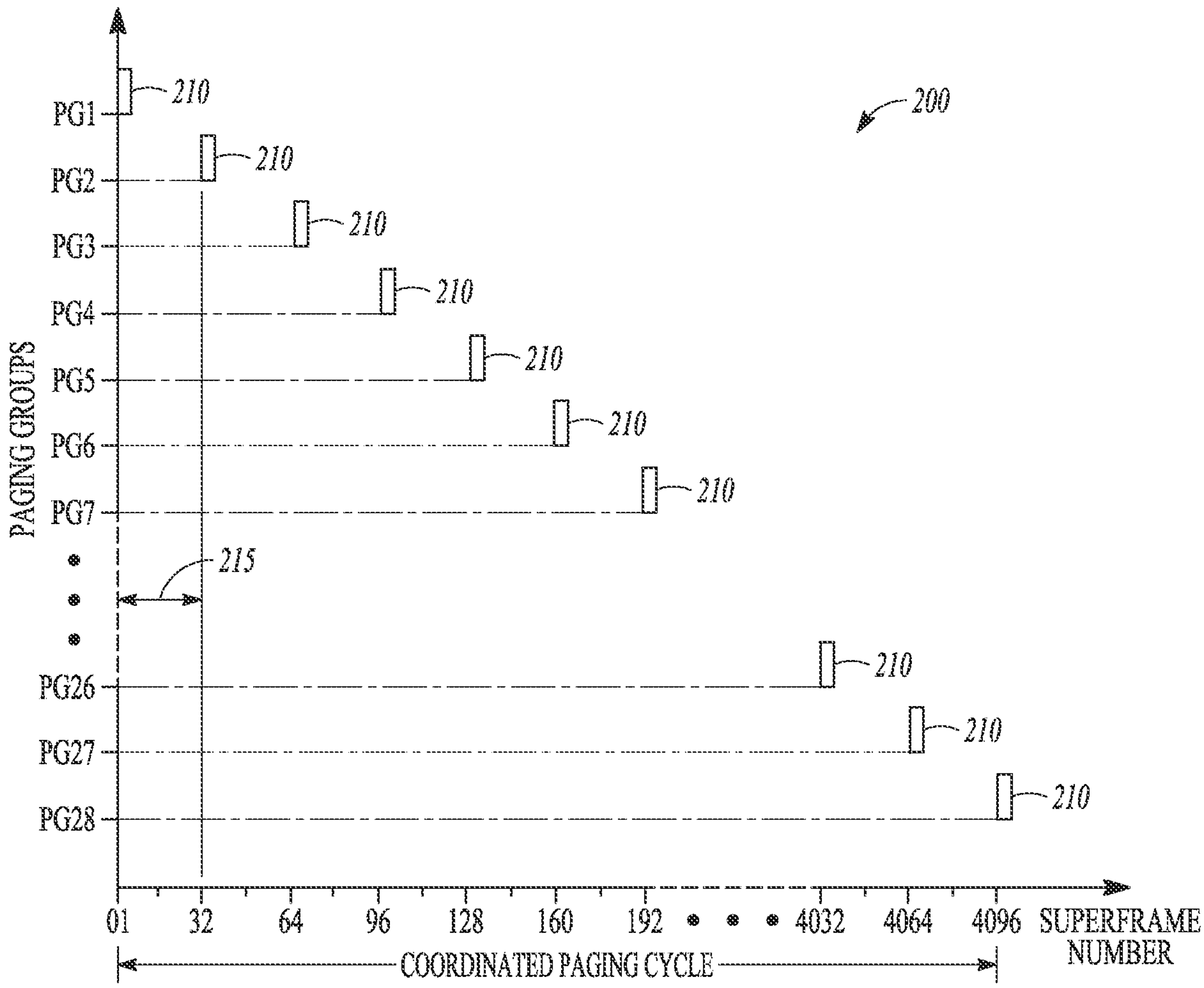
200
PAGING GROUPS
PG1
PG2
PG3
PG4
PG5
PG6
PG7
PG26
PG27
PG28
210
215
01
32
64
96
128
160
192
4032
4064
4096
SUPERFRAME
NUMBER
COORDINATED PAGING CYCLE

FIG. 2

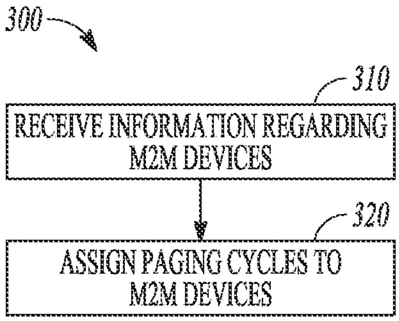
300
310
RECEIVE INFORMATION REGARDING M2M DEVICES
320
ASSIGN PAGING CYCLES TO M2M DEVICES

FIG. 3

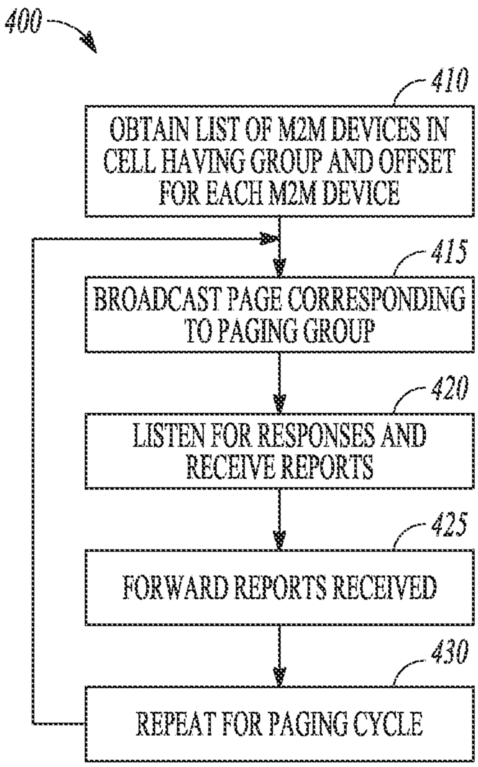
400
410
OBTAIN LIST OF M2M DEVICES IN CELL HAVING GROUP AND OFFSET FOR EACH M2M DEVICE
415
BROADCAST PAGE CORRESPONDING TO PAGING GROUP
420
LISTEN FOR RESPONSES AND RECEIVE REPORTS
425
FORWARD REPORTS RECEIVED
430
REPEAT FOR PAGING CYCLE

FIG. 4

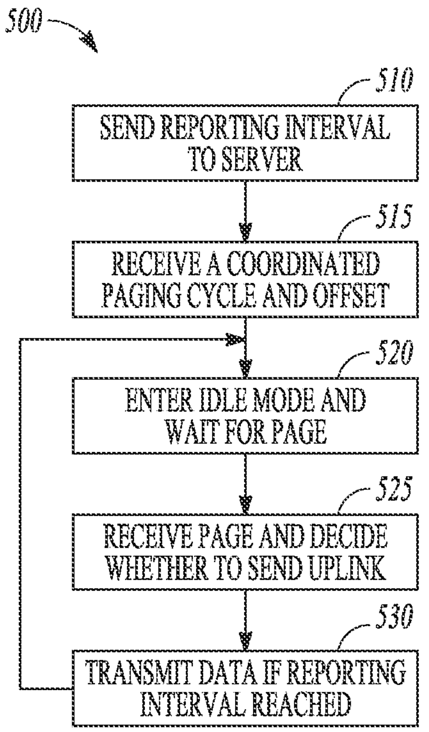
500
510
SEND REPORTING INTERVAL TO SERVER
515
RECEIVE A COORDINATED PAGING CYCLE AND OFFSET
520
ENTER IDLE MODE AND WAIT FOR PAGE
525
RECEIVE PAGE AND DECIDE WHETHER TO SEND UPLINK
530
TRANSMIT DATA IF REPORTING INTERVAL REACHED

FIG. 5

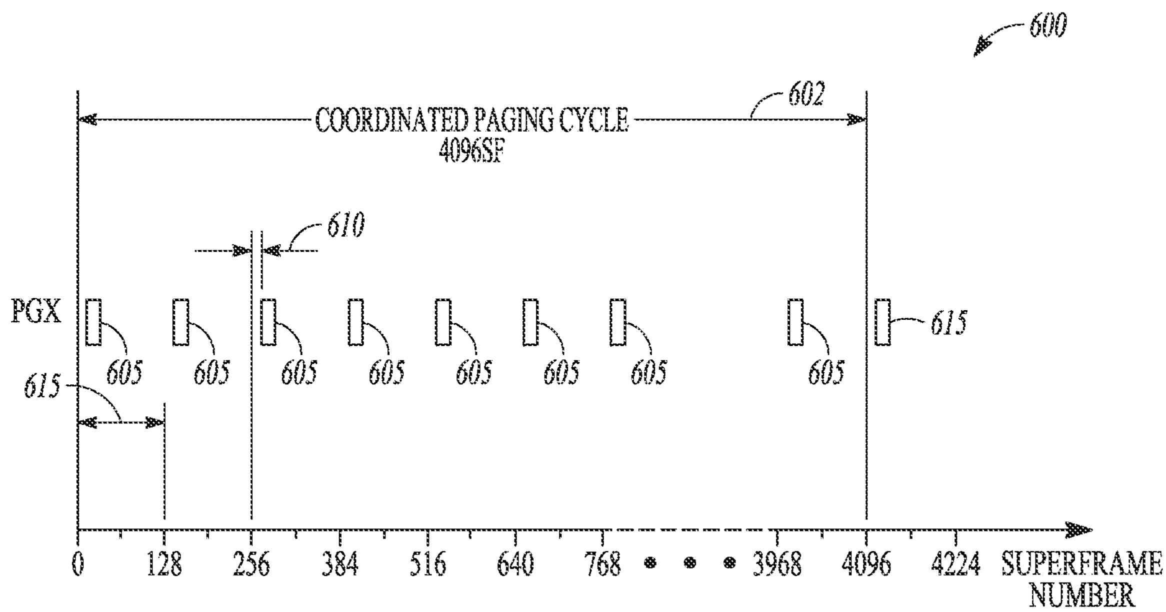
600
602
COORDINATED PAGING CYCLE
4096SF
610
PGX
605
615
0
128
256
384
516
640
768
3968
4096
4224
SUPERFRAME NUMBER

FIG. 6

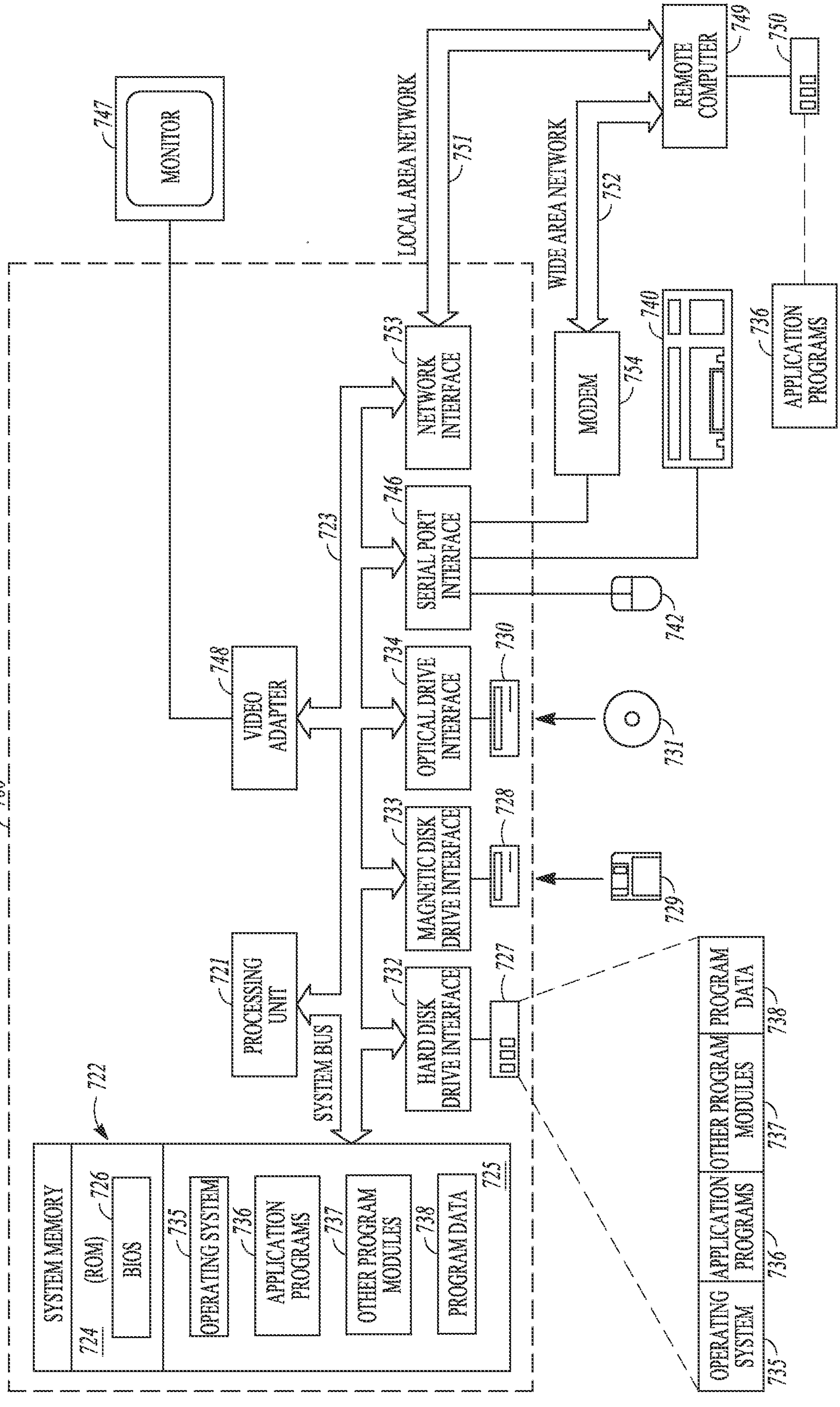
700
SYSTEM MEMORY
722
724
(ROM)
726
BIOS
735
OPERATING SYSTEM
736
APPLICATION PROGRAMS
737
OTHER PROGRAM MODULES
738
PROGRAM DATA
725
SYSTEM BUS
721
PROCESSING UNIT
748
VIDEO ADAPTER
723
747
MONITOR
732
HARD DISK DRIVE INTERFACE
733
MAGNETIC DISK DRIVE INTERFACE
734
OPTICAL DRIVE INTERFACE
746
SERIAL PORT INTERFACE
753
NETWORK INTERFACE
754
MODEM
727
728
729
730
731
742
740
LOCAL AREA NETWORK
751
WIDE AREA NETWORK
752
REMOTE COMPUTER
749
750
736
APPLICATION PROGRAMS
OPERATING SYSTEM
735
APPLICATION PROGRAMS
736
OTHER PROGRAM MODULES
737
PROGRAM DATA
738

FIG. 7

INTERNATIONAL SEARCH REPORT	International application No. **PCT/US2011/066222**

A. CLASSIFICATION OF SUBJECT MATTER

H04B 7/26(2006.01)i, H04W 68/02(2009.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04B 7/26

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords: M2M, group paging, group ID, device ID, paging listening window, paging report code;

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	Giwon Park, et al., "[PWR] Paging operation for 802.16p system", IEEE 802.16 Broadband Wireless Access Working Group, IEEE S802.16p-rg-11_0015, 2011.02.08. See slides 2-7 and Figure 1.	1-30
A	Jaesun Cha, et al., "Device ID and Group ID for M2M Devices", IEEE 802.16 Broadband Wireless Access Working Group, IEEE 802.16p-11/0019, 2011.03.06. See section 2.	1-30
A	Giwon Park, et al., "[PWR] Updated merged text proposal of idle mode operation for PWG RG discussion", IEEE 802.16 Broadband Wireless Access Working Group, IEEE 802.16p-rg-11_0036r1, 2011.02.15. See section 16.2.18.7.1.	1-30
A	Chuan-Yuan Tseng, et al., "Group Paging By Multicast", IEEE 802.16 Broadband Wireless Access Working Group, IEEE C802.16p-11_0004, 2011.03.04. See slides 1-2.	1-30

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
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"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
26 JULY 2012 (26.07.2012)	**30 JULY 2012 (30.07.2012)**

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Facsimile No. 82-42-472-7140	Telephone No. 82-42-481-8171

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
None			