Abstract: A method and an apparatus for providing firmware over the air service to user equipments in a wireless network environment is disclosed. In one embodiment, a device management server sends a notification to a base station indicating availability of new firmware version for associated user equipments. The base station obtains a firmware update resource identifier from the device management server upon receiving the notification. Further, the base station fetches a firmware update associated with the new firmware version from a FOTA server and caches the firmware update in a cache memory. Thereafter, the base station sends a page message indicating availability of the cached firmware update to the user equipments currently attached to the base station. Upon receiving a paging response from the respective user equipments, the base station transmits the cached firmware update to the respective user equipments over a wireless air interface.
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Description

Title of Invention: METHOD AND APPARATUS FOR PROVIDING FIRMWARE OVER THE AIR SERVICE TO USER EQUIPMENTS

Technical Field

The present invention relates to the field of firmware upgrade for user equipment, and more particularly relates to a method and an apparatus for providing firmware over the air service to user equipments in a wireless communication environment.

Background Art

Generally a user equipment operates through firmware. As well known, firmware refers to programming instructions used to control the hardware of a mobile device in operation. Such firmware may often improve and evolve into new versions to provide better performance and debugging. When a new version of specific firmware is developed, users can upgrade the firmware in their user equipments by using various wired or wireless techniques. One of recently remarkable upgrade techniques is a Firmware Over-the-Air service (FOTA) service.

FOTA provides an upgrade of firmware by offering an update package via a wireless network. In a FOTA service, an update package, also referred to as a delta file, is created by the extraction of differences between an old version and a new version of firmware. Typically, a device management server sends a firmware download resource identifier to user equipment for downloading update package. For example, the user equipment may obtain the firmware download resource identifier from the device management server using a push initiation or polling technique. Using the firmware download resource identifier, the user equipment fetches the update package from a FOTA server and upgrades the firmware by replacing modified parts of existing firmware with the update package.

Some of the user equipments in the wireless network may be switched off or operating in emergency mode when the device management server has initiated FOTA service to all the user equipments. Consequently, such user equipments may miss critical FOTA updates. Also, the device management server providing FOTA service to large number of user equipments in the wireless network may lead to overloading of the core network with signalling and data transfers.

Disclosure of Invention

Technical Problem

Aspects of the present invention are to address at least the above-mentioned
problems and/or disadvantages and to provide at least the advantages described below. Accordingly, an aspect of the present invention is to provide a method and an apparatus for providing firmware over the air service to user equipments in a wireless network environment is disclosed.

**Solution to Problem**

[6] In accordance with an aspect of the present invention, a method and system for providing firmware over the air service to user equipments in a wireless network environment is provided. In one embodiment, a device management server sends a notification to a base station indicating availability of new firmware version for associated user equipments. The base station obtains a firmware update resource identifier from the device management server upon receiving the notification. Further, the base station fetches a firmware update associated with the new firmware version from a FOTA server and caches the firmware update in a cache memory. Thereafter, the base station sends a paging message indicating availability of the cached firmware update to the user equipments currently attached to the base station. Upon receiving a paging response from the respective user equipments, the base station transmits the cached firmware update to the respective user equipments.

[7] In accordance with an aspect of the present invention, a method of providing firmware over the air (FOTA) service to user equipments in a wireless network environment is provided. The method comprises obtaining firmware update intended for a plurality of user equipments in a wireless network environment from a FOTA server by a base station, obtaining the user equipment identities for a plurality of user equipments in a wireless network environment for which the FOTA update should be applied by the base station, caching the firmware data intended for the plurality of user equipments in a cache server of the base station, and providing the cached firmware update to one or more user equipments associated with the base station.

[8] In accordance with an aspect of the present invention, a method of providing firmware over the air (FOTA) service to user equipments in a wireless network environment is provided. The method comprises notifying availability of firmware update for a plurality of user equipments to each of a plurality of base station in a wireless network environment, and providing a firmware update resource identifier associated with the firmware update to each base station so the base station obtains the firmware update from a FOTA server using the firmware update resource identifier and caches the firmware update for providing to associated one or more of the plurality of user equipments.

[9] In accordance with an aspect of the present invention, an apparatus of a base station of providing firmware over the air (FOTA) service to user equipments in a wireless network environment is provided. In one embodiment, a device management server sends a notification to a base station indicating availability of new firmware version for associated user equipments. The base station obtains a firmware update resource identifier from the device management server upon receiving the notification. Further, the base station fetches a firmware update associated with the new firmware version from a FOTA server and caches the firmware update in a cache memory. Thereafter, the base station sends a paging message indicating availability of the cached firmware update to the user equipments currently attached to the base station. Upon receiving a paging response from the respective user equipments, the base station transmits the cached firmware update to the respective user equipments.
network environment is provided. The apparatus comprises a processor for obtaining 
firmware update intended for a plurality of user equipments in a wireless network en-
vironment from a FOTA server, and obtaining the user equipment identities for a 
plurality of user equipments in a wireless network environment for which the FOTA 
update should be applied by the base station, and a memory for caching the firmware 
data intended for the plurality of user equipments. The processor is adapted for 
providing the cached firmware update to one or more user equipments associated with 
the base station.

Other aspects, advantages, and salient features of the invention will become apparent 
to those skilled in the art from the following detailed description, which, taken in con-
junction with the annexed drawings, discloses exemplary embodiments of the 
invention.

**Brief Description of Drawings**

The above and other aspects, features, and advantages of certain exemplary em-
bodyiments of the present invention will be more apparent from the following de-
scription taken in conjunction with the accompanying drawings.

**Figure 1** illustrates a block diagram of an exemplary wireless network environment 
in which a base station is configured for caching a firmware update and providing the 
cached firmware update to associated user equipments, according to one embodiment.

**Figure 2** is a flow diagram illustrating a method of caching and providing firmware 
over the air (FOTA) service to user equipments in a wireless network environment, 
according to one embodiment.

**Figure 3** is a flow diagram illustrating a detailed method of providing the cached 
firmware updates to user equipments, according to one embodiment.

**Figure 4a** is a flow diagram illustrating a detailed method of providing the cached 
firmware updates to a user equipment, according to another embodiment.

**Figure 4b** is a flow diagram illustrating another detailed method of providing the 
cached firmware updates to a user equipment, according to another embodiment.

**Figure 4c** is a flow diagram illustrating yet another detailed method of providing the 
cached firmware updates to a user equipment, according to another embodiment.

**Figure 5** is a schematic representation illustrating a scenario in which a base station 
provides cached firmware update to the user equipment attached to another base station 
via an X2 interface, according to one embodiment.

**Figure 6** illustrates a block diagram of an exemplary device management server, 
such as those shown in Figure 1, showing various components for implementing em-
bodyiments of the present subject matter.

**Figure 7** illustrates a block diagram of an exemplary cache server, such as those
shown in Figure 1, showing various components for implementing embodiments of the present subject matter.

[21] The drawings described herein are for illustration purposes only and are not intended to limit the scope of the present disclosure in any way.

**Mode for the Invention**

[22] A method and system for providing firmware over the air service to user equipments in a wireless network environment is disclosed. In the following detailed description of the embodiments of the invention, reference is made to the accompanying drawings that form a part hereof, and in which are shown by way of illustration specific embodiments in which the invention 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 changes may be made without departing from the scope of the present invention. The following detailed description is, therefore, not to be taken in a limiting sense, and the scope of the present invention is defined only by the appended claims.

[23] **Figure 1** illustrates a block diagram of an exemplary wireless network environment 100 in which a base station 102 is configured for caching a firmware update and providing the cached firmware update 122 to associated user equipments 104A-N, according to one embodiment. In Figure 1, the wireless communication environment 100 includes the base station 102, the user equipments 104A-N, a wireless air interface 106, a device management server 108, a FOTA server 110, and a core network entity 118. The base station 102 may be a Node B, an evolved Node B (eNodeB), a femto cell, a home eNodeB and the like.

[24] The base station 102 includes a cache server 112 containing a FOTA service module 114, and a cache memory 116. The FOTA service module 114 may be an integrated circuit such as a microprocessor configured for processing executable program instructions stored therein. The device management server 108 may be an open mobile alliance device management server or any other servers containing a FOTA management module 120. The FOTA server 110 may be configured for storing firmware updates for the user equipments 104A-N. In one embodiment, the device management server 108 and the FOTA server 110 may be two separate servers remotely connected to the base station 102. In another embodiment, the device management server 108 and the FOTA server 110 may be a part of single remote server connected to the base station 102. Although a single base station is shown as part of the wireless network environment for the purpose of illustration, it is understood that the device management server 108 and the FOTA server 110 can be connected to multiple base stations serving different user equipments in a wireless
According to the present invention, the FOTA management module 120 sends a notification to the base station 102 indicating availability of new firmware version for the associated user equipments 104A-N. The FOTA service module 114 obtains a firmware update resource identifier from the device management server 108 upon receiving the notification. Thereafter, the FOTA service module 114 fetches a firmware update (also commonly known as an update package or a delta file) associated with a new firmware version from the FOTA server 110 and caches the firmware update in the cache memory 116.

In one embodiment, the FOTA service module 114 sends a paging message indicating availability of the cached firmware update 122 to the user equipments 104A-N currently attached to the base station 102. Upon receiving a paging response from the respective user equipments 104A-N, the FOTA service module 114 provides the cached firmware update 122 to the respective user equipments 104A-N over the wireless air interface 106. This and other embodiments are now described in greater detail in the following description.

Figure 2 is a flow diagram 200 illustrating a method of caching and providing firmware over the air (FOTA) service to user equipments in a wireless network environment, according to one embodiment. When a firmware update intended for user equipments is available, at step 202, the device management server 108 sends a notification to the base station 102 indicating availability of firmware update. In some embodiments, the device management server 102 sends a notification indicating availability of the firmware update to one or more base stations when a new firmware update is received from an external system (e.g., third party software vendor). In other embodiments, the device management server 102 sends the notification indicating availability of the firmware update to a particular base station (e.g., the base station 102) based on the probability of particular user equipment (e.g., the user equipment 104A) visiting the base station 102 during the course of time.

At step 204, the base station 102 communicates device information (e.g., device type, device identifier, device capabilities, etc.) with the device management server 108. At step 206, the device management server 108 sends a firmware update resource identifier associated with the firmware update to the base station 102. In some embodiment, the firmware resource update identifier may be a universal resource locator indicating location of the firmware update intended for the user equipments.

At step 208, the base station 102 sends a request for the firmware update to the FOTA server 110 using the firmware update resource identifier. In some embodiments, the base station 102 sends a request for download descriptor (i.e., information on structure for downloading firmware update) to the FOTA server 110 and the FOTA
server 110 sends the download descriptor to the base station 102 in response to the request. In these embodiments, the base station 102 sends a request for the firmware update to the FOTA server 110 based on the download descriptor.

At step 210, the FOTA server 110 provides the firmware update associated with the firmware update resource identifier to the base station 102. At step 212, the base station 102 caches the firmware update intended for the user equipments 104A-N in the cache server 112 of the base station 102 and provides the firmware version associated with the cached firmware update 122 to the device management server 108. At step 214, the base station 102 provides the firmware update to user equipments associated with the base station 102 over the wireless air interface 106 as will be described in greater detail in Figure 3 to 4c.

Figure 3 is a flow diagram 300 illustrating a detailed method of providing the cached firmware updates to user equipments, according to one embodiment. At step 302, the base station 102 sends a local paging message indicating availability of the cached firmware update 122 to an associated user equipment (e.g., user equipment 104A) during a paging interval. The local paging message may include a paging clause or paging indication flag set to FOTA update indicator. If no paging response is received from the user equipment 104A, the base station 102 resends a local paging message to the user equipment after a period of time. It is appreciated that, the time period for retransmitting the local paging message when no paging response is received is specific to the implementation at the base station 102.

At step 304, the user equipment 104A sends a request for the cached firmware update 122 to the base station 102 based on the paging message. At step 306, the base station 102 transmits the cached firmware update 122 to the user equipment 104A over the wireless air interface. In some embodiments, the base station 102 may allocate a dedicated set of resources to the user equipment 104A and then transmit the cached firmware update 122 over the allocated resources.

Figure 4a is a flow diagram 400 illustrating a detailed method of providing the cached firmware updates to a user equipment, according to another embodiment. Consider that, a user equipment (e.g., the user equipment 104A) wishes to check whether any new firmware update is available. For example, the user of the user equipment 104A may wish to upgrade the firmware version currently installed on the user equipment 104A. In such case, at step 402, the user equipment 104A sends a request for new firmware update to the device management server 108. At step 404, the FOTA management module 120 in the device management server 108 obtains location information associated with the user equipment 104A from a core network entity 118. At step 406, the FOTA management module 120 identifies a base station (e.g., the base station 102) serving the user equipment 104A based on the location in-
At step 408, the FOTA management module 120 re-directs the request for firmware update to the identified base station 102. At step 410, the base station 108 determines whether the firmware update requested by the user equipment 104A is present in the cache memory 116. If the desired update is available in the cache memory, then at step 412, the base station 108 determines whether the user equipment 104A associated with the re-directed request is currently present in a cell associated with the base station. In some embodiments, the base station 102 transmits a local paging message with a paging clause or paging indication flag set to FOTA update indicator to determine whether the intended user equipments 104A-N are in a cell associated with the base station 102. The base station 102 transmits the local paging message to the intended user equipments 104A-N using respective UE identifier. It can be noted that, the base station 102 obtains the UE identifier (e.g., International Mobile Subscription Identity (IMSI), Temporary Mobile Subscription Identity (TMSI), etc.) from the core network entity 118 (e.g., Mobility Management entity (MME)) either before, during or after the reception of the re-directed request for firmware update from the device management server 108. Alternatively, the base station 102 can obtain the UE identifiers for local paging from the MME immediately after caching the firmware update from the FOTA server 110. If any user equipment is present in the cell and is operating in an idle mode, the user equipment sends a paging response to the base station 102 upon receiving the local paging message. In such case, the base station performs the step 414, else performs steps 452 and 454 in Figure 4b. At step 414, the base station 102 transmits the cached firmware update to the user equipment 104A over the wireless air interface.

Figure 4b is a flow diagram 450 illustrating another detailed method of providing the cached firmware updates to a user equipment, according to another embodiment. It can be noted that the method steps explained in Figure 4a and Figure 4b are same, except the step 414. If the user equipment 104A has reselected another base station 102 during redirection of the request, then at step 452, the base station 102 forwards the re-directed request for firmware update to said another base station 102 currently serving the user equipment 104A. At step 454, the said another base station 102 transmits the cached firmware update 122 to the user equipment 104A over the wireless air interface if the cached firmware update 122 is available in the cache memory 116. Alternatively, if the cached firmware update 122 is not available in the cache memory 116, the said another base station 102 performs the steps 202 to 214.

Figure 4c is a flow diagram 470 illustrating yet another detailed method of providing the cached firmware updates to a user equipment, according to another embodiment. It can be noted that the method steps explained in Figure 4a and Figure 4c are same,
except the step 414. If the user equipment 104A has reselected another base station 102' during the firmware update procedure, then at step 472, the base station 102 continues to transmit the cached firmware update 122 to the user equipment 104A currently associated with the said another base station 102' over an X2 interface as depicted in Figure 5. Alternatively, if the base station 102' has the cached firmware update being transmitted to the user equipment 104A, the base station 102' may take over the transmission of the remaining segments of the cached firmware update and indicate the same to the base station 102.

Figure 5 is a schematic representation 500 illustrating a scenario in which a base station provides cached firmware update 122 to the user equipment 104A attached to another base station via the X2 interface, according to one embodiment. Consider that the user equipment 104A moves from a first cell location to a second cell location during the firmware upgrade to the device management server 108. That is, the user equipment 104A reselects a base station 102' associated with the second cell location during the firmware update. In such case, the base station 102 continues to provide the cached firmware update 122 to the user equipment 104A via an X2 interface between the base station 102 and the base station 102'.

In some embodiments, the base station 102 continues to transmit the cached firmware update 122 to the user equipment 104A via a switch 502 connecting the base station 102 and the base station 102'. For example, the base station 102 and the base station 102' are connected to the switch 502 via a transport link 504 and a transport link 506. The physical path between the base station 102 and the switch 502 and between the switch 502 and the base station 102' is commonly known as X2 interface. According to the present invention, the base station 102 communicates the firmware update to the switch 502 via the transport link 504 and the switch 502 communicates the firmware update to the base station 102' via the transport link 506.

Figure 6 illustrates a block diagram of an exemplary device management server 108, such as those shown in Figure 1, showing various components for implementing embodiments of the present subject matter. In Figure 6, the device management server 108 includes a processor 602, memory 604, a read only memory (ROM) 606, a communication unit 608, and a bus 610.

The processor 602, as used herein, means any type of computational circuit, such as, but not limited to, a microprocessor, a microcontroller, a complex instruction set computing microprocessor, a reduced instruction set computing microprocessor, a very long instruction word microprocessor, an explicitly parallel instruction computing microprocessor, a graphics processor, a digital signal processor, or any other type of processing circuit. The processor 602 may also include embedded controllers, such as generic or programmable logic devices or arrays, application specific integrated
circuits, single-chip computers, smart cards, and the like.

The memory 604 may be volatile memory and non-volatile memory. The memory 604 may include an FOTA management module 120 for managing firmware over the air service in a wireless network environment, according to the embodiments illustrated in Figures 1 to 6. A variety of computer-readable storage media may be stored in and accessed from the memory elements. Memory elements may include any suitable memory device(s) for storing data and machine-readable instructions such as read only memory, random access memory, erasable programmable read only memory, electrically erasable programmable read only memory, hard drive, removable media drive for handling memory cards, Memory Sticks™, and the like.

Embodiments of the present subject matter may be implemented in conjunction with modules including functions, procedures, data structures, and application programs, for performing tasks, defining abstract data types, or low-level hardware contexts. The FOTA management module 120 may be stored in the form of machine-readable instructions on any of the above-mentioned storage media and is executable by the processor 602. For example, a computer program may include the machine-readable instructions capable of managing firmware over the air service in the wireless network environment, according to the teachings and herein described embodiments of the present subject matter. The computer program may be included on a non-transitory computer-readable storage medium and loaded from the storage medium to a hard drive in the non-volatile memory.

The components such as the ROM 606, the communication unit 608, and the bus 610 are well known to the person skilled in the art and hence the explanation is thereof omitted.

Figure 7 illustrates a block diagram of an exemplary cache server 112, such as those shown in Figure 1, showing various components for implementing embodiments of the present subject matter. In Figure 7, the cache server 112 includes the FOTA service module 114, the cache memory 116, a read only memory (ROM) 702, a transceiver 704, a communication interface 706, and a bus 708.

The FOTA service module 114 is configured for obtaining and caching firmware update intended for the user equipments 104A-N, and providing the cached firmware update 122 to the user equipments 104A-N, according to the embodiments illustrated in Figures 1 to 6. In one embodiment, the FOTA service module 114 means any type of computational circuit, such as, but not limited to, a microprocessor, a microcontroller, a complex instruction set computing microprocessor, a reduced instruction set computing microprocessor, a very long instruction word microprocessor, an explicitly parallel instruction computing microprocessor, a graphics processor, a digital signal processor, or any other type of processing circuit. The FOTA service module
114 may also include embedded controllers, such as generic or programmable logic devices or arrays, application specific integrated circuits, single-chip computers, smart cards, and the like.

The cache memory 116 may be volatile memory and non-volatile memory. The cache memory 116 is configured for caching the firmware update obtained from the FOTA server 110. Memory elements may include any suitable memory device(s) for storing data and machine-readable instructions such as read only memory, random access memory, erasable programmable read only memory, electrically erasable programmable read only memory, hard drive, removable media drive for handling memory cards, Memory Sticks™, and the like.

Embodiments of the present subject matter may be implemented in conjunction with modules including functions, procedures, data structures, and application programs, for performing tasks, defining abstract data types, or low-level hardware contexts. In an alternate embodiment, the FOTA service module 114 may be stored in the form of machine-readable instructions on any of the above-mentioned storage media and is executable by a processor. For example, a computer program may include the machine-readable instructions capable of obtaining and caching firmware update intended for user equipments 104A-N and providing the cached firmware update 122 to the user equipment 104A-N, according to the teachings and herein described embodiments of the present subject matter. The computer program may be included on a non-transitory computer-readable storage medium and loaded from the storage medium to a hard drive in the non-volatile memory.

The components such as the ROM 706, the transceiver 708, the communication interface 710, and the bus 712 are well known to the person skilled in the art and hence the explanation is thereof omitted.

The present embodiments have been described with reference to specific example embodiments, it will be evident that various modifications and changes may be made to these embodiments without departing from the broader spirit and scope of the various embodiments. Furthermore, the various devices, modules, and the like described herein may be enabled and operated using hardware circuitry, for example, complementary metal oxide semiconductor based logic circuitry, firmware, software and/or any combination of hardware, firmware, and/or software embodied in a machine readable medium. For example, the various electrical structure and methods may be embodied using transistors, logic gates, and electrical circuits, such as application specific integrated circuit.
Claims

[Claim 1]  A method of providing firmware over the air (FOTA) service to user equipments in a wireless network environment, the method comprising:
obtaining firmware update intended for a plurality of user equipments in a wireless network environment from a FOTA server by a base station;
caching the firmware update intended for the plurality of user equipments in a cache server of the base station; and
providing the cached firmware update to one or more user equipments associated with the base station over a wireless air interface.

[Claim 2]  The method of claim 1, further comprising:
obtaining identity information associated with the one or more user equipments from a core network entity.

[Claim 3]  The method of claim 1, wherein obtaining the firmware update intended for the plurality of user equipments in the wireless network environment from the FOTA server comprises:
obtaining a firmware update resource identifier associated with the firmware update from a device management server when a notification indicating availability of the firmware update for the plurality of user equipments is received from the device management server; and
obtaining the firmware update from the FOTA server using the firmware update resource identifier.

[Claim 4]  The method of claim 1, wherein providing the cached firmware update to the one or more user equipments associated with the base station comprises:
sending a local paging message indicating availability of the cached firmware update to each of the one or more user equipments in a cell associated with the base station;
receiving a request for the cached firmware update from said each user equipment in response to the local paging message; and
providing the cached firmware update to said each user equipment.

[Claim 5]  The method of claim 1, wherein providing the cached firmware update to the one or more user equipments associated with the base station comprises:
providing the cached firmware update to the one or more user equipments associated with the base station when a request for firmware update received from respective user equipment is re-directed
the base station by the device management server.

[Claim 6] The method of claim 5, wherein providing the cached firmware update to the one or more user equipments associated with the base station comprises:

determining whether the user equipment is currently attached to the base station when the request for firmware update received from said user equipment is re-directed to the base station by the device management server;

providing the cached firmware update to said user equipment associated with the base station if said user equipment is currently associated with the base station; and

forwarding the request for firmware update received from said user equipment to another base station if said user equipment is not currently associated with the base station.

[Claim 7] The method of claim 5, wherein providing the cached firmware update to the one or more user equipments associated with the base station comprises:

determining whether any user equipment is currently attached to the base station when the request for firmware update received from said user equipment is re-directed to the base station by the device management server;

providing the cached firmware update to said user equipment associated with the base station if said user equipment is currently associated with the base station; and

providing the cached firmware update to said user equipment currently associated with another base station over a X2 interface if said user equipment is not currently associated with the base station.

[Claim 8] A base station comprising:

a cache server comprising:

a FOTA service module; and

a cache memory, wherein the FOTA service module is configured for obtaining firmware update intended for a plurality of user equipments in a wireless network environment from a FOTA server, and wherein the FOTA service module is configured for caching the firmware update intended for the plurality of user equipments in the cache memory, and wherein the FOTA service module is configured for providing the cached firmware update to associated one or more user equipments over a wireless air interface.
[Claim 9] The base station of claim 8, adapted to perform the method of one of claims 1 to.

[Claim 10] A method of providing firmware over the air (FOTA) service to user equipments in a wireless network environment comprising: notifying availability of firmware update for a plurality of user equipments to each of a plurality of base stations in a wireless network environment; and providing a firmware update resource identifier associated with the firmware update to each base station so said each base station obtains the firmware update from a FOTA server using the firmware update resource identifier and caches the firmware update for providing to associated one or more of the plurality of user equipments.

[Claim 11] The method of claim 10, further comprising: receiving a request for firmware update from at least one of the plurality of user equipments; obtaining location information associated with the at least one user equipment from a core network entity; identifying a base station associated with the at least one user equipment based on the location information associated with the at least one user equipment; and re-directing the request for firmware update from the at least one user equipment to the identified base station so that the identified base station provides the cached firmware update to the at least one user equipment.

[Claim 12] A device management server comprising:
a processor; and
a memory coupled to the processor, wherein the memory comprises a FOTA management module configured for: notifying availability of firmware update for a plurality of user equipments to each of a plurality of base stations in a wireless network environment; and providing a firmware update resource identifier associated with the firmware update to each base station so said each base station obtains the firmware update from a FOTA server using the firmware update resource identifier and caches the firmware update for providing to associated one or more of the plurality of user equipments.

[Claim 13] The server of claim 12, adapted to perform the method of one of claims 10 and.
[Claim 14] A system comprising:
a device management server;
a FOTA server;
a plurality of base stations coupled to the device management server
and the FOTA server; and
a plurality of user equipments attached to the plurality of base stations,
wherein the device management server is configured for sending a notification indicating availability of a firmware update for the plurality of user equipment to said each base station, and wherein the device management server is configured for providing a firmware update resource identifier associated with the firmware update to said each base station, and wherein said each base station is configured for obtaining firmware update from the FOTA server using the firmware update resource identifier, and wherein said each base station is configured for caching the firmware update in the cache memory, and wherein said each base station is configured for providing the cached firmware update to associated one or more of the plurality of user equipments over a wireless air interface.
[Fig. 2]

USER EQUIPMENTS SIMAN

BASE STATION 110

SEND A NOTIFICATION INDICATING AVAILABILITY OF SOFTWARE UPGRADE 202

COMMUNICATE DEVICE INFORMATION 204

SEND A SOFTWARE UPDATE IDENTIFIER ASSOCIATED WITH THE SOFTWARE UPGRADE 206

PROVIDE THE SOFTWARE UPDATE REQUEST 208

CACHE THE SOFTWARE UPDATE IN A CACHE MEMORY 210

DEVICE MANAGEMENT SERVER 108

PROVIDE THE CACHED SOFTWARE UPDATE 212

200
DEVICE MANAGEMENT SERVER 108

SEND A REQUEST FOR FIRMWARE UPDATE 402

BASE STATION 102

BASE STATION 102'

RE-DIRECT THE REQUEST FOR FIRMWARE UPDATE 408

IDENTIFY A BASE STATION BASED ON LOCATION INFORMATION 406

DETERMINE WHETHER THE FIRMWARE UPDATE IS AVAILABLE 410

DETERMINE WHETHER THE USER EQUIPMENT IS CURRENTLY ATTACHED 412

PROVIDE THE CACHED FIRMWARE UPDATE VIA X2 INTERFACE 454
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

H04W 8/24(2009.01)i, H04W 92/10(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)

H04W 8/24; G06F 9/44

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: firmware, update, over the air

C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>US 2007-0169073 Al (PATRICK O'NEILL et al.) 19 July 2007</td>
<td>1-2, 8-10, 12-14</td>
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<tr>
<td>A</td>
<td>See abstract; paragraph [46]; claims 1-33 and figures 1-6.</td>
<td>3-7, 11</td>
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<tr>
<td>A</td>
<td>US 2008-0168435 Al (DAVID TUPMAN et al.) 10 July 2008</td>
<td>1-14</td>
</tr>
<tr>
<td>A</td>
<td>See claims 1-28 and figures 1-11.</td>
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<tr>
<td>A</td>
<td>US 2010-0175062 Al (JUNE YEOB KIM) 08 July 2010</td>
<td>1-14</td>
</tr>
<tr>
<td></td>
<td>See claims 1-21 and figures 1-4.</td>
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</table>

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

* Special categories of cited documents:
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