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(54) Title: A METHOD AND APPARATUS FOR SWITCHING BETWEEN POWER SAVING MODES

(57) Abstract: A method and apparatus may include determining, by an application server, whether a user equipment is reachable or not by a network. The method may also include informing the user equipment to switch from a first power save mode to a second power save mode, if the user equipment is determined to be reachable. The method may also include attempting to reach the user equipment, if the user equipment is determined to not be reachable. The attempting to reach the user equipment comprises initiating device triggering the user equipment by sending a request to the network.

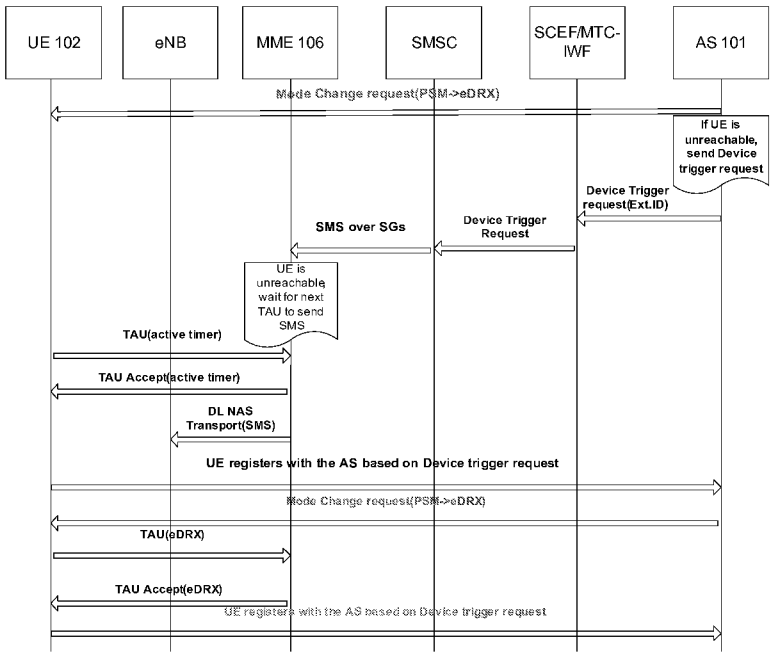

Fig. 1

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A METHOD AND APPARATUS FOR SWITCHING BETWEEN POWER SAVING MODES

BACKGROUND:

Field:

[0001] Embodiments of the present invention relate to switching between power saving modes.

Description of the Related Art:

[0002] Long-term Evolution (LTE) is a standard for wireless communication that seeks to provide improved speed and capacity for wireless communications by using new modulation/signal processing techniques. The standard was proposed by the 3rd Generation Partnership Project (3GPP), and is based upon previous network technologies. Since its inception, LTE has seen extensive deployment in a wide variety of contexts involving the communication of data.

SUMMARY:

[0003] According to a first embodiment, a method may include determining, by an application server, whether a user equipment is reachable or not by a network. The method may also include informing the user equipment to switch from a first power save mode to a second power save mode, if the user equipment is determined to be reachable. The method may also include attempting to reach the user equipment, if the user equipment is determined to not be reachable. The attempting to reach the user equipment comprises initiating device triggering the user equipment by sending a request to the network.

[0004] In the method of the first embodiment, the informing the user equipment comprises informing the user equipment to switch from power-saving mode to an extended discontinuous-reception cycle, or vice versa.

[0005] In the method of the first embodiment, the device triggering is initiated towards at least one of a mobility management entity and a service-capability-exposure function.

[0006] In the method of the first embodiment, the method may further include registering for user-equipment reachability.

[0007] In the method of the first embodiment, the informing the user equipment comprises informing the user equipment to switch a power saving mode based on a number of transactions that were exchanged in the past and/or a running application.

[0008] According to a second embodiment, an apparatus may include at least one processor. The apparatus may also include at least one memory including computer program code. The at least one memory and the computer program code may be configured, with the at least one processor, to cause the apparatus at least to determine whether a user equipment is reachable or not by a network. The apparatus may also be caused to inform the user equipment to switch from a first power save mode to a second power save mode, if the user equipment is determined to be reachable. The apparatus may also be caused to attempt to reach the user equipment, if the user equipment is determined to not be reachable. The attempting to reach the user equipment comprises initiating device triggering the user equipment by sending a request to the network.

[0009] In the apparatus of the second embodiment, the informing the user equipment comprises informing the user equipment to switch from power-saving mode to an extended discontinuous-reception cycle, or vice versa.

[0010] In the apparatus of the second embodiment, the device triggering is initiated towards at least one of a mobility management entity and a service-capability-exposure function.

[0011] In the apparatus of the second embodiment, the apparatus may also be caused to register for user-equipment reachability.

[0012] In the apparatus of the second embodiment, the informing the user equipment comprises informing the user equipment to switch a power saving mode based on a number of transactions that were exchanged in the past and/or a running application.

[0013] According to a third embodiment, a computer program may be embodied on a computer readable medium. The computer program may be configured to control a processor to perform a method according to the first embodiment.

[0014] According to a fourth embodiment, a method may include receiving, by a user equipment, a request for the user equipment to switch from a first power save mode to a second power save mode. The request is received from at least one of an application server and a network. The method may also include deactivating the first power save mode. The method may also include activating the second power save mode.

[0015] In the method of the fourth embodiment, the receiving the request comprises receiving a request to switch from power-saving mode to an extended discontinuous-reception cycle, or vice versa.

[0016] In the method of the fourth embodiment, the deactivating the first power save mode and the activating the second power save mode comprises deactivating and activating when the user equipment performs a tracking area update.

[0017] In the method of the fourth embodiment, the method may further include registering with an application server based on a device trigger request initiated by the application server.

[0018] In the method of the fourth embodiment, the switch from the first power save mode to the second power save mode is based on a number of transactions that were exchanged in the past and/or a running application.

[0019] According to a fifth embodiment, an apparatus may include at least one processor. The apparatus may also include at least one memory including computer program code. The at least one memory and the computer program code may be configured, with the at least one processor, to cause the apparatus at least to receive a request for the user equipment to switch from a first power save mode to a second power save mode. The request is received from at least one of an application server and a network. The apparatus may also be caused to deactivate the first power save mode. The apparatus may also be caused to activate the second power save mode.

[0020] In the apparatus of the fifth embodiment, the receiving the request comprises receiving a request to switch from power-saving mode to an extended discontinuous-reception cycle, or vice versa.

[0021] In the apparatus of the fifth embodiment, the deactivating the first power save mode and the activating the second power save mode comprises deactivating and activating when the user equipment performs a tracking area update.

[0022] In the apparatus of the fifth embodiment, the apparatus is caused to register with an application server based on a device trigger request initiated by the application server.

[0023] In the apparatus of the fifth embodiment, the switch from the first power save mode to the second power save mode is based on a number of transactions that were exchanged in the past and/or a running application.

[0024] According to a sixth embodiment, a computer program may be embodied on a computer readable medium. The computer program configured to control a processor to perform a method according the fourth embodiment.

[0025] According to a seventh embodiment, an apparatus may include determining means for determining, by an application server, whether a user equipment is reachable or not by a network. The apparatus may also include informing means for informing the user equipment to switch from a first power save mode to a second power save mode, if the user equipment is determined to be reachable. The apparatus may also include attempting means for attempting to reach the user equipment, if the user equipment is determined to not be reachable. The attempting to reach the user equipment comprises initiating device triggering the user equipment by sending a request to the network.

[0026] According to an eighth embodiment, an apparatus may include a receiving means for receiving, by a user equipment, a request for the user equipment to switch from a first power save mode to a second power save mode. The request is received from at least one of an application server and a network. The apparatus may also include a deactivating means for deactivating the first power save mode. The apparatus may also include activating means for activating the second power save mode.

BRIEF DESCRIPTION OF THE DRAWINGS:

[0027] For proper understanding of the invention, reference should be made to the accompanying drawings, wherein:

[0028] Fig. 1 illustrates switching a power saving mode in accordance with certain embodiments of the present invention.

[0029] Fig. 2 illustrates switching a power saving mode in accordance with certain other embodiments of the present invention.

[0030] Fig. 3 illustrates a flowchart of a method in accordance with certain embodiments of the invention.

[0031] Fig. 4 illustrates a flowchart of a method in accordance with certain embodiments of the invention.

[0032] Fig. 5 illustrates an apparatus in accordance with certain embodiments of the invention.

[0033] Fig. 6 illustrates an apparatus in accordance with certain embodiments of the invention.

[0034] Fig. 7 illustrates an apparatus in accordance with certain embodiments of the invention.

[0035] Fig. 8 illustrates a system in accordance with certain embodiments of the invention.

DETAILED DESCRIPTION:

[0036] Certain embodiments of the present invention relate to switching between power saving modes. 3GPP System Architecture Group 2 (SA2) has an ongoing study directed to high-latency communication ("Study on Optimizations to Support High Latency Communications") in Technical Report 23.709. Power Saving Mode (PSM) was defined in Release-12 Technical Specification 23.401, wherein a user equipment (UE) is not reachable for paging while the user equipment is in PSM. High-latency communication (Hlcom) defines procedures where a network may buffer mobile-terminated (MT) data until the UE wakes up from the PSM. Another work item in SA2, in the area of MTC,

will be directed to an extended discontinuous-reception (DRX) cycle for power consumption optimization (eDRX). However, the start of this work is still pending the approval of SA plenary.

[0037] The eDRX will be directed to extending an idle mode DRX cycle of the UE for a duration of 10 minutes and more. The mobile terminating data communication aspects of the eDRX may be included into the HLcom study. For example, a similar buffering solution that is defined for PSM should also be applicable for eDRX.

[0038] There is a proposal in HLcom (Solution 2, in section 5.2 of TR 23.709) where a serving gateway (SGW) buffers the downlink (DL) packets until the UE wakes up from the sleep (from either eDRX or PSM) and receives the paging, and the radio bearers for a user plane can be established.

[0039] Customers have identified use cases that may require the UE to switch between different power savings modes. For example, the UE may switch between PSM and eDRX. Some devices may require extensive power savings and may require only 2 MT transactions per day. So, the customers may wish to use PSM for such devices. At the same time, if the network and/or the UE determine that the number of MT transactions (per day) meets/exceeds a certain threshold, the customers may want the UE to be able to deactivate PSM so that the UE is more easily reachable for MT transactions. The customers may wish to increase the probability of reaching the UE, while still implementing power saving.

[0040] The UE, the network, and/or an application server may possibly perform independent switching of the power saving modes. Such independent switching may result in a failure of MT transactions due to the following reasons.

[0041] First, MT transactions may fail if the UE changes a power savings mode from eDRX to PSM, or vice versa, by itself. In such an event, the network will generally not be aware of the UE's reachability cycle. The UE's reachability cycle defines when the UE may be reached by an application server and/or a network. Thus, the network may page more frequently and decide to give up on reaching the UE after a certain number of attempts that result in failure. Alternatively, in the event that the network pages very infrequently, the network may possibly not reach the UE when the network is actually ready to listen for paging messages from the UE.

[0042] Second, MT transactions may fail if the application server requests the UE to switch power saving modes, but the access network is not informed of the switching.

[0043] Third, MT transactions may fail if the network informs the UE regarding the switching of power saving modes, without informing the application server. In such an event, the application server may attempt to reach the UE more frequently because the application server is not aware of whether the UE is reachable. The buffering capacity in the network may be reached, thus resulting in MT transaction failure.

[0044] Certain embodiments of the present invention may be directed to an end-to-end solution that enables an operator to switch a power saving mode of a device. The power saving mode may be switched based on a type of application that is running (at any particular time), the number of MT transactions executed during a certain period of time, the type of UE, the subscription, other possible statistical behavior of the UE, and/or other behavior triggered by Operations, Administration, and Maintenance (OA&M). Switching between the power saving modes may comprise any combination of switching between normal discontinuous reception (DRX), eDRX, PSM, and/or newly-specified power saving modes, for example. PSM and eDRX may be used as examples of power saving modes that can be switched between.

[0045] Possible options of implementing the switching between power modes are discussed below. In certain embodiments of the present invention, based on the application characteristics, an Application Server may inform the UE that the UE should change from PSM to eDRX (or to normal DRX) or vice versa (when the UE is reachable). Based on the request from the Application Server (AS), the UE may trigger a change in power savings mode by reaching out to the network.

[0046] In certain embodiments of the present invention, based on the application characteristics, the Application Server and/or Service-Capability-Exposure-Function (SCEF) may inform the network that the network should change from PSM to eDRX (or to normal DRX) or vice versa (when the UE is not reachable). The Application Server / SCEF may inform a Home Subscriber Server (HSS) and/or a Mobility Management Entity (MME)) that the network should change from PSM to eDRX (or to normal DRX) or vice versa (when UE is not reachable). Based on the request, the network may trigger the change in power saving mode for the UE when the UE becomes reachable next time.

[0047] In certain embodiments of the present invention, the network may determine that a change from PSM to eDRX (or to normal DRX) or vice versa is required based on a certain number of MT transactions, UE, subscription type, some other statistical data regarding the UE behavior, and/or some other behavior triggered by OA&M. The change may be triggered the next time that the UE becomes reachable, and the network may inform the application server regarding the change.

[0048] Similar options may also be applied for a mode to change from eDRX/normal DRX to PSM. Certain embodiments of the present invention may ensure that a power-saving mode is changed in the UE, network, and application server (in unison, for example) to make sure that the UE reachability information is updated in all the entities at the same time. The UE reachability information may be updated to ensure that there is no failure nor delay in MT transactions toward the UE.

[0049] Fig. 1 illustrates switching a power saving mode in accordance with certain embodiments of the present invention. With a first embodiment, an Application Server (AS) 101 may determine whether or not UE 102 is reachable.

[0050] If UE 102 is reachable, AS 101 directly informs UE 102 that UE 102 should switch from PSM to eDRX, or vice versa. AS 101 may inform UE 102 of the switching via an application layer message. Upon receiving the instruction relating to the switching over the application layer, UE 102 may deactivate PSM and may initiate a request for eDRX. UE 102 may deactivate PSM and may request eDRX when UE 102 performs the next tracking area update (TAU) towards the network. UE 102 may also request a TAU immediately after receiving the application layer notification.

[0051] On the other hand, if UE 102 is not reachable by AS 101, AS 101 may attempt to reach UE 102. For example, AS 101 may initiate device triggering towards the network.

[0052] The network (via MME 106, for example) may attempt to trigger UE 102. If UE 102 is not reachable, then the network may notify AS 101 that UE 102 is unreachable at this time. Optionally, the network could indicate to AS 101 when UE 102 is reachable again.

[0053] AS 101 may register for UE reachability with the network and may attempt to trigger (for example, by sending an SMS message) just before UE 102 becomes reachable

again. AS 101 can register with the HSS for a "UE reachability" event. In this case, HSS registers with the MME/SGSN to be notified when UE 102 becomes reachable again, i.e., when UE 102 performs the next TAU or Service request, for example. A device trigger request from the AS may result in an SMS request from Short Message Service Center (SMSC) towards UE 102.

[0054] Eventually, when UE 102 performs the next TAU, the network sends the device trigger (for example, send an SMS) to UE 102.

[0055] UE 102 may acknowledge the device trigger and may register with AS 101 (based on information within the device trigger message). For instance, UE 102 can indicate its IP address information to AS 101 so that AS 101 can directly reach UE 102 using the IP address of UE 102 – via user plane communication, for example.

[0056] AS 101 may inform UE 102 that AS 101 wants to change from PSM mode to eDRX.

[0057] In certain embodiments, UE 102 may have to initiate another TAU in order to deactivate PSM. UE 102 can then request the network to initiate eDRX.

[0058] Fig. 2 illustrates switching a power saving mode in accordance with certain other embodiments of the present invention. According to a second embodiment, AS 201 may determine whether UE 202 is reachable or not. If UE 202 is reachable, AS 201 can directly inform UE 202 that UE 202 should switch from PSM to eDRX. AS 201 can inform UE 202 over the application layer. The switching can be based on the number of transactions that were exchanged in the past and/or based on future applications to run between UE 202 and AS 201.

[0059] If the UE is not reachable, the AS can notify the network via SCEF 205 that a certain UE should change from a PSM to an eDRX mode of operation for power savings. The AS may notify the network by notifying a mobility management entity 203 (MME) via SCEF, for example.

[0060] When the network receives the request, the network determines UE reachability. If the UE is not reachable, then the network (for example, MME 203) may wait for the UE to perform the next TAU in order to execute the mode change.

[0061] When the UE performs the next TAU, the network may deactivate the use of PSM, and the network may propose to activate eDRX in the TAU accept.

[0062] The network may confirm the change of PSM mode to eDRX to SCEF 205. The network may eventually inform the AS so that the AS can initiate MT transactions depending on the current mode used by the UE.

[0063] According to a third embodiment, a network (via an MME of the network, for example) may determine whether PSM is an appropriate mode for power saving. The network may determine whether PSM is appropriate, for example, based on the number of MT transactions for a certain UE during a configurable duration. In certain embodiments of the present invention, the network may also determine whether PSM is an appropriate mode for power saving based on the number of MT transactions that fail when the UE is in PSM mode.

[0064] If the network determines that PSM is not appropriate/optimal for the UE, then, if the UE is not reachable, the network may wait for the UE to perform the next TAU.

[0065] When the UE performs the next TAU, the network may deactivate the use of PSM, and the network may activate eDRX in the TAU accept.

[0066] The network may confirm the change of PSM to eDRX. The change may be confirmed to the SCEF, and the SCEF may eventually inform the AS so that the AS can initiate MT transactions. The AS may initiate MT transactions based on the current mode used by the UE.

[0067] In view of the above, certain embodiments of the present invention may provide procedures for performing mode changes. The procedures for performing mode changes may introduce flexibility when using power savings mode. The use of power savings mode may depend on the type of application running at the moment and may depend on the needs of the devices/operator at any given point in time.

[0068] In view of the above, certain embodiments of the present invention may provide end-to-end mode change procedures that enable the application server, the UE, and the network to be synchronized. Thus, certain embodiments of the present invention may help

to reduce failed mobile terminated transactions due to the use of power saving mechanisms.

[0069] Fig. 3 illustrates a flowchart of a method in accordance with certain embodiments of the invention. The method illustrated in Fig. 3 includes, at 310, determining, by an application server, whether a user equipment is reachable or not by a network. The method may also include, at 320, informing the user equipment to switch from a first power save mode to a second power save mode, if the user equipment is determined to be reachable. The method may also include, at 330, attempting to reach the user equipment, if the user equipment is determined to not be reachable. The attempting to reach the user equipment comprises initiating device triggering the user equipment by sending a request to the network.

[0070] Fig. 4 illustrates a flowchart of a method in accordance with certain embodiments of the invention. The method illustrated in Fig. 4 includes, at 410, receiving, by a user equipment, a request for the user equipment to switch from a first power save mode to a second power save mode. The request is received from at least one of an application server and a network. The method may also include, at 420, deactivating the first power save mode. The method may also include, at 430, activating the second power save mode.

[0071] Fig. 5 illustrates an apparatus in accordance with certain embodiments of the invention. In one embodiment, the apparatus can be a application server, user equipment, MME, and/or SCEF, for example. Apparatus 10 can include a processor 22 for processing information and executing instructions or operations. Processor 22 can be any type of general or specific purpose processor. While a single processor 22 is shown in Fig. 5, multiple processors can be utilized according to other embodiments. Processor 22 can also include one or more of general-purpose computers, special purpose computers, microprocessors, digital signal processors (DSPs), field-programmable gate arrays (FPGAs), application-specific integrated circuits (ASICs), and processors based on a multi-core processor architecture, as examples.

[0072] Apparatus 10 can further include a memory 14, coupled to processor 22, for storing information and instructions that can be executed by processor 22. Memory 14 can be one or more memories and of any type suitable to the local application environment, and can be implemented using any suitable volatile or nonvolatile data

storage technology such as a semiconductor-based memory device, a magnetic memory device and system, an optical memory device and system, fixed memory, and removable memory. For example, memory 14 include any combination of random access memory (RAM), read only memory (ROM), static storage such as a magnetic or optical disk, or any other type of non-transitory machine or computer readable media. The instructions stored in memory 14 can include program instructions or computer program code that, when executed by processor 22, enable the apparatus 10 to perform tasks as described herein.

[0073] Apparatus 10 can also include one or more antennas (not shown) for transmitting and receiving signals and/or data to and from apparatus 10. Apparatus 10 can further include a transceiver 28 that modulates information on to a carrier waveform for transmission by the antenna(s) and demodulates information received via the antenna(s) for further processing by other elements of apparatus 10. In other embodiments, transceiver 28 can be capable of transmitting and receiving signals or data directly.

[0074] Processor 22 can perform functions associated with the operation of apparatus 10 including, without limitation, precoding of antenna gain/phase parameters, encoding and decoding of individual bits forming a communication message, formatting of information, and overall control of the apparatus 10, including processes related to management of communication resources.

[0075] In an embodiment, memory 14 can store software modules that provide functionality when executed by processor 22. The modules can include an operating system 15 that provides operating system functionality for apparatus 10. The memory can also store one or more functional modules 18, such as an application or program, to provide additional functionality for apparatus 10. The components of apparatus 10 can be implemented in hardware, or as any suitable combination of hardware and software.

[0076] Fig. 6 illustrates an apparatus in accordance with certain embodiments of the invention. Apparatus 600 can be a network element/entity such as an application server, for example. Apparatus 600 can include a determining unit 610 that determines whether a user equipment is reachable or not by a network. Apparatus 600 may also include an informing unit 620 that informs the user equipment to switch from a first power save mode to a second power save mode, if the user equipment is determined to be reachable.

Apparatus 600 may also include an attempting unit 630 that attempts to reach the user equipment, if the user equipment is determined to not be reachable. The attempting to reach the user equipment comprises initiating device triggering the user equipment by sending a request to the network.

[0077] Fig. 7 illustrates an apparatus in accordance with certain embodiments of the invention. Apparatus 700 can be a user equipment, for example. Apparatus 700 can include a receiving unit 710 that receives a request for the user equipment to switch from a first power save mode to a second power save mode. The request is received from at least one of an application server and a network. Apparatus 700 can also include a deactivating unit 720 that deactivates the first power save mode. Apparatus 700 can also include an activating unit 730 that activates the second power save mode.

[0078] Fig. 8 illustrates a system in accordance with certain embodiments of the invention. A system 800 may comprise a first apparatus 810 that can be a network element/entity such as an application server, for example. System 800 may also comprise a second apparatus 820 that can be a user equipment, for example. First apparatus 810 can include a determining unit 811 that determines whether the second apparatus 820 is reachable or not by a network. First apparatus 810 may also include an informing unit 812 that informs the second apparatus 820 to switch from a first power save mode to a second power save mode, if the second apparatus 820 is determined to be reachable. First apparatus 810 may also include an attempting unit 813 that attempts to reach the second apparatus 820, if the second apparatus 820 is determined to not be reachable. The attempting to reach the second apparatus 820 comprises initiating device triggering the second apparatus 820 by sending a request to the network. Second apparatus 820 can include a receiving unit 821 that receives a request for the second apparatus 820 to switch from a first power save mode to a second power save mode. The request is received from at least one of an application server and a network. Second apparatus 820 can also include a deactivating unit 822 that deactivates the first power save mode. Second apparatus 820 can also include an activating unit 823 that activates the second power save mode.

[0079] The described features, advantages, and characteristics of the invention can be combined in any suitable manner in one or more embodiments. One skilled in the relevant art will recognize that the invention can be practiced without one or more of the specific

features or advantages of a particular embodiment. In other instances, additional features and advantages can be recognized in certain embodiments that may not be present in all embodiments of the invention. One having ordinary skill in the art will readily understand that the invention as discussed above may be practiced with steps in a different order, and/or with hardware elements in configurations which are different than those which are disclosed. Therefore, although the invention has been described based upon these preferred embodiments, it would be apparent to those of skill in the art that certain modifications, variations, and alternative constructions would be apparent, while remaining within the spirit and scope of the invention.

WE CLAIM:

1. A method, comprising:

determining, by an application server, whether a user equipment is reachable or not by a network;

informing the user equipment to switch from a first power save mode to a second power save mode, if the user equipment is determined to be reachable; and

attempting to reach the user equipment, if the user equipment is determined to not be reachable, wherein the attempting to reach the user equipment comprises initiating device triggering the user equipment by sending a request to the network.

2. The method according to claim 1, wherein the informing the user equipment comprises informing the user equipment to switch from power-saving mode to an extended discontinuous-reception cycle, or vice versa.

3. The method according to claim 1 or 2, wherein the device triggering is initiated towards at least one of a mobility management entity and a service-capability-exposure function.

4. The method according to any of claims 1-3, further comprising registering for user-equipment reachability.

5. The method according to any of claims 1-4, wherein the informing the user equipment comprises informing the user equipment to switch a power saving mode based on a number of transactions that were exchanged in the past and/or a running application.

6. An apparatus, comprising:

at least one processor; and

at least one memory including computer program code,

the at least one memory and the computer program code configured, with the at least one processor, to cause the apparatus at least to

determine whether a user equipment is reachable or not by a network;

inform the user equipment to switch from a first power save mode to a second power save mode, if the user equipment is determined to be reachable; and

attempt to reach the user equipment, if the user equipment is determined to not be reachable, wherein the attempting to reach the user equipment comprises initiating device triggering the user equipment by sending a request to the network.

7. The apparatus according to claim 6, wherein the informing the user equipment comprises informing the user equipment to switch from power-saving mode to an extended discontinuous-reception cycle, or vice versa.

8. The apparatus according to claim 6 or 7, wherein the device triggering is initiated towards at least one of a mobility management entity and a service-capability-exposure function.

9. The apparatus according to any of claims 6-8, wherein the apparatus is also caused to register for user-equipment reachability.

10. The apparatus according to any of claims 6-9, wherein the informing the user equipment comprises informing the user equipment to switch a power saving mode based on a number of transactions that were exchanged in the past and/or a running application.

11. A computer program, embodied on a computer readable medium, the computer program configured to control a processor to perform a method according to claim 1.

12. A method, comprising:

receiving, by a user equipment, a request for the user equipment to switch from a first power save mode to a second power save mode, wherein the request is received from at least one of an application server and a network;

deactivating the first power save mode; and

activating the second power save mode.

13. The method according to claim 12, wherein the receiving the request comprises receiving a request to switch from power-saving mode to an extended discontinuous-reception cycle, or vice versa.

14. The method according to claim 12 or 13, wherein the deactivating the first power save mode and the activating the second power save mode comprises deactivating and activating when the user equipment performs a tracking area update.

15. The method according to any of claims 12-14, further comprising registering with an application server based on a device trigger request initiated by the application server.

16. The method according to any of claims 12-15, wherein the switch from the first power save mode to the second power save mode is based on a number of transactions that were exchanged in the past and/or a running application.

17. An apparatus, comprising:

at least one processor; and

at least one memory including computer program code,

the at least one memory and the computer program code configured, with the at least one processor, to cause the apparatus at least to

receive a request for the user equipment to switch from a first power save mode to a second power save mode, wherein the request is received from at least one of an application server and a network;

deactivate the first power save mode; and

activate the second power save mode.

18. The apparatus according to claim 17, wherein the receiving the request comprises receiving a request to switch from power-saving mode to an extended discontinuous-reception cycle, or vice versa.

19. The apparatus according to claim 17 or 18, wherein the deactivating the first

power save mode and the activating the second power save mode comprises deactivating and activating when the user equipment performs a tracking area update.

20. The apparatus according to any of claims 17-19, wherein the apparatus is caused to register with an application server based on a device trigger request initiated by the application server.

21. The apparatus according to any of claims 17-20, wherein the switch from the first power save mode to the second power save mode is based on a number of transactions that were exchanged in the past and/or a running application.

22. A computer program, embodied on a computer readable medium, the computer program configured to control a processor to perform a method according to claim 12.

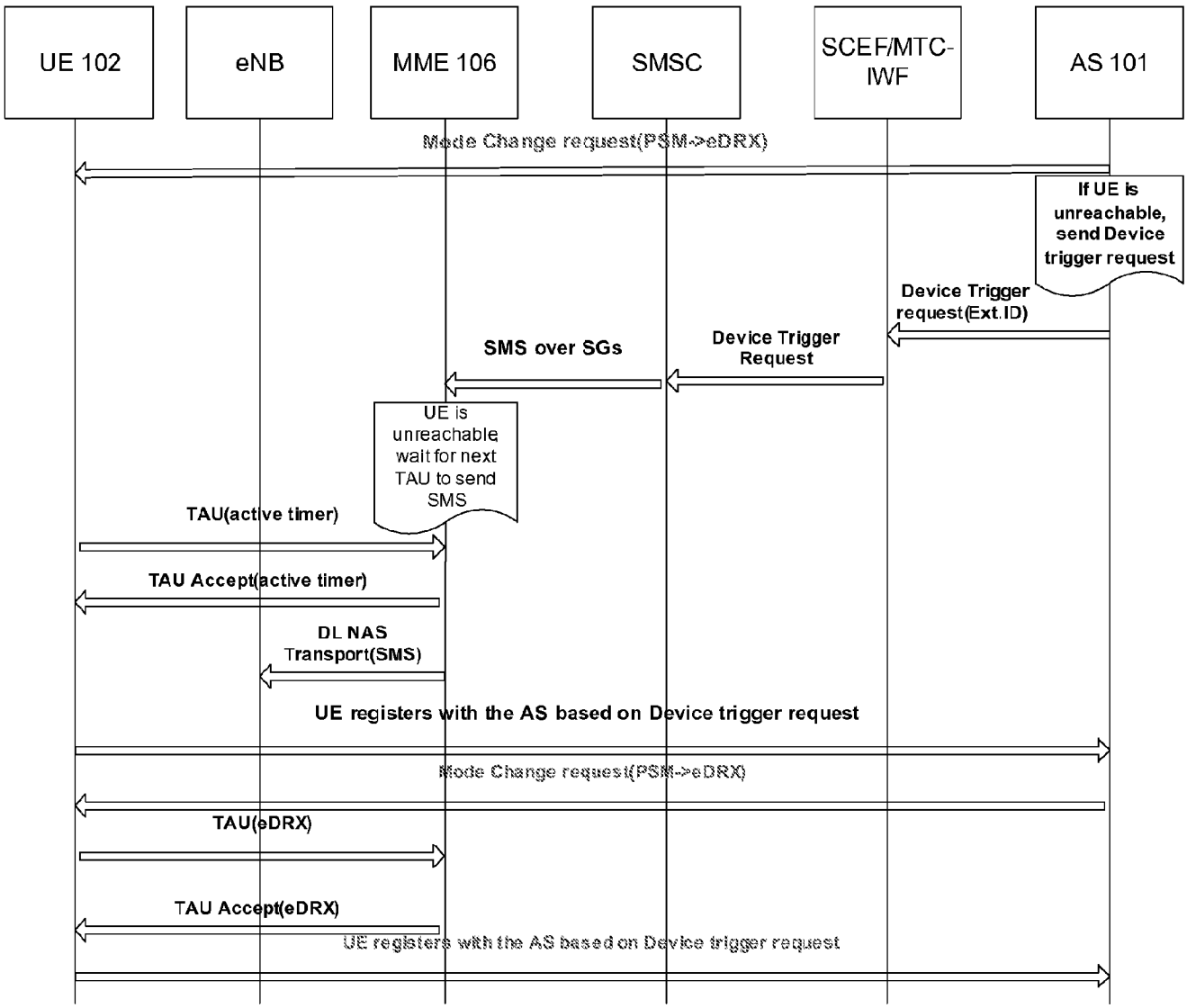
UE 102
eNB
MME 106
SMSC
SCEF/MTC-IWF
AS 101
Mode Change request(PSM->eDRX)
If UE is unreachable, send Device trigger request
Device Trigger request(Ext.ID)
SMS over SGs
Device Trigger Request
UE is unreachable wait for next TAU to send SMS
TAU(active timer)
TAU Accept(active timer)
DL NAS Transport(SMS)
UE registers with the AS based on Device trigger request
Mode Change request(PSM->eDRX)
TAU(eDRX)
TAU Accept(eDRX)
UE registers with the AS based on Device trigger request

Fig. 1

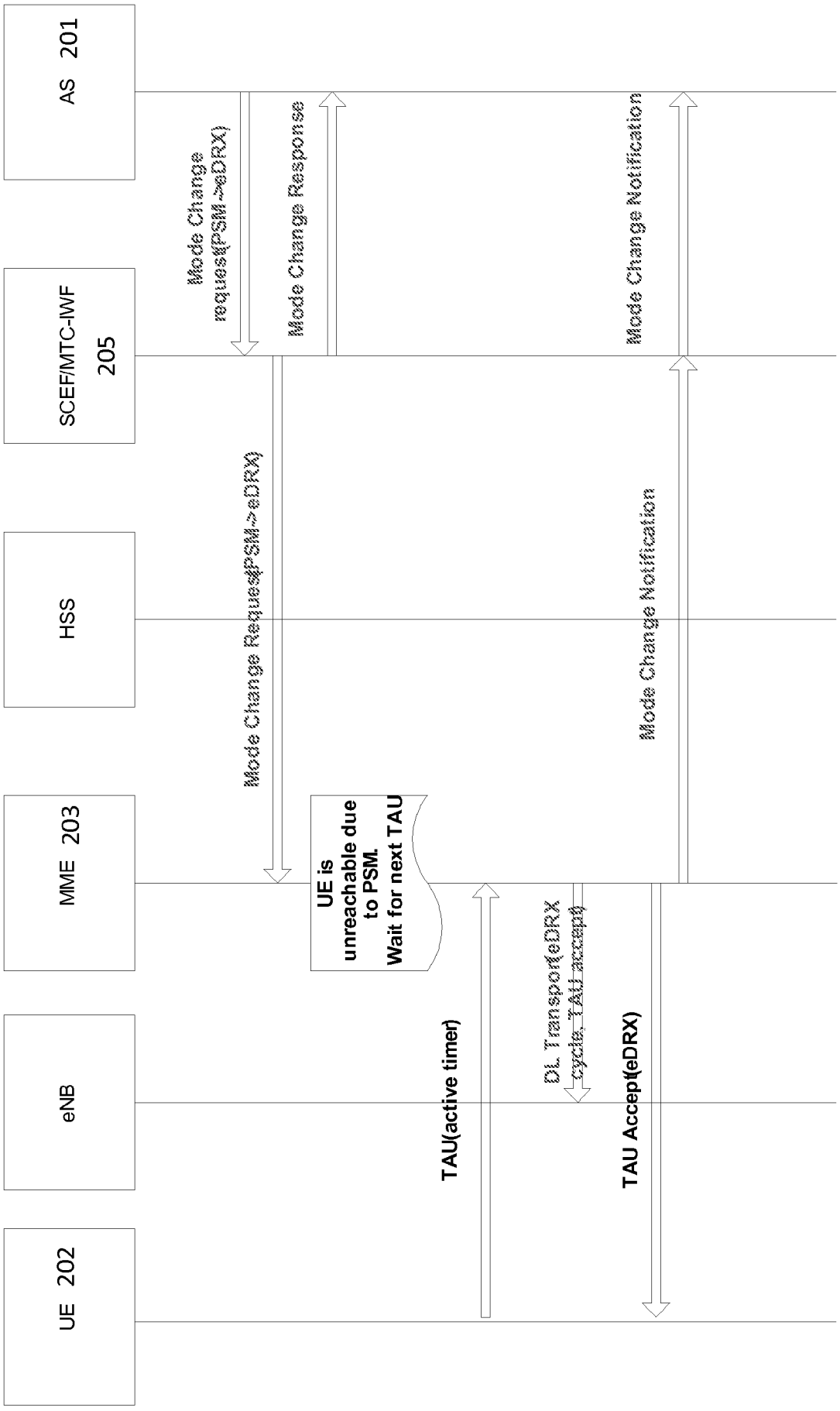
AS 201
SCEF/MTC-IWF 205
HSS
MME 203
eNB
UE 202
Mode Change request(PSM->eDRX)
Mode Change Response
Mode Change Notification
Mode Change Request(PSM->eDRX)
Mode Change Notification
UE is unreachable due to PSM. Wait for next TAU
TAU(active timer)
DL Transport(eDRX cycle, TAU accept)
TAU Accept(eDRX)

Fig. 2

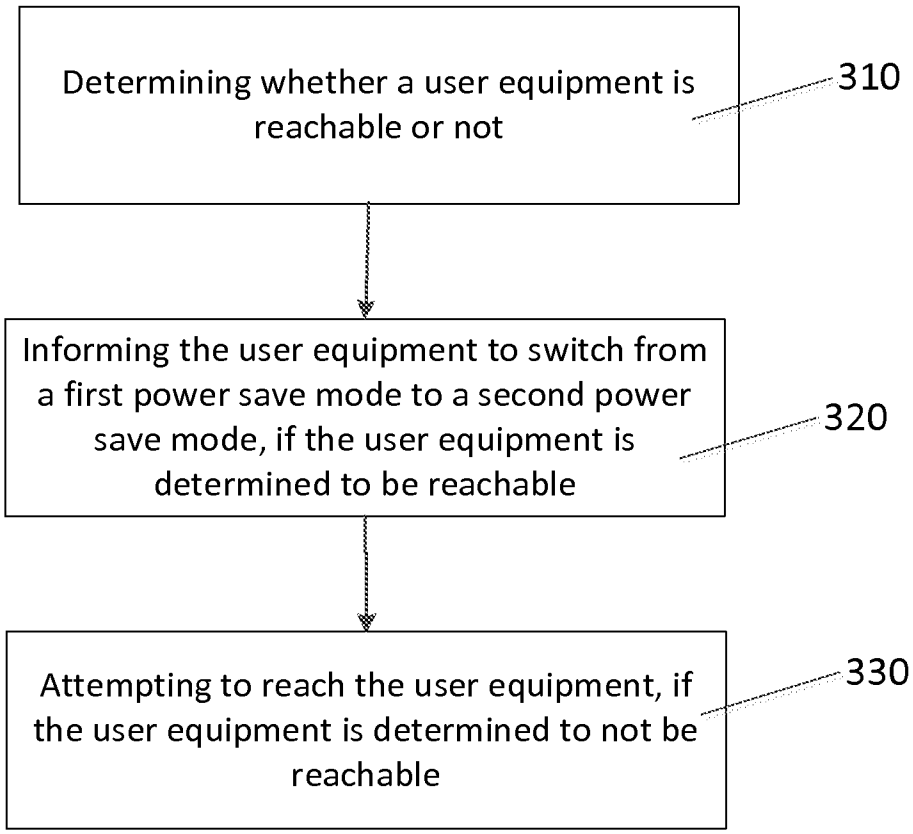
Determining whether a user equipment is reachable or not
310
Informing the user equipment to switch from a first power save mode to a second power save mode, if the user equipment is determined to be reachable
320
Attempting to reach the user equipment, if the user equipment is determined to not be reachable
330

Fig. 3

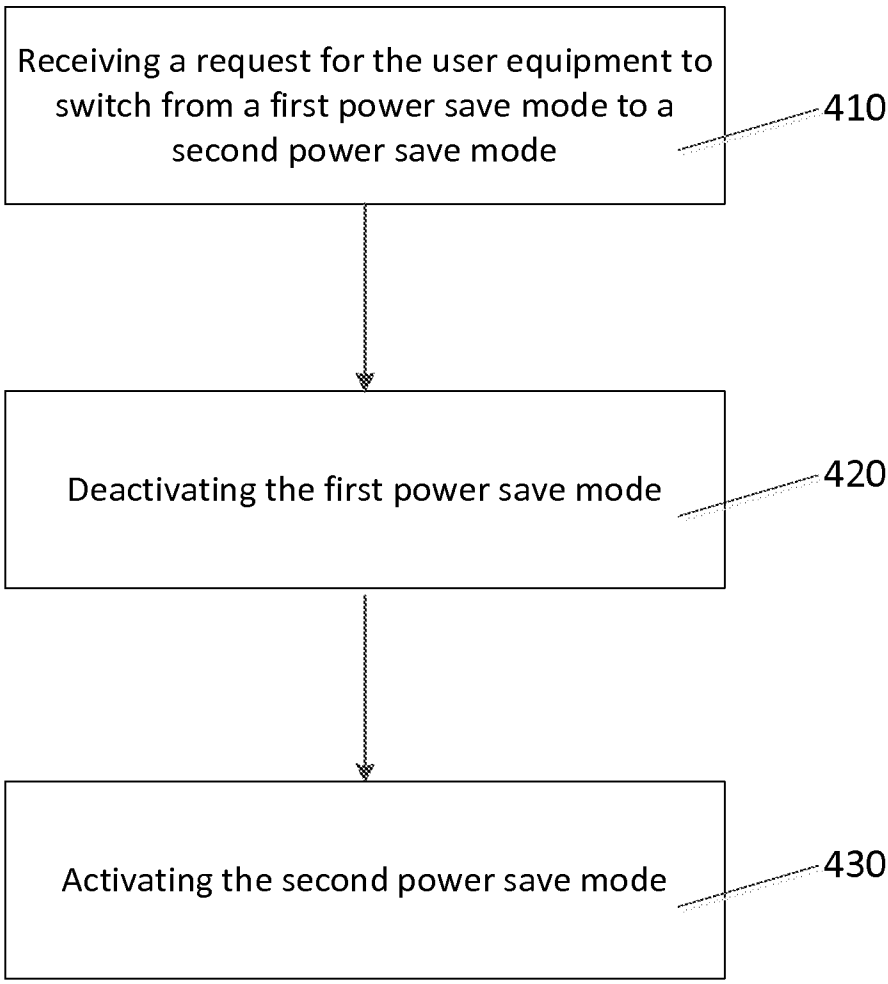
Receiving a request for the user equipment to switch from a first power save mode to a second power save mode
410
Deactivating the first power save mode
420
Activating the second power save mode
430

Fig. 4

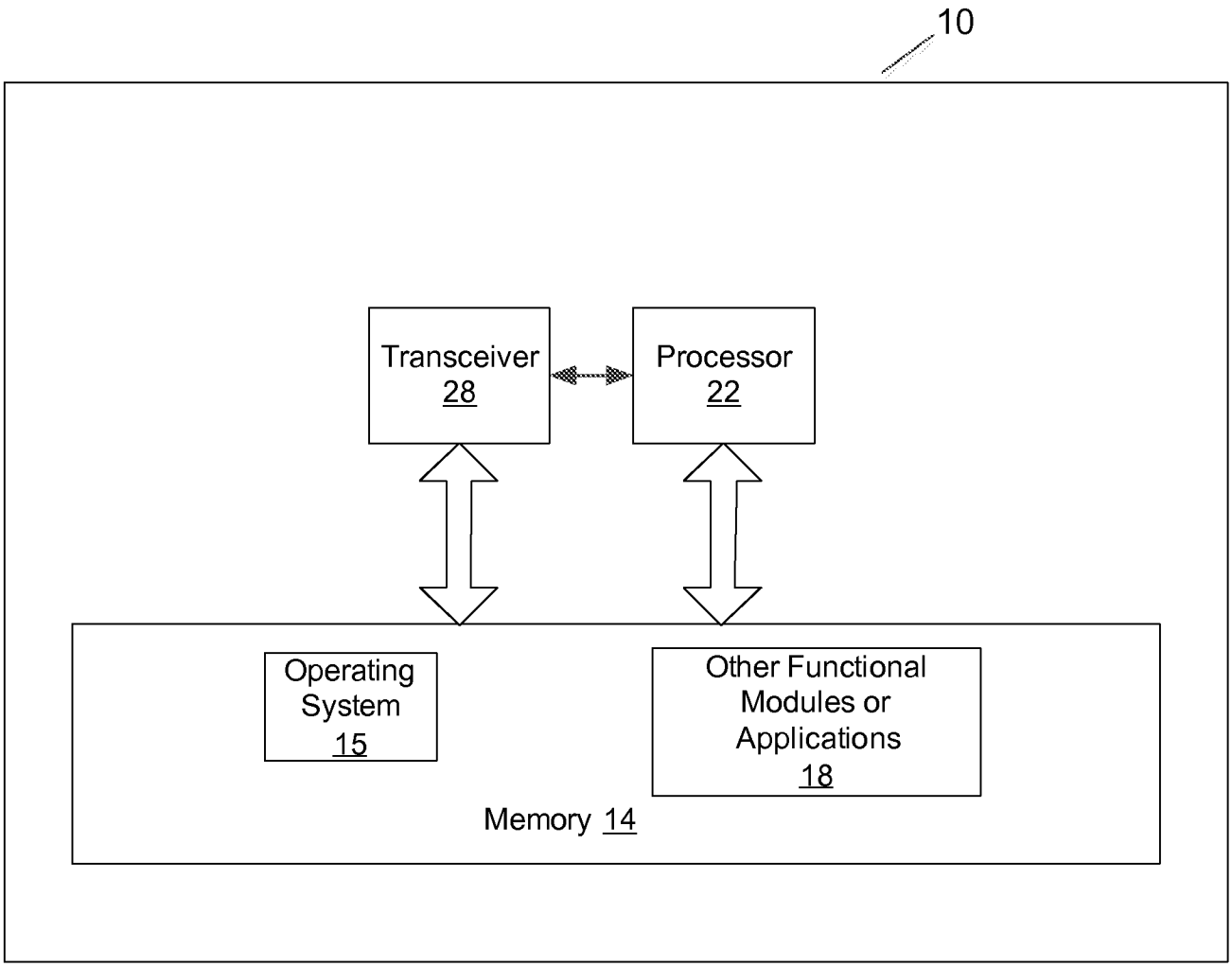
10
Transceiver
28
Processor
22
Operating
System
15
Other Functional
Modules or
Applications
18
Memory 14

Fig. 5

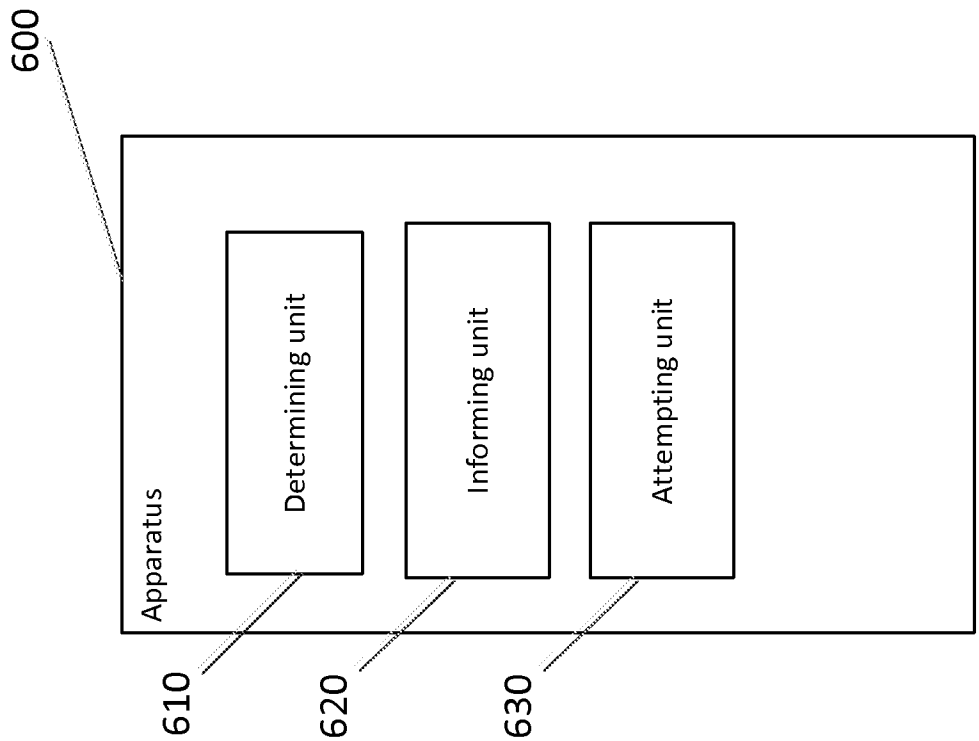
600
Apparatus
Determining unit
Informing unit
Attempting unit
610
620
630

Fig. 6

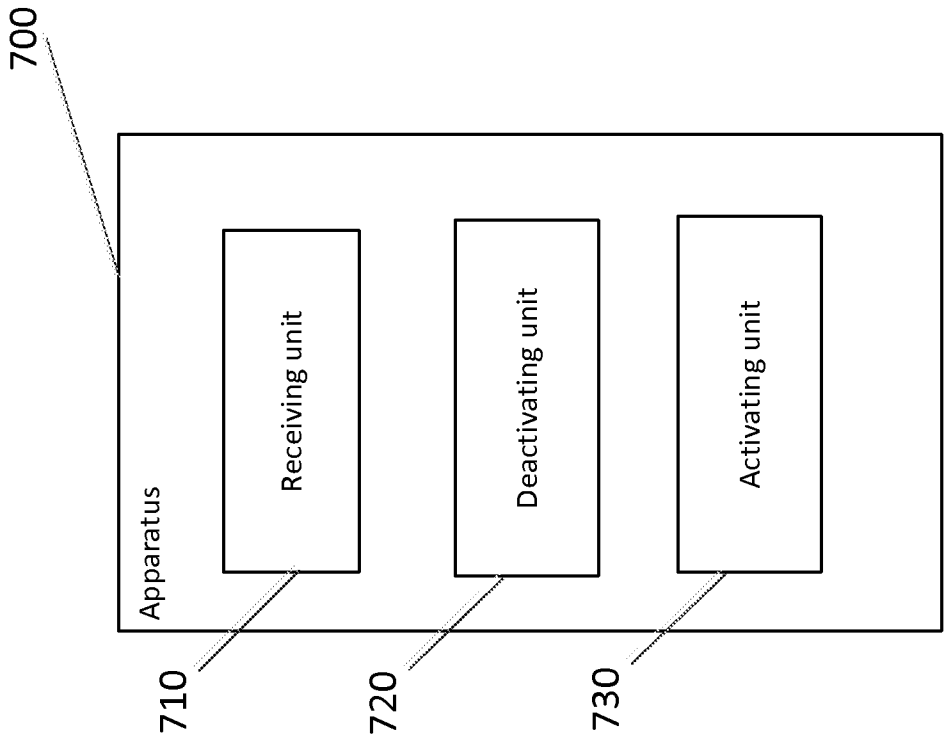
700
Apparatus
Receiving unit
Deactivating unit
Activating unit
710
720
730

Fig. 7

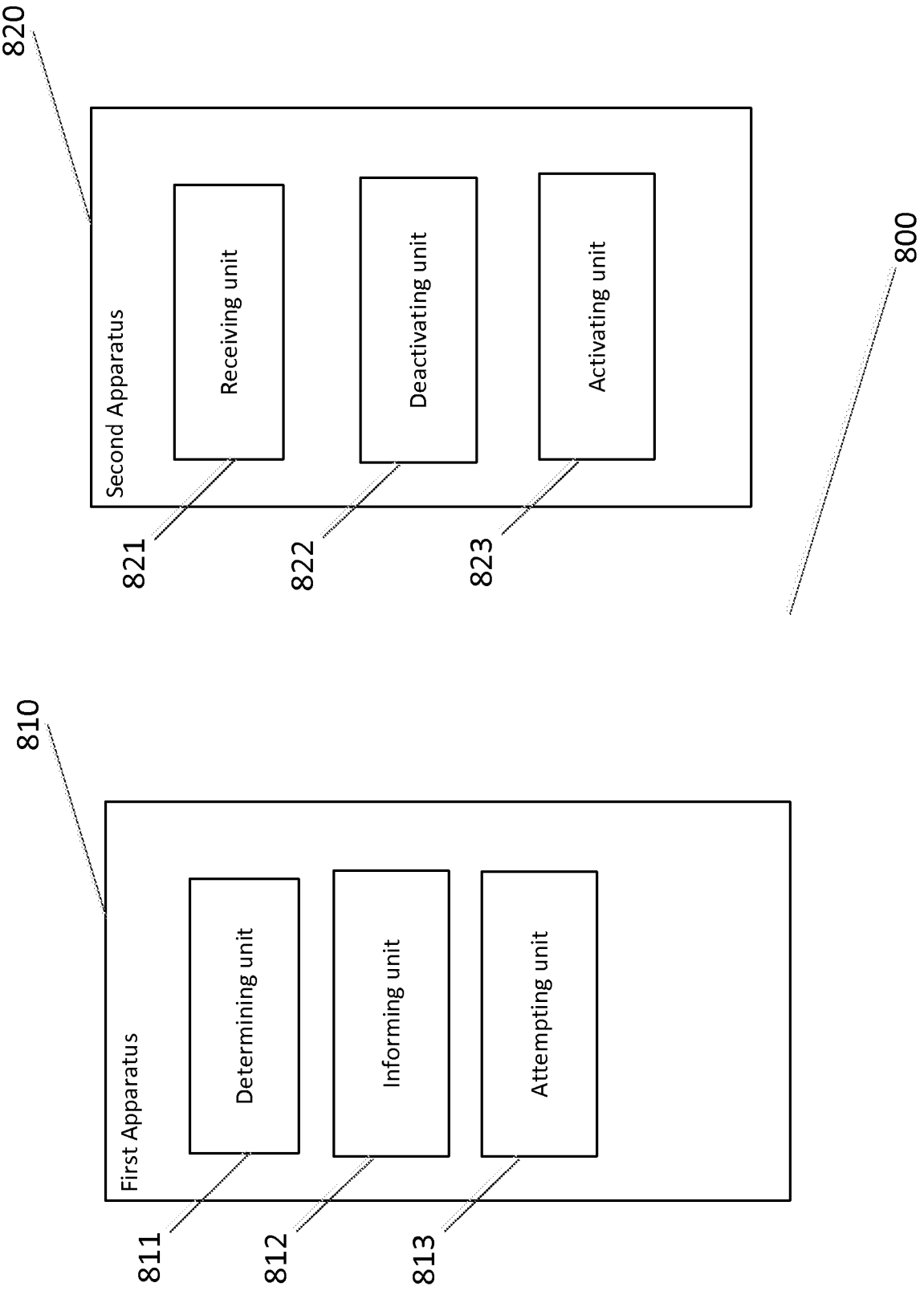
820
Second Apparatus
Receiving unit
Deactivating unit
Activating unit
821
822
823
800
810
First Apparatus
Determining unit
Informing unit
Attempting unit
811
812
813

Fig. 8

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US15/17809

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - H04L 12/26; H04W 4/06, 52/02 (2015.01)
CPC - H04L11/812; H04W 52/02, 52/0209
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)
IPC(8)-H04L 12/26; H04W 4/06, 52/02 (2015.01)
CPC-H04L11/812; H04W 52/02, 52/0209

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
PatSeer (US, EP, WO, JP, DE, GB, CN, FR, KR, ES, AU, IN, CA, INPADOC Data); Google Scholar/ Google Patents; IEEE.org; IP.com; discontinuous reception cycle, DRX, power sav*, switch, mobile, mode

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X -- Y	US 2012/0188922 A1 (LE, Y et al.) July 26, 2012, paragraphs [0050]-[0051], [0055], [0060]-[0072], [0076]-[0079]	1, 3/1, 6, 8/6, 11-12, 14/12, 17, 19/17, and 22 --- 2, 3/2, 7, 8/7, 13, 14/13, 18, and 19/18
Y	US 2015/0029920 A1 (HOEHNE, H. et al.) January 29, 2015, paragraph [0083]	2, 3/2, 7, 8/7, 13, 14/13, 18, and 19/18

☐ 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
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
12 May 2015 (12.05.2015)	09 JUN 2015
Name and mailing address of the ISA/ Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-8300	Authorized officer Shane Thomas PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US15/17809

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☒ Claims Nos.: 4, 5, 9, 10, 15, 16, 20, and 21
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.