Title: A METHOD OF STATE CONTROL OF NON-ACCESS STRATUM IN WIRELESS NETWORK

Abstract: Current UEs need to perform periodic tracking area update, thus generating more signaling overhead and power consumption. For solving the problem, the invention proposes a method of state control of non-access stratum. Wherein the UE is governed by a connection and mobility management device as an access network. The non-access stratum in UE can be in a sleep state in which the UE cuts off the connection with the access network, stops periodic tracking area update procedures, detects and manages signaling messages. The non-access stratum of the management device cuts off the connection with the access network, and stops mobile reachability of the UE, stores MM context of the UE, acquires the location of the UE in the TA resolution, and reserves paging resources for the UE. The invention reduces the signaling overhead and power consumption of UEs, especially the MTC UEs.
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A method of state control of non-access stratum in wireless network

**Technology field**
The invention relates to the field of wireless communication, specially to optimization of non-access stratum in wireless communication.

**background of the art**
The UEs of machine type communication are introduced in current 3GPP network. The UEs have some distinctive features compared with ordinary user equipments. E.g. the MTC UEs comprise auto-vending machines, smart metering devices and city automation devices. The MTC UEs can communicate with the device managing the MTC UEs via wireless network, in order to exchange information such as inventory and measurement result etc. Due to their usage, the MTC UEs are generally stationary or move only in a certain area for a very long time, even for its whole life.
The connection management and mobility management in wireless network are divided into different layers, i.e. access stratum layer and non-access stratum layer. In access stratum layer, the patent with application number PCT/CN2010/000206 proposes a new RRC sleep state which can save the power consumption of user equipment, especially the power consumption of low or no mobility MTC UEs. But in non-access stratum layer there is not an energy-saving scheme for user equipment, especially the MTC UEs. The following is the brief description of mobility management for the MTC UEs in current non-access stratum layer.
Taking the LTE standard as an example, the connection management
and mobility management in non-access stratum layer is accomplished by the MME (Mobility Management Entity) which is a network element of core network. The user equipment in EMM-registered state and in ECM-idle state need to proceed periodic tracking area update, which is called tracking area update procedure in LTE system. Wherein EMM represents the EPS (Evolution Packet System) mobility management and ECM represents the EPS connection management. The periodic tracking area update is performed by a periodic RA update timer of the user equipment. And the MME operates a mobile reachability timer, with similar values as the periodic RA update timer of the user equipment. If the timer expires and the update from the user equipment is not received, the MME concludes the user equipment is not in the coverage currently. Then the MME clears the maintained paging procedure flag (PPF) of the user equipment. After clearing the PPF, the MME doesn't paging the user equipment when receiving from server gateway the paging triggering message, whose destination is the user equipment.

Currently the ECM model of user equipments in LTE system is illustrated in fig.1. Wherein user equipments transfer between the ECM-idle state and the ECM-connected state, and the condition of transfer is the setting up and release of RRC connection (the control connection of wireless resources: the connection between user equipments and the access network NE i.e. base station eNB). The ECM model of the MME in LTE system is illustrated in fig.2. Wherein the MME transfers between the ECM-idle state and the ECM-connected state and the condition of transfer is the setting up and release of SI connection (the connection between the access network NE i.e. base station eNB and the core network NE i.e. MME). The PMM (Packet Mobility Management) model of user equipments in
WCDMA system is illustrated in fig. 3. Wherein user equipments transfer among the PMM-idle state, the PMM-connected state and the PMM-detached state, and the condition of transfer is illustrated in fig. 3, wherein PS represents packet switch. The PMM model of the core network NE i.e. SGSN (Serve GPRS Supported Node) in WCDMA system is illustrated in fig. 4. Wherein the SGSN transfers among the PMM-idle state, the PMM-connected state and the PMM-detached state, and the condition of transfer is illustrated in fig. 4, wherein PS represents packet switch. Similarly, the WCDMA standard also defines the periodic tracking area update procedure which is called as routing area update procedure in the PS field of WCDMA system.

It can clearly be seen that, on the one hand, the above mobility management needs the MTC UEs to proceed periodic tracking area update, which generates more signaling overhead, needs power consumption and reduces the battery life. So the activity of user equipments currently defined in 3GPP may be optimized to save power. On the other hand, in order to ensure the network can still communicate with the MTC UEs, the MTC UEs need to be in reachable state from the side of network.

So the core network operations currently defined in 3GPP need be optimized, so as to avoid losing the MTC UEs. Further, after the operations of mobility management in non-access stratum layer are optimized, the model of mobility management and connection management in user equipments (MTC UEs) and the core network NE needs to be updated correspondingly in order to be merged to the detailed interoperable solution better supporting mobility management between access stratum layer and non-access stratum layer. In detail the ECM model of user equipments and the MME needs
to be optimized for the LTE system. The PMM model of user equipments and the SGSN needs to be optimized for the WCDMA system.

**Summary of the Invention**

It can be seen that, the control scheme in non-access stratum layer that can save signaling overhead and power is very preferable. And the control scheme can preferably keep the UEs in reachable state.

According to one aspect of the invention, a method of state control of non-access stratum is proposed in UE which is governed by a connection and mobility management device via an access network. The non-access stratum in UE can be in a sleep state in which the UE cuts off the connection with the access network, stops periodic tracking area update procedure, and detects paging messages. In this aspect, the UE doesn't proceed periodic tracking area update, thereby saving signaling overhead and reducing power consumption. And the UE still detects paging message to keep in reachable state and can communicate directly with the network without the procedure of attaching to the network again.

According to one preferable embodiment, the non-access stratum in UE can also be in an idle state or a connected state, wherein, in the idle state the UE performs periodic tracking area update procedure; in the connected state there is signaling connection between the UE and the management device; the non-access stratum in UE can transfer between the sleep state and the idle state, and/or between the sleep state and the connected state. In the embodiment, the sleep state is incorporated into the current control of non-access stratum in UE, and inter-transfers between current idle state and connected state to improve the flexibility of non-access stratum in UE.
According to a further preferable embodiment, the non-access stratum in UE is in the idle state, and the non-access stratum in UE transfers from the idle state into the sleep state and stops the periodic RA update timer when any of the following conditions happens: the access stratum in UE enters into the sleep state; being configured by the network to stop periodic tracking area update procedure.

In the embodiment, the non-access stratum in UE transfers from the idle state into the sleep state is triggered by the access stratum entering into the sleep state, which is in accordance with the logical structure between the non-access stratum and the access stratum and strengthens inter-operation between the two layers; or is triggered by being configured by the network to stop periodic tracking area update procedure, which is in accordance with the network's need.

According to a further preferable embodiment, the non-access stratum in UE is in the sleep state, the non-access stratum in UE transfers from the sleep state into the idle state and starts the periodic RA update timer when any of the following conditions happens: the access stratum in UE transfers from the sleep state into the idle state; being configured by the network to stop periodic tracking area update procedure; and the non-access stratum in UE transfers from the sleep state into the connected state when any of the following conditions happens: The connection with access network is set up.

In the embodiment the non-access stratum in UE transfers from the sleep state into the idle state is triggered by access stratum transferring from the sleep state into the idle state, which is in accordance with the logical structure between the non-access
stratum and the access stratum and strengthens inter-operation between two layers; Or triggered by being configured by the network to stop periodic tracking area update procedure, which is in accordance with the network's need. The non-access stratum in UE may directly transfer from the sleep state into the connected state without taking the idle state as an intermediate state, after the connection in the access stratum is set up, in order to save the time of setting up the connection in the non-access stratum, which is benefit to e.g. urgent communication.

According to a further preferable embodiment, the non-access stratum in UE is in the connected state, the non-access stratum in UE returns back from the connected state to the latest state before transferring into the connected state when any of the following conditions is happened: The connection with the access network is released.

Due to the connected-state is used as a temporal state of traffic data or signaling transmission, and the access stratum needs to return to other more stable states after finishing transfer and releasing the connection, the embodiment proposes a scheme for returning to other states.

According to a further preferable embodiment, the non-access stratum in UE is aware of the state change of the access stratum in UE by primitive.

In the embodiment it has little time and low overhead for the non-access stratum in UE is aware of the state change of the access stratum by primitive.

According to a preferable embodiment, the UE comprises no or low mobility UE with capability of machine type communication. The connection and mobility management devices comprise MME based on
LTE network or SGSN based on WCDMA network.
For low or no mobility MTC UE, the area in which it's located generally is invariable and the periodic tracking area update procedure is little useful for it. So the invention is especially suitable for the MTC UEs. And the invention may be suitable for GSM, WCDMA and LTE system of current 3GPP. Not limited to this, e.g. it's equally suitable for 3GPP2 cdma2000 system and its enhanced system. So it has good applicability.

Correspondingly, according to the other aspect of the invention a method of state control of non-access stratum, in connection and mobility management devices is proposed, and a UE is governed by the management devices via an access network; the non-access stratum of the management device can be in a sleep state in which the management device cuts off the connection with the access network, stops detecting mobile reachability of the UE, stores MM context of the UE, acquires the location of the UE in the T.A resolution, and reserves paging resources for the UE.

In this respect, the connection and mobility management devices can also be in the sleep state and don't need to keep detecting the mobile reachability of the UE to save processing resources. And since paging resources are reserved for the UE and send paging message to the UE is allowed, it ensures the reachability from management devices to the UE.

According to a preferable embodiment, the non-access stratum in the management device can also be in an idle state or a connected state. Wherein, in the idle state the management device performs reachability detection for the UE; In the connected state there is signaling connection between the UE and the management device; the non-access stratum in the management device can transfer between
the sleep state and the idle state, and/or between the sleep state and the connected state.

In the embodiment, the sleep state is incorporated into the current control of non-access stratum in the connection and mobility management devices and inter-transfers between current idle state and connected state to improve the flexibility of non-access stratum in UE.

According to a further preferable embodiment, the non-access stratum in management device is in the idle state, the non-access stratum in management device transfers from the idle state into the sleep state and stops the mobile reachable timer for the UE when any of the following conditions happens: The management device confirms that the UE is in no or low mobility status and the mobile reachable timer expires for the UE; being configured by the network to stop detecting mobile reachability for the UE.

The above and other features in the invention will be clearly described in the following examples.

Brief description of the drawings

Objects, features, and advantages of the present invention will become apparent upon reading the following description in conjunction with the drawing figures, in which:

Fig. 1 is the current ECM model of user equipments in LTE.
Fig. 2 is the current ECM model of the MME in LTE.
Fig. 3 is the current PMM model of user equipments in WCDMA.
Fig. 4 is the current PMM model of SFSN in WCDMA.
Fig. 5 is the ECM model of user equipments in LTE according to one embodiment of the invention.
Fig. 6 is the ECM model of the MME in LTE according to one embodiment.
of the invention.

Fig. 7 is one ECM state transfer diagram during the operational process of the LTE system according to one embodiment of the invention.

Fig. 8 is the other ECM state transfer diagram during the operational process of the LTE system according to one embodiment of the invention.

Fig. 9 is the PMM model of user equipments in WCDMA according to one embodiment of the invention.

Fig. 10 is the PMM model of SGSN in WCDMA according to one embodiment of the invention.

Fig. 11 is one PMM state transfer diagram during the operational process of the WCDMA system according to one embodiment of the invention.

Detailed description of the embodiments

In the invention, it proposes the solution of optimization of connection and mobility management in non-access stratum. Wherein new activities of user equipments and new operations of the core network devices are defined, and the user equipments, especially the MTC UEs with low or no mobility are allowed to be in the sleep state to save signaling overhead and power. For user equipments, its main concept is:

- For the LTE system, if in the sleep state, it doesn't proceed periodic tracking area update;
- For the WCDMA system, if in the sleep state, it doesn't proceed periodic routing area update;
- It provides better inter operation of connection and mobility management between access stratum and non-access stratum.
Based on the current requirement of the MTC phase 1, the MTC features may be configured and controlled by subscription, wherein the MTC features comprise low or no mobility. Part or all of the configured features may be based on the strategy of the operator and defaulted to be activated when subscribing (made enable). The following are embodiments which respectively describe in detail the application of the invention in LTE and WCDMA standard.

**Embodiment 1 (LTE standard)**

A new state is proposed in the embodiment and it's introduced in the current state model of connection management in LTE. It's called as ECM-sleep state which provides the sleep state for the MME and user equipments, especially the MTC UEs to save power and optimize signaling overhead. Simultaneously the sleep state is introduced into both the user equipments (UEs) and the MME. The following is the description of the two schemes.

When in the sleep state, as to the UE:

- No RRC connection with access network NE i.e. eNB;
- Detect paging message;
- Acquire the location of the UE by the network via tracking area resolution;
- Stop the periodic RA update timer and not proceed periodic tracking area update.

Combined with the current state model of connection management in LTE, the current ECM model of UEs comprises three state: ECM-sleep state, ECM-idle state and ECM-connected state as illustrated in fig. 5. Wherein, in the idle state the UE proceeds periodic tracking area update; in the connected state there is the signaling connection between the MME and the UE which comprises RRC and SI connections. And the UE transfers between the two states according to whether RRC
connection is set up or released. This is similar with current activity of UEs in the two states. And it is not concerned by the invention and will not be described again. The following will mainly describe non-access stratum in the UE’s transferring between ECM-sleep state and ECM-idle state, and between ECM-sleep state and ECM-idle state. It may be understood that the UE should be in the EMM-registered state, i.e. registered in the MME.

**ECM-idle state**

In case that the non-access stratum in UE is in the ECM-idle state, the non-access stratum in UE transfers into the ECM-sleep state and stops the periodic tracking area update timer when any of the following conditions happens:

- The non-access stratum knows the access stratum enters into the RRC-sleep state via the notice of the access stratum. Preferably, the non-access stratum is aware of the state change of the access stratum by primitive.
- The UE stops the periodic tracking area update procedure due to receiving the configuration from the network. The configuration may be from any non-access stratum message sent from the MME to the inUE. E.g. the message is the Ack message of the tracking area update, which is the response to the tracking area update request message from the UE. It will be further described in the following embodiment.

**ECM-sleep state**

In case that the non-access stratum in UE is in the ECM-sleep state, the non-access stratum in UE transfers into the ECM-idle state and starts the periodic RA update timer when any of the following conditions happens:
• The non-access stratum knows the access stratum enters into the RRC-sleep state via the notice of the access stratum. Preferably the non-access stratum is aware of the state change of the access stratum by primitive.

• The UE receives the configuration from the network, instructing it to start the periodic tracking area update procedure. Otherwise, the non-access stratum in UE transfers into the ECM-connected state when any of the following conditions happens:
  • The RRC connection of the access stratum in UE is set up. One example of the condition is: needing to send urgent signaling or data. Then the non-access stratum directly transfers from the ECM-sleep state into the ECM-connected state, not passing the ECM-idle state, thus saving the time of ECM connection establishment.

ECM-connected state
In case that the non-access stratum in UE is in the ECM-connected state, the non-access stratum in UE returns to the latest state of the non-access stratum before transferring into the ECM-connected state, when any of the following conditions is happened:
- The RRC connection between the UE and the access network is released.

When in the sleep state, as to the MME:
  • There's no SI connection with the access network NEs i.e. eNBs for the UE;
  • The paging resource is saved for the UE, enabling triggering the paging message sent to the UE in related coverage of the access network, when receiving from the superior NE the paging message whose destination is the UE.
  • Stores MM context of the UE, acquires the location of the
UE in the TA resolution.

- Stops the mobile reachable timer and not expect to proceed periodic tracking area update with the UE.

After combined with the current state model of connection management in LTE, the current ECM model comprises three states: ECM-sleep state, ECM-IDLE state and ECM-connected state as illustrated in fig.6. Wherein, in the idle state, the MME detects reachability of the UE and expects the periodic tracking area update procedure from the UE; in the connected state, the signaling connection between the MME and the UE comprises RRC and SI connection. And the MME transfers between the two states based on whether the SI connection is set up or released. This is similar with the activity of current MME in the two states. And it's not mainly concerned by the invention, thus is not described again. The following mainly describes that the non-access stratum in the MME transfers between the ECM-sleep state and the ECM-idle state, and between the ECM-sleep state and the ECM-connected state.

**ECM-idle state**

In case that the non-access stratum in the MME is in the ECM-idle state, the non-access stratum in the MME transfers into the ECM-sleep state and stops the mobile reachable timer for the UE when any of the following conditions happens:

- Determining that the UE is in no or low mobility status and the mobile reachable timer expires for the UE. In detail, the determining process can be: the UE may activate the no or low mobility status and informs the MME on its own, or the network configures at the MME that the UE is in the no or low mobility status.
- It's configured by the network to stop the mobile
reachability detect for the UE. E.g., when the network is overloaded or jammed, it configures to stop the periodic tracking area update procedure of the UE.

**ECM-sleep state**

In case that the non-access stratum in the MME is in the ECM-sleep state, the non-access stratum in the MME transfers into the ECM-idle state and starts the mobile reachable timer for the UE when any of the following conditions happens:

- Determining that the UE is not in no or low mobility status. E.g. the situation happens when the UE recovers the mobile capability. In detail, the determining process is: the UE may activate the no or low mobility status and informs the MME on its own, or the network configures in the MME that the UE is not in no or low mobility status.
- It's configured by the network to restart the mobile reachability detect for the UE.

The non-access stratum in the MME transfers into the ECM-connected state when any of the following conditions happens:

- The SI connection with the access network NE i.e. eNB for the UE is set up.

**ECM-connected state**

In case that the non-access stratum in the MME is in the ECM-connected state, the non-access stratum in the MME returns to the latest state before transferring to the ECM-connected state when any of the following conditions is happened:

- The SI connection with the access network NE i.e. eNB for the UE is released.

The above describes the features of the sleep state of the UE and the MME, and the transfer with other states. Generally, the states
transfer is triggered by the self-activity of devices or the network configuration. The above citations are just some examples and the invention isn't limited to those.

The following will describe more detailed examples to elucidate the states transfer in operational process of the LTE system.

Fig. 7 illustrates an example. Wherein, the MTC UE is deployed in the LTE system. The MTC UE is configured as low or no mobility and transmits the uplink data after being paged. The interaction process between the MME and the MTC UE is illustrated as fig. 7. The following describes each step and the caused states change of the non-access stratum. Wherein, the white dots represent the ECM-idle state, the black dots represent the ECM-connected state, and the mesh dots represent the ECM-sleep state.

• The power up MTC UE proceeds the attaching process with the MME, and enters into the EMM-registered state and the ECM-idle state after finishing the attaching process.

• Due to not receiving the downlink signaling and not expecting to send the uplink data to the network, the RRC layer of the MTC UE decides to enter into the RRC sleep state to save power. The detail of the technology may be referred to the patent application with the application number with PCT/CN2010/000206.

• The non-access stratum of the MTC UE enters into the ECM-sleep state following the RRC entering into the sleep state, and the MTC UE stops periodic tracking area update timer.

• In the MME, when the MME detects the mobile reachability timer expires for the MTC UE, the non-access stratum in the MME enters into the ECM-sleep state and stops the mobile reachability timer for the MTC UE.
After some time, the MME receives the signaling from the upper layer and sends the paging message to the MTC UE via eNB. The paging message is attached with the cause: call set up. The paging message is sent to all the eNB within the tracking area of the MTC UE. The detail paging method is known by those skilled in the art and isn't described in the invention.

The MTC UE which detects the paging message confirms to respond to the paging message to the network. Then it starts the process of non-access stratum connection establishment with the MME. In the process:

♦ The non-access stratum should inform the access stratum to begin the process of the RRC connection establishment between the MTC UE and eNB. Thus the RRC stratum will transfer from the sleep state into the idle state firstly. Then the non-access stratum transfers into the ECM-idle state in response to the RRC transferring into the idle state.

♦ The process of the RRC connection establishment between the MTC UE and eNB keeps going until the RRC connection establishment is finished. The non-access stratum transfers from the ECM-idle state further into the ECM-connected state in response to the RRC connection establishment.

♦ And the SI connection is set up between the eNB and the MME. The MME will transfer from the ECM-sleep state into the ECM-connected state when detecting the SI connection establishment is finished.

♦ The MTC UE will send the service request message to the MME after the non-access stratum connection with in the MME is
established. The call type carried by the message is terminating call.

- The MME feeds back the service accept message to the MTC UE. Then the data transmission connection between the MTC UE and the network is successfully set up.
- The MTC UE sends the uplink data to the network.
- The access stratum connection between the network and the MTC UE will be released after the data transmission finished. Wherein it comprises the RRC connection between the MTC UE with the eNB and the SI connection between the eNB and the MME. The MME returns back the last state i.e. ECM-sleep state, and the MTC UE returns back the last state i.e. ECM-idle state.
- Due to not receiving the downlink signaling and not expecting to send the uplink data to the network, the RRC layer in the MTC UE decides to enter into the RRC-sleep state. Accordingly, the non-access stratum in the MTC UE enters into the ECM-sleep state and stops the period tracking area update timer.

Another example is illustrated in fig. 8. Wherein, the MTC UE is deployed in the LTE system. The MTC UE hasn't been configured as low or no mobility and will send the uplink data after some time expires. The interaction process between the MME and the MTC UE is illustrated in fig. 8. The following describes each step and the caused states change of the non-access stratum. Wherein, the white dots represent the ECM-idle state, the black dots represent the ECM-connected state, and the mesh dots represent the ECM-sleep state.

- The power up MTC UE proceeds attaching process with the MME, and enters into the EMM-registered state and the ECM-idle state after finishing the attaching process.
The MTC UE proceeds the tracking area update with the MME, and it will send the TAU requirement to the MME.

- when the network is overloaded or jammed currently, it decides to stop the periodic tracking area update procedure of the MTC UE.
- The MME sends the TAU confirm message to the MTC UE and configures the MTC UE to stop the periodic tracking area update timer in the ACK message of the tracking area update.
- The non-access stratum in the MME enters into the ECM-sleep state after receiving the finish message of the tracking area update of the MTC UE, and stops the mobile reachability timer of the MTC UE.
- Due to the MTC UE receives the ACK message of the tracking area update from the network and the message configures the MTC UE to stop the periodic tracking area update timer, the non-access stratum in the MTC UE enters into the ECM-sleep state and stops the periodic tracking area update timer.
- After some time expires, e.g. the uplink data transmission timer expires, the MTC UE needs to transmit the uplink data. It starts the process of the non-access stratum connection establishment with in the MME. In the process:
  - The non-access stratum should inform the access stratum to begin the process of RRC connection establishment with the base station. Thus, firstly the RRC layer transfers from the RRC-sleep state into the RRC-idle state. Then the non-access stratum transfers into the ECM-idle state in response to the RRC transferring into the RRC-idle state.
  - The process of the RRC connection establishment between
the MTC UE and eNB keeps going until the RRC connection establishment is finished. The non-access stratum transfers from the ECM-idle state further into the ECM-connected state in response to the RRC connection establishment.

- And the SI connection is set up between the eNB and the MME. The MME will transfer from the ECM-sleep state into the ECM-connected state when detecting the SI connection establishment is finished.

- The MTC UE will send the service request message to the MME after the connection establishment with the non-access stratum in the MME is finished. The call type carried by the message is originating call.

- The MME feeds back the service accept message to the MTC UE after receiving the service request message. Then the data transmission connection between the MTC UE and the network is successfully set up.

- The MTC UE sends the uplink data to the network.

- The access stratum connection between the network and the MTC UE will be released after the data transmission finished. Wherein it comprises the RRC connection between the MTC UE with the eNB and the SI connection between the eNB and the MME. The MME returns back the last state i.e. ECM-sleep state, the MTC UE returns back the last state i.e. ECM-idle state.

- Due to not receiving the downlink signaling and not expecting to send the uplink data to the network, the RRC layer in the MTC UE decides to enter into the RRC-sleep state. Accordingly, the non-access stratum in the MTC UE enters into the ECM-sleep state and stops the period tracking area.
update timer.
The above describes in detail the application of the invention in the LTE system. The following will describe the application of the invention in the WCDMA system.

Embodiment 2 (WCDMA standard)
A new state is proposed in the embodiment, and it's introduced in the current state model of connection management in WCDMA. It's called as PMM-sleep state which provides the sleep state for the SGSN and user equipments, especially the MTC UEs to save power and optimize signaling overhead. Simultaneously the sleep state is introduced to both the user equipments (UEs) and the SGSN. The following is the description of the two schemes.

When in the sleep state, as to the UE:
- No RRC connection with the access network;
- Detect paging message;
- Acquire the location of the UE by the network via tracking area resolution;
- Stop the periodic RA update timer and not proceed periodic tracking area update.

After combined with current state model of connection management in WCDMA, the current PMM model of user equipments comprises four state: PMM-sleep state, PMM-idle state, PMM-connected state and PMM-detached state, as illustrated in fig. 9. Wherein, in the idle state the UE proceeds periodic routing area update; in the connected state there is the signaling connections between the SGSN and the UE which comprises RRC and Iu connections; in the detached state the UE and the network are detached. The activity of the UE in the three states and conditions of the states transfer thereamong are similar with current technology. And it is not mainly concerned by the invention and will not be
described again. The following will mainly describe non-access stratum in the UE transferring between PMM-sleep state and PMM-idle state, and between PMM-sleep state and PMM-connected state.

**PMM-idle state**

In case that the non-access stratum in UE is in the PMM-idle state, the non-access stratum in UE transfers into the PMM-sleep state and stops the periodic tracking area update timer when any of the following conditions happens:

- The non-access stratum knows the access stratum enters into the RRC-sleep state via the notice of the access stratum. Preferably the non-access stratum is aware of the state change of the access stratum by primitive.
- The UE receives the configuration from the network to stop the periodic tracking area update. The configuration may be from any non-access stratum message sent from the SGSN to the in UE.

**PMM-sleep state**

In case that the non-access stratum in UE is in the PMM-sleep state, the non-access stratum in UE transfers into the PMM-idle state and starts the periodic RA update timer when any of the following conditions happens:

- The non-access stratum knows the access stratum transfers from the RRC-sleep state into the RRC-sleep state via the notice of the access stratum. Preferably the non-access stratum is aware of the state change of the access stratum by primitive.
- The UE receives the configuration of the network to start the periodic routing area update.

Otherwise, the non-access stratum in UE transfers into the
PMM-connected state when any of the following conditions happens:

- The RRC connection of the access stratum in UE is set up. One example of the condition is the needing to send urgent signaling or data. Then the non-access stratum directly transfers from the PMM-sleep state into the PMM-connected state, not passing the PMM-idle state, thus saving the time of PMM connection establishment.

**PMM-connected state**

In case that the non-access stratum in UE is in the PMM-connected state, the non-access stratum in UE returns to the latest state before transferring to the PMM-connected state when any of the following conditions is happened:

- The RRC connection between the UE and the access network is released.

When in the sleep state, as to the SGSN:

- There's no Iu connection with the access network NE i.e. radio network controller (RNC) for the UE;
- The paging resource is saved for the UE, thus enabling triggering the paging message sent to the UE in related coverage of the access network when receiving from the superior NE the paging message whose destination is the UE.
- Stores MM context of the UE, acquires the location of the UE in the TA resolution.
- Stops the mobile reachable timer and not expect to proceed periodic tracking area update with the UE.

After combined with current state model of connection management in WCDMA, the current PMM model comprises four states: PMM-sleep state, PMM-idle state, PMM-connected state and PMM-detached state as
illustrated in fig. 10. Wherein, in the idle state the SGSN detects the reachability of the UE and expects the periodic routing area update procedure from the UE; in the connected state there is the signaling connection between the SGSN and the UE which comprises RRC and Iu connections; in the detached state the SGSN and the UE are detached. The activity of the SGSN in the three states and conditions of the states transfer are similar with current technology. And it is not mainly concerned by the invention and will not be described again. The following will mainly describe non-access stratum in the SGSN transferring between PMM-sleep state and PMM-idle state, and between PMM-sleep state and PMM-connected state.

**PMM-idle state**

In case that the non-access stratum in SGSN is in the PMM-idle state, the non-access stratum in SGSN transfers into the PMM-sleep state and stops the periodic reachability timer when any of the following conditions happens:

- Determining the UE in no or low mobility status and the mobile reachability timer for the UE expires. In detail, the determining process is: the UE may activate the no or low mobility status and informs the SGSN on its own, or the network configures in the SGSN the UE to be in no or low mobility status.
- It's configured by the network to stop the mobile reachability detect for the UE. E.g. when the network is overloaded or jammed, the network configures to stop the periodic routing area update procedure of the UE, and the SGSN is configured to stop the mobile reachability timer for the UE.

**PMM-sleep state**

In case that the non-access stratum in SGSN is in the PMM-sleep
state, the non-access stratum in SGSN transfers into the PMM-idle state and starts the mobility reachability timer when any of the following conditions happens:

- Determining the UE in no or low mobility status. E.g. the situation happens when the UE recovers the mobile capability. In detail, the determining process is: the UE may cancel the no or low mobility status and informs the SGSN on its own, or the network configures in the SGSN the UE not in the no or low mobility status.
- It's configured by the network to start the mobile reachability detect for the UE.

The non-access stratum in SGSN transfers into the PMM-connected state when any of the following conditions happens:

- The Iu connection with the access network NE i.e. RNC for the UE is set up.

**PMM-connected state**

In case that the non-access stratum in SGSN is in the PMM-connected state, the non-access stratum in SGSN returns the latest state before transferring into the PMM-connected state when any of the following conditions is happened:

- The Iu connection with the access network i.e. RNC for the UE is released.

The above describes the features of the sleep state of the UE and the SGSN, and transfer with other states. Generally the states transfer is triggered by the self-activity of devices or the network configuration. The above citations are just some examples. The invention isn't limited to those.

The following will describe the states transfer in the operational process of WCDMA system with more detailed examples. Wherein, the
MTC UE is deployed in the WCDMA system. The MTC UE is configured low or no mobility. The interaction process between the SGSN and the MMC UE is illustrated as fig. 11. The following describes each step and the caused states change of the non-access stratum. Wherein, the white dots represent the PMM-idle state, the black dots represent the PMM-connected state, and the mesh dots represent the PMM-sleep state.

- The power up MTC UE proceeds the attaching process with the SGSN, and enters into the PMM-idle state after finishing the attaching process.
- Due to not receiving the downlink signaling and not expecting to send the uplink data to the network, the RRC layer of the MTC UE decides to enter the RRC-sleep state to save power. The detail of the technology may be referred to the patent application with the application number with PCT/CN2010/000206.
- The non-access stratum of the MTC UE enters into the PMM-sleep state following the RRC entering into the sleep state, and the MTC UE stops periodic routing area update timer.
- In the SGSN, when the SGSN detects the mobile reachability timer expires for the MTC UE, the non-access stratum in the SGSN enters into the PMM-sleep state and stops the mobile reachability timer for the MTC UE.
- After some time, the SGSN receives the signaling from the upper layer and sends the paging message to the MTC UE via RNC. The paging message is attached with the cause: urgent report. The paging message is sent to all the RNC within the routing area of the MTC UE.
- The MTC UE which detects the paging message confirms to respond to the paging message to the network. Then it starts the process
of the non-access stratum connection establishment with the SGSN. In the process:

♦ The non-access stratum should inform the access stratum to begin the process of the RRC connection establishment with the access network. And the non-access stratum finds the paging message is the urgent report. Then the non-access stratum transfers directly from the PMM-sleep state into the PMM-connected state after the RRC connection establishment finishing.

♦ After the RRC connection establishment, the non-access stratum transfers from the PMM-idle state further into the PMM-connected state in response to the RRC connection establishment finishing.

♦ And the Iu connection is set up between the access network and the SGSN. The SGSN will transfer from the PMM-sleep state into the PMM-connected state when detecting the Iu connection establishment is finished.

• The MTC UE will send the service request message to the SGSN after the connection establishment with the non-access stratum in the SGSN is finished. The paging type carried by the message is terminating call.

• The network will configure the SGSN to start the mobile reachability timer for the MTC UE and configure the MTC device to start the periodic routing area update timer. The SGSN feeds the service request message back to the MTC UE and configures the MTC UE to start the routing area update timer in the message.

• After the MTC UE receives the service accept message, it is aware of needing to recover the periodic routing area update procedure, via reading the indication to start the routing
area update timer. Concurrently the connection between the MTC UE and the network is successfully set up.

- The MTC UE sends the urgent report to the network.
- After the transmission of the urgent report, the access stratum connection between the network and the MTC UE is released. Wherein it comprises the RRC connection between the MTC UE and the access network and the Iu connection between the network and the SGSN.
- The SGSN returns to the last state i.e. the PMM-sleep state and the MTC UE returns to the last state i.e. the PMM-sleep state. It's to be noted that the SGSN and MTC UE will further return to the PMM-idle state due to that previously the network has been configured to start the mobile reachability timer of the SGSN and the routing area update timer of the MTC UE. Then the MTC UE will proceed periodic routing area update under the control of the periodic routing area update timer. For simplicity the process is not illustrated in the diagram.

The above embodiments are more suitable to the UEs with low or no mobility in wireless network since the UEs in the embodiments are in the sleep state to avoid participating the periodic tracking area update procedure and save the signaling overhead and power consumption used in the procedure. It's understood that the sleep state in the non-access stratum proposed by the invention is not limited to the UEs with low or no mobility and other UEs are suitable.

Those ordinary technicians of the technology field may understand and implement other changes to the embodiments disclosed by studying the instruction, open contents, diagrams and attached claims. In the claims the word "comprise" doesn't exclude other elements and steps and "one" doesn't exclude plural. In the practical application one
part may implement multiple functions with technical feature cited by the claims. The diagram marks in the claims shouldn't be understood as the limitation to the scope.
What is claimed is:

1. A method of state control of non-access stratum, in UE which is governed by a connection and mobility management device via an access network,

   The non-access stratum in UE can be in a sleep state in which the UE cuts off the connection with the access network, stops periodic tracking area update procedure, and detects paging messages.

2. A method according to claim1, wherein the non-access stratum in UE can be in an idle state or a connected state,

   Wherein, in the idle state the UE performs periodic tracking area update procedure; in the connected state there is signaling connection between the UE and the management device;

   The non-access stratum in UE can transfer between the sleep state and the idle state, and/or between the sleep state and the connected state.

3. A method according to claim2, wherein, in case that the non-access stratum in UE is in the idle state, the non-access stratum in UE transfers from the idle state into the sleep state and stops the periodic RA update timer when any of the following conditions happens:

   - the access stratum in UE enters into the sleep state;
   - being configured by the network to stop periodic tracking area update procedure.

4. A method according to claim2, wherein, in case that the non-access stratum in UE is in the sleep state, the non-access stratum in UE transfers from the sleep state into the idle state and starts the periodic RA update timer when any of the following conditions happens:
- the access stratum in UE transfers from the sleep state into the idle state;
- being configured by the network to stop periodic tracking area update procedure;

5  and the non-access stratum in UE transfers from the sleep state into the connected state when any of the following conditions happens:
- The connection with access network is set up.

5. A method according to claim 2, wherein, in case that the non-access stratum in UE is in the connected state, the non-access stratum in UE returns back from the connected state to the latest state before transferring into the connected state when any of the following conditions is happened:
- The connection with the access network is released.

6. A method according to claim 3 or 4, wherein the non-access stratum in UE is aware of the state change of the access stratum in UE by primitive.

7. A method according to claim 1, wherein the UE comprises no or low mobility UE with capability of machine type communication.

The connection and mobility management devices comprise MME based on LTE network or SGSN based on WCDMA network.

8. A method of state control of non-access stratum, in connection and mobility management devices, and a UE is governed by the management devices via an access network;

The non-access stratum of the management device can be in a sleep state in which the management device cuts off the connection with the access network, stops detecting mobile reachability of the UE, stores MM context of the UE, acquires the location of the UE in the TA resolution, and reserves paging resources for the UE.

9. A method according to claim 8, wherein the non-access stratum
in the management device can also be in an idle state or a connected state.

Wherein, in the idle state the management device performs reachability detection for the UE; In the connected state there is signaling connection between the UE and the management device; the non-access stratum in the management device can transfer between the sleep state and the idle state, and/or between the sleep state and the connected state.

10. A method according to claim9, wherein in case that the non-access stratum in management device is in the idle state, the non-access stratum in management device transfers from the idle state into the sleep state and stops the mobile reachable timer for the UE when any of the following conditions happens:

- The management device confirms that the UE is in no or low mobility status and the mobile reachable timer expires for the UE;
- being configured by the network to stop detecting mobile reachability for the UE.

11. A method according to claim9, wherein in case the non-access stratum in the management device is in the sleep state, the non-access stratum in the management device transfers from the sleep state into the idle state and starts the mobile reachable timer for the UE when any of the following condition happens;

- The management device confirms that the UE is not in no or low mobility status;
- being configured by the network to start detecting mobile reachability for the UE;

The non-access stratum in management device transfers into the connected state when any of the following conditions happens:

- The connection with access network is set up.
12. A method according to claim 9, wherein in case that the non-access stratum in management device is in the connected state, the non-access stratum in management device returns back from the connected state to the latest state before transferring into the connected state when any of the following conditions happens:
- The connection with access network is released.

13. A method according to claim 9, wherein the connection and mobility management devices comprise MME based on LTE network or SGSN based on WCDMA network;
The UE comprises no or low mobility UE with capability of machine type communication.
Fig. 6

- ECM-IDLE to ECM-CONNECTED: S1 connection released
- ECM-CONNECTED to ECM-SLEEP: S1 connection established
- ECM-SLEEP to ECM-IDLE: MTC device is deactivates with the no/low mobility feature
- ECM-SLEEP to ECM-CONNECTED: S1 connection released
- ECM-IDLE to ECM-SLEEP: Mobile reachable timer expires for no/low mobility feature or the NW configures to stop the timer
Fig. 8
Fig. 9

Fig. 10

Mobile reachable timer expires for no/low mobility feature or The NW configures to stop the timer
Fig. 11
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

See extra sheet

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: H04L; H04M; H04W

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)

WPI, EPODOC, CNPAT,CNKI: non w access, stratum, NAS, UE, control, state, sleep, idle, connected, awake, network, cut w off, periodic, update, paging w message, transfer, RR, CN

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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<th>Relevant to claim No.</th>
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<td>X</td>
<td>US2009/0074090A1 (SHARP LABORATORIES OF AMERICA, INC.) 19 Mar.2009 (19.03.2009) page 1 paragraph 3 to page 4 paragraph 55</td>
<td>1-2,5,7-9,12-13</td>
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<td>CN101459935A (ZTE CORP.) 17 Jun.2009(17.06.2009) the whole document</td>
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<td>CN101442812A (BEIJING T3G TECHNOLOGY CO., LTD.) 27 May 2009(27.05.2009) the whole document</td>
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Foreign language documents cited were translated into English. The citation refers to the translated text.

[ ] 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)
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  "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
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  "&"document member of the same patent family

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Form PCT/ISA /210 (second sheet) (July 2009)
Continuous of: CLASSIFICATION OF SUBJECT MATTER

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H04W76/04 (2009.01) i
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