

APPLICATION OF A DISCONTINUOUS RECEPTION (DRX) CYCLE

TECHNICAL FIELD

Embodiments of the present technology presented herein generally relate to radio
5 communication. More particularly, the embodiments presented herein generally relate
to the application, or utilization, of a discontinuous reception (DRX) cycle.

BACKGROUND

This section is intended to provide a background to the various embodiments of the
10 technology that are described in this disclosure. The description herein may include
concepts that could be pursued, but are not necessarily ones that have been previously
conceived or pursued. Therefore, unless otherwise indicated herein, what is described
in this section is not prior art to the description and/or claims of this disclosure and is
not admitted to be prior art by the mere inclusion in this section.

15 Radio communication networks are widely deployed to provide various communication
services such as telephony, video, data, messaging, broadcasts, and so on. Such
communication networks support communications for multiple user equipments (UEs)
by sharing the available network resources. One example of such a network is the
20 Universal Mobile Telecommunications System (UMTS), a third generation (3G) mobile
phone technology standardized by the 3rd Generation Partnership Project (3GPP).
UMTS includes a definition for a Radio Access Network (RAN), referred to as UMTS
Terrestrial Radio Access Network (UTRAN). The UMTS, which is the successor to
Global System for Mobile Communications (GSM) technologies, supports various air
25 interface standards, such as Wideband-Code Division Multiple Access (W-CDMA),
Time Division-Code Division Multiple Access (TD-CDMA), and Time Division-
Synchronous Code Division Multiple Access (TD-SCDMA). The UMTS also supports
enhanced 3G data communications protocols, such as High Speed Packet Access
(HSPA), which provides higher data transfer speeds and capacity to associated UMTS
30 networks. As the demand for mobile broadband access continues to increase, research
and development continue to advance the UMTS technologies not only to meet the
growing demand for mobile broadband access, but to advance and enhance the user
experience with mobile communications. For example, third-generation UMTS based
on W-CDMA has been deployed in many places the world. To ensure that this system

remains competitive in the future, 3GPP began a project to define the long-term evolution of UMTS cellular technology. The specifications related to this effort are formally known as Evolved UMTS Terrestrial Radio Access (E-UTRA) and Evolved UMTS Terrestrial Radio Access Network (E-UTRAN), but are more commonly referred to by the name Long Term Evolution (LTE). More detailed descriptions of radio communication networks and systems can be found in literature, such as in Technical Specifications published by, e.g., the 3GPP. The core network (CN) of the evolved network architecture is sometimes referred to as Evolved Packet Core (EPC) and when referring to a complete cellular system, including both radio access network and core network, as well as other possible entities, such as service related entities, the term Evolved Packet System (EPS) can be used.

As a mere background only, figure 1A illustrates an example 3GPP LTE radio communication system 100. Accordingly, fig 1A illustrates a radio access network in an LTE radio communication system 100. In this example, there are two radio network nodes 110a and 110b, each of which is exemplified as an evolved NodeB, eNB. A first eNB 110a is configured to serve one or several UEs, 120a-e, located within the eNB's 100a geographical area of service or the radio cell 130a. The eNB 110a is connectable to a CN. The eNB 110a is also connectable, e.g. via an X2 interface, to a neighboring eNB 110b configured to serve another cell 130b. Accordingly, the second eNB 110b is configured to serve one or several UEs, 120f-j, located within the eNB's 100b geographical area of service or the cell 130b. The eNB 110b is also connectable to a CN.

A currently popular vision of the future development of the communication in radio communication networks comprises huge numbers of small autonomous devices, which typically, more or less infrequently (e.g. once per week to once per minute) transmit and receive only small amounts of data (or are polled for data). These devices are not assumed to be associated with humans, but are rather sensors or actuators of different kinds, which communicate with application servers (which configure the devices and receive data from them) within or outside the cellular network. Hence, this type of communication is often referred to as machine-to-machine (M2M) communication and the devices may be denoted machine devices (MDs). In the 3GPP standardization, the corresponding alternative terms are machine type communication

(MTC) and machine type communication devices (MTC devices), with the latter being a subset of the more general term UE. More detailed descriptions of MTC communication can be found in literature, e.g., in the Technical Specification 3GPP TS 22.368 V.12.0.0.

5

With the nature of MTC devices and their assumed typical uses follow that these devices will often have to be energy efficient, since external power supplies will often not be available and since it is neither practically nor economically feasible to frequently replace or recharge their batteries. In some scenarios, the MTC devices may not even be battery powered, but may instead rely on energy harvesting, e.g. gathering energy from the environment, that is, utilizing (the often limited) energy that may be tapped from sun light, temperature gradients, vibrations, etc. For such energy deprived devices, whose traffic is characterized by relatively small and more or less infrequent transactions (often delay tolerant), it may be important to minimize their energy consumption, e.g. between and in conjunction with the communication events. These devices generally consume energy between the various communication events, e.g. by keeping the radio receiver active to monitor transmissions from the cellular network. Since the periods between the communication events are generally much longer than the actual communication events, this energy consumption may represent a significant part of the overall energy consumption and may even dominate the energy consumption in scenarios where the communication events are infrequent or very infrequent.

The inventors have realized that the actual uplink (UL) transmissions naturally consume significant amounts of energy during the communication events. This may be magnified by the relatively large control signaling overhead that may be associated with a certain communication event, especially since an infrequently communicating MTC device (or other UE) will generally go through the idle to connected mode transition prior to every communication event. Figure 1B shows a signaling diagram illustrating an example message sequence during the idle to connected mode transition in LTE. As can be seen, the signaling procedure involved during idle to connected mode transition for a UE may be relatively extensive.

25

30

A mechanism that has been introduced in radio communication networks in order to save energy in the UEs, e.g. between communication events, is discontinuous reception (DRX), which allows a UE to remain in an energy-saving sleep state most of the time, while waking up to listen for pages in idle mode DRX or downlink resource assignments (i.e. downlink transmissions) in connected mode DRX. Furthermore, in order to make the DRX mechanism even more effective for energy MTC devices, 3GPP is currently working on extending the maximum DRX cycle length, and thus the sleep period, both for idle mode DRX cycle and the connected mode DRX cycle. A DRX cycle thus essentially consists of a sleep period followed by an active period and this cycle is repeated over and over again until the device is detached from the network. Typically, but not necessarily, the sleep period is longer than the active period. A DRX cycle may have a more complex structure than described above, e.g. including a few repetitions of a shorter DRX cycle at the end of the active period, but for the purpose of this disclosure, the simplified DRX cycle description suffices in order to understand the principles of the various embodiments described herein. The idle mode DRX cycle, i.e., the paging cycle, is generally configured in the UE through parameters in the system information (SI) that is broadcast in each radio cell, in conjunction with UE specific parameters in the form of $IMSI \bmod 1024$, and an optional UE specific DRX cycle length. Alternatively, it is also possible to configure a UE specific paging cycle. The connected mode DRX cycle and other DRX parameters (when used) may be configured in the UE through optional parameters typically in the *RRConnectionReconfiguration* message, or later in connected mode. A more detailed description of DRX mechanisms can be found in literature, such as in the reference book *4G LTE/LTE-Advanced for Mobile Broadband* by Erik Dahlman, Stefan Parkvall and Johan Sköld, Academic Press, 2011, ISBN:978-0-12-385489-6, see e.g. chapter 13.2.6 "Discontinuous Reception (DRX) and Component Carrier Deactivation". More detailed descriptions of DRX cycles can also be found in, e.g. 3GPP TS 36.304 V.11.3.0 (see e.g. chapter 7), 3GPP TS 36.300 V.11.5.0 (see e.g. chapter 12), 3GPP TS 36.321 V.11.2.0 (see e.g. chapter 5.7). As will be appreciated, the DRX mechanisms are defined for both idle mode and connected mode. Generally speaking, these DRX mechanisms are excellent UE energy saving mechanisms.

However, the inventors have realized that when the communication events are short and infrequent, each communication event is likely to be preceded by an idle to

connected mode transition, and this transition is likely to take a significant portion of time from the whole time needed to perform the data transmission. The potential use of long connected mode DRX cycles may increase the risk of radio link failure during mobility between radio cells, which means that idle to connected mode transition may be triggered many times in such scenarios too. In addition, since the connection setup procedure often involves exchange of a large number of signaling messages, this control plane communication is likely to dominate i.e. comprise more messages, larger data volumes and consume more energy, over the user plane communication. Furthermore, since the signaling procedure involves many nodes in the network as well as significant processing in the network nodes, e.g. in order to set the appropriate configuration parameters, the time intervals separating the messages may be significant. Hence, having the MTC device (or other UE) actively listening for downlink transmissions during the entire idle to connected mode transition, due to the lack of DRX sleep mode possibilities, may cause an a relatively high UE energy consumption in many scenarios. In turn, this may have a significant negative impact on the battery lifetime of a UE, e.g. a MTC device.

SUMMARY

It is in view of the above considerations and others that the various embodiments disclosed herein have been made.

In one of its aspects, the technology presented herein concerns a method performed by a user equipment (UE). The UE is configured to be either in an idle mode (i.e. an idle state) or in a connected mode (i.e. a connected state). The method comprises applying a discontinuous reception (DRX) cycle during a time period when the UE is in transition from the idle mode to the connected mode. It is to be understood that although the DRX cycle may be applied during the entire time period during which the UE is in transition from the idle mode to the connected mode, the DRX cycle does not necessarily have to be applied during the entire transition from the idle mode to the connected mode. In other words, the DRX cycle is not necessarily applied during the entire time period during which the UE is in transition from the idle mode to the connected mode. Instead, the DRX cycle may be applied during a part, or portion, of the transition from the idle mode to the connected mode. That is, the DRX cycle may be applied during a part, or portion, of the time period during which the UE is in

transition from the idle mode to the connected mode. The idle mode and the connected mode, respectively, may be RRC states. RRC is an abbreviation for Radio Resource Control as is known among persons skilled in the art. That is to say that the idle mode may be an RRC_IDLE mode. Also, the connected mode may be a RRC_CONNECTED mode.

This method differs from the existing prior art in that it allows for applying, or utilizing, a DRX mechanism during the time period when the UE is in transition from the idle mode (e.g. RRC_IDLE) to the connected mode (e.g. RRC_CONNECTED). In the existing art, neither the idle mode DRX cycle nor the connected mode DRX cycles are applied during the time period when the UE is in transition from the idle mode to the connected mode. Accordingly, in the existing art no DRX cycle is applied during the time period when the UE is in transition from the idle mode to the connected mode.

Advantageously, the above-mentioned DRX cycle may be a temporary DRX cycle. For example, the temporary DRX cycle may be applied only when the UE is in transition from the idle mode to the connected mode. When the UE has transitioned to the connected mode (e.g. RRC_CONNECTED), the temporary DRX cycle may be inactivated, or even invalidated. The DRX cycle may therefore be called temporary DRX cycle, since it is only utilized when the UE is in the transition from the idle mode to the connected mode. In some embodiments, the method may thus comprise ceasing to apply the temporary DRX cycle when the UE has transitioned to the connected mode (e.g. RRC_CONNECTED). Or said differently, the method may comprise stopping to apply the temporary DRX cycle upon the UE entering the connected mode.

The method may also comprise applying one or several DRX configuration parameters during the time period when the UE is in transition from the idle mode to the connected mode. Again, although the one or several DRX configuration parameters may be applied during the entire time period during which the UE is in transition from the idle mode to the connected mode, the one or several DRX configuration parameters are not necessarily applied during the entire time period during which the UE is in transition from the idle mode to the connected mode. Instead, the one or several DRX configuration parameters may be applied during a part, or portion, of the time period during which the UE is in transition from the idle mode to the connected mode.

In one embodiment, the method may comprise, prior to applying the DRX cycle during the time period when the UE is in transition from the idle mode to the connected mode, transmitting a data message to a radio network node, wherein the data message
5 comprises a request to apply the DRX cycle during the time period when the UE is in transition from the idle mode to the connected mode. The method may also comprise, prior to applying the DRX cycle during the time period when the UE is in transition from the idle mode to the connected mode, receiving a data message from the radio network node, wherein the data message comprises an acknowledgement of said request.

10

In some embodiments, the method may comprise, prior to applying the DRX cycle during the time period when the UE is in transition from the idle mode to the connected mode, retrieving the DRX cycle to be applied during the time period when the UE is in transition from the idle mode to the connected mode. For example, retrieving the DRX
15 cycle to be applied during the time period when the UE is in transition from the idle mode to the connected mode may comprise receiving a data message from a radio network node, the data message comprising information about the DRX cycle. Additionally, or alternatively, retrieving the DRX cycle to be applied during the time period when the UE is in transition from the idle mode to the connected mode may
20 comprise retrieving information about the DRX cycle from a memory associated with the UE.

In some embodiments, the method may comprise, prior to applying the DRX cycle during the time period when the UE is in transition from the idle mode to the connected mode, retrieving DRX configuration parameter(s) to be applied during the time period
25 when the UE is in transition from the idle mode to the connected mode. For instance, retrieving the DRX configuration parameter(s) to be applied during the time period when the UE is in transition from the idle mode to the connected mode may comprise receiving a data message from a radio network node, wherein the data message
30 comprises the DRX configuration parameter(s). Additionally, or alternatively, retrieving the DRX configuration parameter(s) to be applied during the time period when the UE is in transition from the idle mode to the connected mode may comprise retrieving the DRX configuration parameter(s) from a memory associated with the UE.

In another of its aspects, the technology presented herein concerns a method performed by a radio network node. The method comprises transmitting a data message to a user equipment (UE), wherein the data message comprises information about a DRX cycle to be applied by the UE during the time period when the UE is in transition from the idle mode to the connected mode. The method may additionally
5 comprise transmitting a data message to the UE, wherein the data message comprises DRX configuration parameter(s) to be applied by the UE during the time period when the UE is in transition from the idle mode to the connected mode.

10 In yet another of its aspects, the technology presented herein concerns a method performed by a radio network node. The method comprises receiving a data message from a user equipment (UE), wherein the data message comprises a request to apply a DRX cycle during the time period when the UE is in transition from the idle mode to the connected mode. The method may additionally comprise transmitting a data message
15 to the UE, wherein the data message comprises an acknowledgement of said request.

In still another of its aspects, the technology presented herein concerns a user equipment (UE) configured to be either in an idle mode or in a connected mode. The UE comprises a *processor*, and a *memory* storing computer program code, which,
20 when run in the *processor* causes the UE to apply a discontinuous reception (DRX) cycle during a time period when the UE is in transition from the idle mode to the connected mode. As mentioned earlier, although the DRX cycle may be applied during the entire time period during which the UE is in transition from the idle mode to the connected mode, the DRX cycle does not necessarily have to be applied during the
25 entire transition from the idle mode to the connected mode. In other words, the DRX cycle is not necessarily applied during the entire time period during which the UE is in transition from the idle mode to the connected mode. Instead, the DRX cycle may be applied during a part, or portion, of the transition from the idle mode to the connected mode. That is, the DRX cycle may be applied during a part, or portion, of the time
30 period during which the UE is in transition from the idle mode to the connected mode.

Also as mentioned earlier, the DRX cycle may be a temporary DRX cycle. For example, the *memory* may store computer program code, which, when run in the

processor causes the UE to apply the temporary DRX cycle only when the UE is in transition from the idle mode to the connected mode.

5 In some embodiments, the *memory* may store computer program code, which, when run in the *processor* causes the UE to cease to apply the temporary DRX cycle when the UE has transitioned to the connected mode.

10 In some embodiments, the *memory* may store computer program code, which, when run in the *processor* causes the UE to apply one or several DRX configuration parameters during the time period when the UE is in transition from the idle mode to the connected mode.

15 For example, the UE may also comprise a *transmitter* configured to transmit a data message to a radio network node, wherein the data message comprises a request to apply the DRX cycle during the time period when the UE is in transition from the idle mode to the connected mode. Moreover, the UE may comprise a *receiver* configured to receive a data message from the radio network node, the data message comprising an acknowledgement of said request.

20 In some embodiments, the *memory* may also store computer program code, which, when run in the *processor* causes the UE to retrieve the DRX cycle to be applied during the time period when the UE is in transition from the idle mode to the connected mode. Also, the *receiver* may be configured to receive a data message from a radio network node, wherein the data message comprises information about the DRX cycle.
25 Additionally, or alternatively, the *memory* may store computer program code, which, when run in the *processor* causes the UE to retrieve information about the DRX cycle from a memory associated with the UE.

30 Furthermore, the *memory* may store computer program code, which, when run in the *processor* causes the UE to retrieve the DRX configuration parameters to be applied during the time period when the UE is in transition from the idle mode to the connected mode. Also, the *receiver* may be configured to receive a data message from a radio network node, wherein the data message comprises the DRX configuration parameters. Additionally, or alternatively, the *memory* may store computer program

code, which, when run in the *processor* causes the UE to retrieve the DRX configuration parameters from a memory associated with the UE.

The above-mentioned UE may be a Machine Type Communication (MTC) device.

5

In another of its aspects, the technology discussed herein concerns a radio network node. The radio network node comprises a *transmitter* configured to transmit a data message to a user equipment (UE), wherein the data message comprises information about a DRX cycle to be applied by the UE during the time period when the UE is in transition from the idle mode to the connected mode. The *transmitter* may also be configured to transmit a data message to the UE, wherein the data message comprises DRX configuration parameters to be applied by the UE during the time period when the UE is in transition from the idle mode to the connected mode.

15 The radio network node may be an evolved NodeB (eNB). Alternatively, the radio network node may be a Home Subscriber Server (HSS). Alternatively, the radio network node may be a Mobility Management Entity (MME). Yet further, it is conceivable that a distributed solution is utilized. That is, several of the eNB, HSS and MME may implement the herein described functionality of the radio network node in a distributed manner. It is also conceivable that embodiments described herein can be applied in a UMTS system, e.g. providing a W-CDMA or HSPA radio interface, in which case the radio network node may be a Node B, a Radio Network Controller (RNC), a HSS, a Home Location Register (HLR) or a Serving General Packet Radio Service Support Node (SGSN) or a distributed solution involving several of these nodes.

25

In still another of its aspects, the technology discussed herein concerns a radio network node. The radio network node comprises a *receiver* configured to receive a data message from a user equipment (UE), wherein the data message comprises a request to apply a DRX cycle during the time period when the UE is in transition from the idle mode to the connected mode. The radio network node may further comprise a *transmitter* configured to transmit a data message to the UE, wherein the data message comprises an acknowledgement of said request.

30

The radio network node may be an evolved NodeB (eNB). Alternatively, the radio network node may be a Home Subscriber Server (HSS). Alternatively, the radio network node may be a Mobility Management Entity (MME). Yet further, it is conceivable that a distributed solution is utilized. That is, several of the eNB, HSS and MME implement the herein described functionality of the radio network node in a distributed manner. It is also conceivable that embodiments described herein can be applied in a UMTS system, e.g. providing a W-CDMA or HSPA radio interface, in which case the radio network node may be a Node B, a Radio Network Controller (RNC), a HSS, a Home Location Register (HLR) or a Serving General Packet Radio Service Support Node (SGSN) or a distributed solution involving several of these nodes.

As will be appreciated and according to some of the embodiments described throughout this disclosure, it is proposed to apply a DRX cycle during a time period when the UE is in transition from the idle mode to the connected mode. Advantageously, the DRX cycle is temporary and applied only when the UE is in the transition from the idle mode to the connected mode. As soon as the UE is in connected mode, the normal (or, regular) connected mode DRX cycle can be applied in a conventional way.

Applying a DRX cycle in the time period between idle mode and connected mode provides several advantages. For example, this may allow the UE to save power during its transition from idle mode to connected mode. Indeed, much energy is generally consumed during the multitude of transitions between idle mode and connected mode. This may be particularly true for MTC devices, since the idle-to-connected mode transition signaling procedure may represent a significant part of the total communication for these devices. Therefore, allowing MTC devices to save power during the otherwise power-consuming idle-to-connected mode transition signaling procedure may be beneficial. It should be appreciated that the above advantage is not limited to MTC devices. Also other UEs, such as many of today's smartphones, would benefit from reducing power consumption during the idle-to-connected mode transition signaling procedure.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other aspects, features and advantages will be apparent and elucidated from the following description of various embodiments, reference being made to the accompanying drawings, in which:

5 Fig. 1A shows an example 3GPP LTE radio communication system;

Fig. 1B shows a signaling diagram during a time period when a UE transitions from an idle mode to a connected mode;

10 Fig. 2 shows a flowchart of a method according to an embodiment performed in a user equipment;

Fig. 3 shows a flowchart of a method according to an embodiment performed in a user equipment;

15

Fig. 4 shows a flowchart of a method according to an embodiment performed in a user equipment;

20 Fig. 5 shows a flowchart of a method according to an embodiment performed in a radio network node;

Fig. 6 shows a flowchart of a method according to an embodiment performed in a radio network node;

25 Fig 7 shows an example embodiment of a user equipment; and

Fig. 8 shows an example embodiment of a radio network node.

DETAILED DESCRIPTION

30 The technology will now be described more fully hereinafter with reference to the accompanying drawings, in which certain embodiments are shown. The technology may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided by way of example so that this disclosure will be thorough and complete, and will fully

convey the scope of the technology to those persons skilled in the art. Like reference numbers refer to like elements or method steps throughout the description.

As used in this disclosure, the term “user equipment (UE)” is used to mean any device,
5 which can be used by a user to communicate. Also, the term UE may be referred to as a mobile terminal, a terminal, a user terminal (UT), a wireless terminal, a wireless communication device, a wireless transmit/receive unit (WTRU), a mobile phone, a cell phone, etc. Yet further, the term UE includes MTC devices, which do not necessarily involve human interaction. Also, the term “radio network node” as used herein
10 generally denotes a fixed point being capable of communicating with the UE. As such, it may be referred to as a base station, a radio base station, a NodeB or an evolved NodeB (eNB), a Radio Network Controller (RNC), access point, etcetera. Within the context of this disclosure it should be understood that the term “radio network node” may denote a node that is not necessarily part of what is typically referred to as a
15 “radio access network”, e.g. a Mobility Management Entity (MME), a Serving General Packet Radio Service Support Node(SGSN), a Home Subscriber Server (HSS) or a Home Location Register (HLR). Thus, when used herein the term “radio network node” may also include, e.g., CN nodes.

20 In one of its aspects, the technology presented herein concerns the application, or utilization, of a discontinuous reception (DRX) mechanism during a time period when a user equipment (UE) is in transition from an idle mode to a connected mode. It should be appreciated that although the DRX cycle may be applied during the entire time period during which the UE is in transition from the idle mode to the connected mode,
25 the DRX mechanism does not necessarily have to be applied during the entire transition from the idle mode to the connected mode. In other words, the DRX mechanism is not necessarily applied during the entire time period during which the UE is in transition from the idle mode to the connected mode. Instead, the DRX mechanism may be applied during a part, or portion, of the transition from the idle
30 mode to the connected mode. That is, the DRX mechanism may be applied during a part, or portion, of the time period during which the UE is in transition from the idle mode to the connected mode.

Figure 2 shows a flowchart of a method implemented in a UE according to an example embodiment. That is, a method 200 performed by a UE is proposed. The UE is configured to be either in an idle mode (e.g. RRC_IDLE) or in a connected mode (e.g. RRC_CONNECTED). The method comprises applying 210 a DRX cycle during a time period when the UE is in transition from the idle mode to the connected mode. The DRX cycle may be a temporary DRX cycle. Furthermore, the temporary DRX cycle may be applied only when the UE is in transition from the idle mode to the connected mode. In other words, the temporary DRX cycle is not applied when the UE is in idle mode (e.g. RRC_IDLE). Similarly, the temporary DRX cycle is not applied when the UE is in connected mode (e.g. RRC_CONNECTED). Rather, the temporary DRX cycle is only applied when the UE is in a transition between the two modes, i.e. when the UE is in a transition from the idle mode to the connected mode. For example, the time period when the UE is in transition from the idle mode to the connected mode may be understood to mean the time period from step 1 (i.e. RA Msg 1, where RA is an abbreviation for Random Access) up to and including step 21 (i.e. RRCConnectionReconfigurationComplete) in figure 1B.

The method may preferably also comprise applying 220 one or several DRX configuration parameters during the time period when the UE is in transition from the idle mode to the connected mode. DRX configuration parameters may, for example, include one or more of the following parameters:

- DRX start offset (which is generally used to define when the DRX cycle starts)
- DRX cycle length
- On Duration
- On duration timer
- DRX Inactivity Timer
- DRX Retransmission Timer
- Short DRX cycle
- Short DRX cycle timer
- The nB parameter (which is involved in the definition of idle mode DRX and is described in chapter 7 of 3GPP Technical Specification 36.304 V11.3.0 “3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) procedures in idle mode (Release 11)”)

The method may additionally comprise ceasing 230, or stopping, to apply the temporary DRX cycle when the UE has transitioned to the connected mode. That is, as soon as the UE enters connected mode (e.g. RRC_CONNECTED), the UE may stop
5 applying the temporary DRX cycle. Upon entering the connected mode, the UE may begin applying the normal, or regular, connected mode DRX cycle.

Also, the method may additionally comprise ceasing 240, or stopping, to apply the DRX configuration parameters when the UE has transitioned to the connected mode. That
10 is, as soon as the UE enters connected mode (e.g. RRC_CONNECTED), the UE may stop applying the DRX configuration parameters. Upon entering the connected mode, the UE may instead begin applying the normal, or regular, connected mode DRX configuration parameter(s).

15 Applying a DRX cycle (and optionally also the DRX configuration parameters) in the time period between idle mode and connected mode may allow the UE to save power during its transition from idle mode to connected mode. Indeed, much energy is generally consumed during the multitude of transitions between idle mode and connected mode. Therefore, it may be beneficial for many UEs devices to apply a
20 temporary DRX cycle in the idle-to-connected mode transition signaling procedure, since this signaling procedure may represent a significant part of the total communication for these devices. Therefore, allowing UEs to save power during the otherwise power-consuming idle-to-connected mode transition signaling procedure may be advantageous for many devices.

25

Fig. 3 shows a flowchart of a method 300 implemented in a UE according to another example embodiment. In this embodiment, the UE transmits 310 a data message to a radio network node, wherein the data message comprises a request to the radio network node to apply the DRX cycle during the time period when the UE is in
30 transition from the idle mode to the connected mode. In other words, the UE can transmit an indication to a radio network node that it requests, or wishes, to apply the earlier-mentioned DRX cycle during its transition from idle mode to connected mode. In one example implementation, the above-mentioned data message comprises one or more data fields wherein at least one of the data fields comprises or otherwise

indicates said request to apply the DRX cycle during the time period when the UE is in transition from the idle mode to the connected mode.

In response and if the radio network node accepts the request, the UE may receive 320
5 a data message from the radio network node, wherein the received data message comprises an acknowledgement (ACK) of said request. In one example implementation, the received data message includes one or more data fields where at least one of the data fields includes or otherwise indicates the ACK. Alternatively, if the radio network node does not accept the request, the UE may receive 330 a data
10 message from the radio network node, wherein the received data message comprises a negative acknowledgement (NACK). In one example implementation, the received data message includes one or more data fields where at least one of the data fields includes or otherwise indicates the NACK. If, or when, the UE receives 320 the ACK from the radio network node, the method continues to the method 200 described
15 hereinabove. In other words, the transmission 310 of the data message including the above-mentioned request as well as the reception 320 may be performed prior to the UE applying 210 (see fig. 2) the idle-to-connected mode transition DRX cycle, i.e. the temporary DRX cycle.

20 Fig. 4 shows a flowchart of a method 400 implemented in a UE according to still another example embodiment. In this embodiment, the UE retrieves 410 the DRX cycle to be applied during the time period when the UE is in transition from the idle mode to the connected mode. For example, the retrieval 410 of the DRX cycle may comprise receiving 411 (see fig. 4B) a data message from a radio network node, wherein this
25 data message comprises information about the DRX cycle. For example, the data message may comprise one or more data fields wherein at least one of the data fields comprises or otherwise indicates the information about the DRX cycle. Alternatively, the retrieval 410 of the DRX cycle may comprise retrieving 412 (see fig. 4C) information about the DRX cycle from a memory associated with the UE, e.g. a
30 memory internal to the UE. Also, the method may optionally comprise retrieving 420 DRX configuration parameters to be applied during the time period when the UE is in transition from the idle mode to the connected mode. For example, the retrieval 420 of the DRX configuration parameters may comprise receiving 421 (see fig. 4D) a data message from a radio network node, wherein this data message comprises the DRX

configuration parameters. For example, the data message may comprise one or more data fields wherein at least one of the data fields comprises or otherwise indicates said DRX configuration parameters. Alternatively, the retrieval 420 of the DRX configuration parameters may comprise retrieving 422 (see fig. 4E) the DRX configuration parameters from a memory associated with the UE, e.g. a memory internal to the UE. As is illustrated in fig. 4A, the method 400 may precede the method 200 or method 300 described with reference to fig. 2 and 3, respectively.

It should be appreciated that retrieving 410 the DRX cycle to be applied during the time period when the UE is in transition from the idle mode to the connected mode may occur simultaneously, or substantially simultaneously, as retrieving 420 DRX configuration parameters to be applied during the time period when the UE is in transition from the idle mode to the connected mode. In other words, even if Fig. 4A indicates that these method steps, or actions, occur serially in two subsequent method steps or actions, it should be appreciated that these methods steps, or actions (i.e. 410 and 420), may occur simultaneously, or substantially simultaneously. Thus, in some embodiments these methods steps, or actions (i.e. 410 and 420), may be seen as occurring in one single method step, or action. Alternatively, these method steps, or actions (i.e. 410, 420) may occur in parallel.

Similarly, the method steps, or actions, of receiving 411 (see fig. 4B) the data message from the radio network node, wherein this data message comprises information about the DRX cycle and receiving 421 (see fig. 4D) a data message from a radio network node, wherein this data message comprises the DRX configuration parameters do not have to occur serially. Rather, these method steps, or actions, may occur simultaneously, or substantially simultaneously. For example, the data messages comprising information about the DRX cycle and the DRX configuration parameters, respectively, may be a single data message comprising both information about the DRX cycle and the DRX configuration parameters. Thus, these methods steps, or actions (i.e. 411 and 421) may be seen as occurring in one single method step, or action. Alternatively, these method steps, or actions (i.e. 411, 421) may occur in parallel.

Also in a similar manner, the method steps, or actions, of retrieving 412 (see fig. 4C) information about the DRX cycle from a memory associated with the UE (e.g. a memory internal to the UE) and retrieving 422 (see fig. 4E) the DRX configuration parameters from a memory associated with the UE (e.g. a memory internal to the UE)
5 may occur serially, in parallel or simultaneously.

The methods 200, 300, and 400 described hereinabove may preferably, though not necessarily, be implemented in, or otherwise performed by, a MTC device.

10 Fig. 5 shows a flowchart of a method 500 implemented in a radio network node according to an example embodiment. The radio network node transmits 510 a first data message to a user equipment (UE), wherein the first data message comprises information about a DRX cycle to be applied by the UE during the time period when the UE is in transition from the idle mode (e.g. RRC_IDLE) to the connected mode (e.g.
15 RRC_CONNECTED). In one example implementation, the first data message may comprise one or more data fields wherein at least one of said data fields comprises or otherwise indicates the information about the DRX cycle to be applied by the UE during the time period when the UE is in transition from the idle mode to the connected mode. The method may preferably also include transmitting 520 a second data message to
20 the UE, wherein the second data message comprises DRX configuration parameters to be applied by the UE during the time period when the UE is in transition from the idle mode to the connected mode. In one example implementation, the second data message may comprise one or more data fields wherein at least one of said data fields comprises or otherwise indicates said DRX configuration parameters to be applied by
25 the UE during the time period when the UE is in transition from the idle mode to the connected mode.

For illustration purpose only, Fig. 5 illustrates the first and second data messages as two separate messages. However, the first and second data messages do not
30 necessarily have to be transmitted in separate data messages. Instead, the first and second data messages may be sent in one single data message. In fact, those skilled in the art will appreciate that it may be preferred to transmit the first and second messages in one single data message.

Furthermore, it should also be appreciated that the method shown in Fig. 5 may be conditionally performed depending on whether the radio network node has received a data message from the UE requesting the radio network node to return the DRX cycle and/or the DRX configuration parameter(s).

5

Fig. 6 shows a flowchart of a method 600 implemented in a radio network node according to another example embodiment. The method 600 comprises receiving 610 a data message from a user equipment (UE), wherein the data message comprises a request to apply a DRX cycle during the time period when the UE is in transition from the idle mode to the connected mode. Said data message may comprise one or more data fields where at least one of the data fields comprises or otherwise indicates the request to apply a DRX cycle during the time period when the UE is in transition from the idle mode to the connected mode

15 If the radio network node accepts the received 610 request, the method may additionally comprise transmitting 620 a data message to the UE, wherein the data message comprises an acknowledgement (ACK) of said request. In one example implementation, the data message may include one or more data fields where at least one of the data fields includes or otherwise indicates the ACK. Alternatively, i.e. if the radio network node does not accept the received 610 request, the method may comprise transmitting 630 a data message to the UE, wherein the data message comprises a negative acknowledgement (NACK) of said request, thus, rejecting the received 610 request. In one example implementation, the data message may include one or more data fields where at least one of the data fields includes or otherwise indicates the NACK.

The radio network node may be an evolved NodeB (eNB). Alternatively, the radio network node may be a Home Subscriber Server (HSS). Alternatively, the radio network node may be a Mobility Management Entity (MME). Yet further, it is conceivable that a distributed solution can be utilized. That is, several of the eNB, HSS and MME implement the herein described functionality of the radio network node in a distributed manner. It is also possible that the embodiments described herein can be applied in a UMTS system, e.g. providing a W-CDMA or HSPA radio interface, in which case the radio network node may be a Node B, a Radio Network Controller (RNC), a

HSS, a Home Location Register (HLR) or a Serving General Packet Radio Service Support Node (SGSN) or a distributed solution involving several of these nodes.

It should be appreciated that the methods 500 and 600 can be combined.

5

Some exemplary embodiments of the technology will now be described in some more detail hereinafter:

As is understood from the above, it is proposed to introduce a possibility to apply a DRX mechanism (i.e. DRX cycle and/or DRX configuration parameter(s)) during the idle to connected mode transition signaling procedure. The DRX cycle and/or the DRX configuration parameter(s) may be temporary. Thus, the DRX cycle and/or the DRX configuration parameter(s) may advantageously be used only during the idle to connected mode transition procedure. When the idle to connected mode transition signaling procedure is finalized, the temporary DRX configuration may be invalidated. Then, the connected mode DRX configuration which is generally conveyed in the *RRConnectionReconfiguration* RRC message at the end of the idle to connected mode transition signaling procedure (see fig. 1B) may take over. Alternatively, if no connected mode DRX is configured in the *RRConnectionReconfiguration* RRC message, the UE may continue to operate without DRX mechanism in connected mode. As yet another alternative, if no connected mode DRX is configured in the *RRConnectionReconfiguration* RRC message, the UE may continue to operate with the temporary DRX configuration (which is thus thereafter to be regarded as regular, non-temporary DRX configuration).

25

Various detailed embodiments will be described in the following. In order to support the application, or utilization, of a DRX mechanism during the idle to connected mode transition signaling procedure, novel DRX configuration possibilities are proposed herein below. This may be achieved in a number of different ways, which are elaborated in the subsections below. Following these subsections is also a subsection about avoidance of potential incompatibility challenges.

30

The signaling to use a temporary DRX mechanism during the idle to connected mode transition signaling procedure may comprise the following: 1) Indication of temporary DRX configuration usage, 2) Deriving the temporary DRX configuration.

- 5 In the first step, the UE may indicate to the network (or, rather, one or more radio network nodes of said network) that it will use or would prefer to use a temporary DRX configuration. In the latter case, the network may need to confirm the usage of the configuration. There are multiple options where the indication from the UE to the network may be included:
- 10
- Indication in the *RRCCConnectionRequest* message (see fig. 1B);
 - Indication in the *RRCCConnectionSetupComplete* message (see fig. 1B);
 - Indication in the subscriber data;
 - Indication in a Non-Access Stratum (NAS) message (see e.g. 3GPP TS 24.301 V.11.4.0)
- 15
- Indication in *RA Msg1* (see fig. 1B)
 - Based on device category or capability;

In the second step, the UE may derive the temporary configuration to be used during the *RRC Connection Setup* procedure (i.e. the idle to connected mode transition procedure) until the actual, semi-permanent configuration is received in the *RRCCConnectionReconfiguration* message. The parameter types (e.g. various timers) used to define the temporary DRX configuration should preferably be the same as the ones used for definition of regular connected mode DRX configurations. There are multiple options for this:

20

- 25
- The network may signal the temporary DRX configuration to the UE in the system information (SI);
 - The temporary DRX configuration may be signaled in the *RRCCConnectionSetup* message;
 - The temporary DRX configuration may be preconfigured in subscriber data;
- 30
- The temporary DRX configuration may be signaled in a NAS message (see e.g. 3GPP TS 24.301 V.11.4.0);
 - The temporary DRX configuration may be signaled in *RA Msg2* (see e.g. fig. 1)
 - The temporary DRX configuration may be hard-coded in accordance with future 3GPP technical specifications.

The above two steps (indication and derivation) may not necessarily occur in this order. The UE may retrieve the temporary DRX configuration before it indicates to the network that it will use or would prefer to use the temporary DRX configuration. The two steps may also be integrated with each other, so that the indication comprises the configuration parameters, in which case the two steps occur simultaneously, or essentially simultaneously.

1.1. Indication in the *RRCCConnectionRequest* Message

In one embodiment, the UE is configured to indicate in the *RRCCConnectionRequest* RRC message (see e.g. 3GPP TS 36.331 V.11.1.0) that it wishes to apply a temporary DRX configuration during the idle to connected mode signaling procedure. The indication, or request, could come in various shapes. In its simplest form the indication, or request, may be a flag, e.g. one bit, indicating that temporary DRX should be applied. The actual configuration parameters to be applied could then be either standardized or signaled in the system information (SI) message(s). A slightly more elaborated alternative would be to let the indication, or request, have the form of an index indicating one out of a set of possible temporary DRX configurations. The DRX configuration parameters that each index value maps to could be standardized or signaled in a SI message(s). Still another alternative would be that the UE includes the complete set of DRX configuration parameters in the *RRCCConnectionRequest* message. A combination, where a subset of the temporary DRX configuration parameters are indicated in the *RRCCConnectionRequest* message while the rest are standardized or signaled in the SI message(s) is also conceivable. Yet another possibility is to utilize one or both of the spare values of the *establishmentCause* IE (information element) to indicate that a preconfigured, temporary DRX configuration should be applied. Using both spare values provides the possibility to indicate two different temporary DRX configurations. The *establishmentCause* IE is further detailed in 3GPP TS 36.331. It would even be possible to change the interpretation of the value of the *establishmentCause* IE that currently indicates 'delay tolerant access' so that it also indicates that a preconfigured temporary DRX configuration is applied by the UE. The preconfigured parameters could be standardized or indicated in signaled system information. One possibility is to restrict the use of temporary DRX configuration to the delay tolerant establishment cause. One of the spare bits of the

RRConnectionRequest message can be used in combination with this establishment cause. An indication in the *RRConnectionRequest* message combined with temporary DRX parameters in the system information is probably, but not necessarily, the most attractive of the alternatives presented herein. It allows the temporary DRX configuration to be applied immediately after the *RRConnectionRequest* message and may allow an operator flexibility to define the actual parameters to be used for the temporary DRX configuration.

1.2. Indication in the *RRConnectionRequest* and Configuration in the *RRConnectionSetup* Messages

In one embodiment, the UE and the eNB may “cooperate” to configure the temporary DRX cycle. The UE may, for example, indicate in the *RRConnectionRequest* message, in either of the ways described above in section 1.1, that it wishes, or requests, to apply temporary DRX during the idle to connected mode transition signaling procedure. The eNB may then respond with the actual temporary DRX configuration parameters in the *RRConnectionSetupRRC* message, thereby concluding the configuration.

1.3. Indication in the *RRConnectionSetupComplete* Message

In one embodiment, the UE may indicate in the *RRConnectionSetupComplete* message that it wishes, or requests, to apply a temporary DRX configuration during the idle to connected mode signaling procedure. This is similar to the alternative with indication in the *RRConnectionRequest* message (see section 1.1). A difference is that the *establishmentCause* IE is not included in the *RRConnectionSetupComplete* message, so the spare values of that IE are not used, or cannot be used.

A difference of this approach compared to the example of including the indication in the *RRConnectionRequest* message is that the temporary DRX configuration cannot be applied until the *RRConnectionSetupComplete* message has been sent, which means that the UE cannot save energy in DRX sleep mode while waiting for the *RRConnectionSetup RRC* message (i.e. RA Msg4, see fig. 1) from the eNB.

On the other hand, an advantage of this approach compared to the example of including the indication in the *RRConnectionRequest* message is that there is

generally more room for extensions in the *RRCCConnectionSetupComplete* message than in the *RRCCConnectionRequest* message (for which the ambition in 3GPP has been to keep it very short). As a result, according to the current RRC specification (see 3GPP TS 36.331 V.11.1.0), the *RRCCConnectionSetupComplete* message can be
5 extended with a non-critical extension, whereas the *RRCCConnectionRequest* message cannot generally be extended in this manner. This makes it easier to include more elaborate information, such as a complete set of configuration parameters for the temporary DRX configuration in the *RRCCConnectionSetupComplete* message.

10 **1.4. Preconfigured in Subscriber Data**

In one embodiment, the temporary DRX configuration is included in the subscriber data associated with the UE. Hence, it may be stored in the HSS (Home Subscriber Server) and in the USIM (Universal Subscriber Identity Module) in the UE. As described for the alternative of including an indication and potentially configuration in the
15 *RRCCConnectionRequest* message (see section 1.1), the indication (or, request) and configuration can come in various forms. The same indication alternatives as described in section 1.1 can be used in combination with this embodiment. The indication and/or configuration may be downloaded from the HSS to the MME (Mobility Management Entity) together with other subscriber data when the UE registers in the MME. From the
20 MME the indication/temporary configuration may be forwarded to the eNB in the first message from the MME to the eNB in the idle to connected mode transition procedure, e.g. the *Initial Context Setup Request S1AP* message (message 17 in the message sequence of figure 1B) or the *Downlink NAS Transport S1AP* message carrying the Authentication Request NAS message (message 9 in the message sequence of figure
25 1B) (see e.g. also 3GPP TS 36.413 V11.1.0).

According to this embodiment, the UE can apply the temporary DRX configuration after sending the *RRCCConnectionSetupComplete* message, since the eNB will receive the temporary DRX configuration indication (or full parameter set) from the MME before it
30 sends its next message to the UE. Optionally, the eNB (and the UE) activates the temporary DRX configuration only if the eNB has previously received an indication in either the *RRCCConnectionRequest* message (a new indication, e.g. one of the currently unused values of the *establishmentCause* IE, or tied to an existing value of the *establishmentCause* IE) or the *RRCCConnectionSetupComplete* message. If this option

is used, it should preferably be extended such that the indication from the UE triggers the eNB to include a similar indication in the Initial UE Message S1AP message (i.e. message 6 in the message sequence of figure 1B) to trigger the MME to forward the temporary DRX configuration information to the eNB (and in the absence of such an indication from the eNB the MME would not forward the temporary DRX configuration information). After receiving the indication in the *RRCCConnectionRequest* message or based on some other reason, the eNB may optionally confirm usage of temporary DRX configuration in the *RRCCConnectionSetup* message with a one bit flag.

10 **1.5. *Explicit Indication in a NAS Message***

According to one embodiment, the UE indicates in a NAS (Non-Access Stratum) message to the MME that it wishes (or requests) to apply a temporary DRX configuration during the idle to connected mode transition signaling procedure. The NAS message (see e.g. 3GPP TS 24.301 V11.4.0) should preferably, but not necessarily, be the one that is included in the *RRCCConnectionSetupComplete* RRC message (i.e. message 5 in the message sequence of figure 1B). In figure 1B this NAS message is a Service Request NAS message, but in other scenarios it may also be another NAS message, such as an Attach Request NAS message, an Extended Service Request NAS message or a Tracking Area Update Request NAS message.

20 In order to inform the eNB, the MME can forward the indication (or, request) to the eNB in the *Initial Context Setup Request S1AP* message (i.e. message 17 in the message sequence of figure 1B) or the Downlink NAS Transport S1AP message carrying the Authentication Request NAS message (i.e. message 9 in the message sequence of figure 1B).

It will be appreciated that the same examples for the indication, or request, as described in section 1.1 may be used in combination with this embodiment.

30 According to this embodiment, the UE can apply the temporary DRX configuration after sending the indication in the NAS message, i.e. after sending the *RRCCConnectionSetupComplete* message, since (similar to the case where the temporary DRX indication is included in the subscriber data) the eNB will receive the

temporary DRX configuration indication (or full parameter set) from the MME before it sends its next message to the UE.

1.6. Based on Device Category or Capability

5 According to another embodiment, the indication is associated with a category or capability of the UE. It could then be included in any of the IEs in the Attach Request NAS message that indicates various properties of the UE, i.e. the *UE network capability* IE, the *MS network capability* IE, the *Mobile station classmark 2* IE or the *Device properties* IE. As these IEs are included in a NAS message they are delivered
10 to the MME. Hence, the MME can inform the eNB so that it may apply the temporary DRX configuration. The MME can do this by forwarding the indication to the eNB in the *Initial Context Setup Request S1AP* message (i.e. message 17 in the message sequence of figure 1B) or the Downlink NAS Transport S1AP message carrying the Authentication Request NAS message (i.e. message 9 in the message sequence of
15 figure 1B). Again, the same examples for the indication as described in section 1.1 may be used also with this embodiment, i.e. in combination with this embodiment.

After receiving the temporary DRX indication (irrespective of its level of elaboration) the MME would keep it in the UE context (i.e. its records of UE associated information) and
20 in case of an MME relocation, the indication would be forwarded to the new MME.

Another, more preferable variant of basing the solution on the UE capability is to make use of radio capability related parameters. In this variant the *UE-EUTRA-Capability* IE may be extended with the temporary DRX indication/configuration. The same
25 elaboration alternatives for the indication as described in section 1.1 may be used also with this alternative.

In the current RRC specification (see e.g. 3GPP TS 36.331 V11.1.0), the *UE-EUTRA-Capability* IE is included in the *ue-CapabilityRAT-Container* IE, which in turn is included
30 in the *ue-CapabilityRAT-ContainerList* IE in the *UECapabilityInformation* message.

In conjunction with the Attach procedure (i.e. when the UE first registers in the network and relevant contexts are established in core network nodes, such as the MME, the SGW and the PGW) the eNB may request the capability information from the UE by

sending the RRC message *UECapabilityEnquiry* to the UE. The UE may then respond with the RRC message *UECapabilityInformation*, including the capability information as described above. The eNB may then forward the information to the MME as follows. It includes the *UECapabilityInformation* message in a *ue-RadioAccessCapabilityInfo* IE, which it includes in a *UERadioAccessCapabilityInformation* message (which is specified as an RRC message), which in turn is included in a *UE Radio Capability* IE, which the eNB sends to the MME in the S1AP message *UE CAPABILITY INFO INDICATION*. The MME may store the UE capability information in its UE context and keeps it for as long as the UE remains attached to the network (and transfers it to a new MME in case of MME relocation).

In subsequent cases (during the same attach session) where the UE connects to the network, i.e. transits from idle to connected mode, the MME transfers the UE capability information to the eNB in the *UE Radio Capability* IE in the S1AP message *INITIAL UE CONTEXT SETUP REQUEST* (message 17 in the message sequence in figure 1B). The *UE Radio Capability* IE is optional in the *INITIAL UE CONTEXT SETUP REQUEST* message and during the Attach procedure it is absent. This absence triggers the eNB to request the information from the UE and forward it to the MME, as described above.

This mechanism may allow the eNB to apply the temporary DRX configuration when it has received the UE capability information from the MME, i.e. starting with the transmission of message 18 in figure 1B, i.e. the downlink RRC message *SecurityModeCommand*. From the UE's perspective this means that it may apply the temporary DRX configuration after receiving the preceding downlink message in the sequence, i.e. after receiving message 14 in Figure 1B. Note that messages 7-16 are optional in the message sequence of figure 1B, but the UE cannot know in advance whether they will be used or not. Therefore the UE cannot apply the temporary DRX configuration after receiving the *RRConnectionSetup* message (message 4 in figure 1B), which means that if messages 7-16 in figure 1B are not used, the UE will not apply the temporary DRX configuration until it has received the *SecurityModeCommand* message (message 18 in figure 1B) from the eNB.

Similar to the embodiment with the temporary DRX indication in the subscriber data (see section 1.4) an option is to let the activation of the temporary DRX configuration be triggered by an indication from the UE, using the same mechanism as described in section 1.4. This option may be used with both the method variants elaborated in this section.

1.7 Indication in a MAC Control Element

In one embodiment, the UE indicates in a MAC (Medium Access Control) Control Element that it wishes, or requests, to apply a temporary DRX configuration during the idle to connected mode signaling procedure. The MAC Control Element would preferably be included in the MAC PDU (Protocol Data Unit) carrying one of the uplink RRC messages, e.g. (preferably) the RRCConnectionRequest RRC message or the RRCConnectionSetupComplete RRC message, but it could also be conveyed in a separate MAC PDU (i.e. a MAC PDU without SDU). Optionally, the indication could be confirmed by the eNB in a MAC Control Element in a subsequent downlink MAC PDU, preferably a MAC PDU carrying one of the downlink RRC messages, e.g. the RRCConnectionSetup RRC message (assuming that the indication was conveyed in the MAC PDU carrying the RRCConnectionRequest RRC message). The same alternatives of the temporary DRX indication as described in section 1.1 may be used in combination with this embodiment, e.g. a flag or an index, full or partial configuration (or a combination).

1.8. Indication in RA Msg1 and/or RA Msg2

With this embodiment, the indication (or request) of application of a temporary DRX configuration is included in the first and/or the second message of the random access procedure, i.e. RA Msg1 (random access preamble) or RA Msg2 (Random Access Response MAC PDU) (messages 1 and 2 in the message sequence of figure 1B) (see e.g. also 3GPP TS 36.321 V11.0.0). If RA Msg1 is used, the only means to indicate anything is to use a preamble from a dedicated group of preambles. This implies that the current (maximum) two preamble groups, A and B, would have to be complemented with another preamble group for indication of temporary DRX configuration. A preamble from this group would indicate that temporary DRX configuration is applied by the UE during the idle to connected mode transition signaling procedure. The actual temporary DRX configuration parameters could be

standardized or specified in the system information. If it is desired to be able to indicate one out of a set of temporary DRX configurations, then a preamble group would have to be defined for each set. Such preamble groups would be indicated in the system information, just as the presently existing preamble groups A and B. Alternatively, the
5 preamble from a dedicated preamble group may be considered as a request for temporary DRX configuration to be used, whereby this must be confirmed by the eNB, (which optionally also may provide the actual configuration parameters). The eNB would confirm the usage of the temporary DRX configuration in RA Msg2, which thus may include an indication/configuration of temporary DRX with any of the elaboration
10 alternatives described in section 1.1, i.e. a flag, an index, full or partial configuration (or a combination). A possible variant of using RA Msg2 for this purpose could be that the eNB takes the initiative to configure the UE with temporary DRX without a prior indication from the UE.

15 **1.9 Avoidance of Incompatibility Problems - Indication of Support of Temporary DRX in the Cell**

For those of the above described embodiments where the UE takes some action related to the temporary DRX feature before or without receiving any indication of support for the temporary DRX feature in the cell, it may be beneficial to include a
20 parameter in the system information (SI) indicating support of the temporary DRX feature in the cell. Absence of this indication would then imply lack of support, which would make the UE refrain from the temporary DRX feature related action(s) that could otherwise cause incompatibility problems.

25 Such actions could be that the UE sends an indication of intention and/or desire to use the temporary DRX feature or that the UE starts using the temporary DRX feature. The potential incompatibility problems that may be avoided by refraining from such actions could be e.g. that the eNB rejects (or discards) a message from the UE including a temporary DRX related indication that the eNB does not understand (or support), e.g.
30 the RRCConnectionRequest RRC message or the RRCConnectionSetupComplete RRC message, that the MME rejects a NAS message including a temporary DRX related indication or that the UE one-sidedly starts using the temporary DRX feature, i.e. goes into DRX sleep mode, causing the UE to miss downlink signaling messages from the eNB.

Turning now to figure 7, an example embodiment of a user equipment (UE) 10 will be described. The UE 10 may preferably, though not necessarily, be embodied as a MTC device. Furthermore, the UE 10 is configured to be either in an idle mode (e.g. RRC_IDLE) or in a connected mode (e.g. RRC_CONNECTED). In this embodiment, the UE 10 comprises an interface module 11, a processor 12, and a memory 13. Optionally, the UE 10 may also comprise a user interface 14 through which a user can operate and interact with the UE 10. The interface module 11 may comprise a transmitting module (Tx), or transmitter. The interface module may also comprise a receiving module (Rx), or receiver. Alternatively, the interface module 11 may comprise a transceiving module (Tx/Rx), or transceiver, with both transmission and reception capabilities.

The memory 13 may store computer program code, which, when run in the processor 12 causes the UE 10 to apply a discontinuous reception, DRX, cycle during a time period when the UE is in transition from the idle mode to the connected mode. As mentioned earlier, the DRX cycle may be a temporary DRX cycle. For example, the memory 13 may store computer program code, which, when run in the processor 12 causes the UE 10 to apply the temporary DRX cycle only when the UE is in transition from the idle mode to the connected mode.

In some embodiments, the *memory* 13 may store computer program code, which, when run in the *processor* 12 causes the UE 10 to cease, or stop, to apply the temporary DRX cycle when the UE has transitioned to the connected mode (e.g. RRC_CONNECTED).

In some embodiments, the memory 13 may also store computer program code, which, when run in the processor 12 causes the UE 10 to apply one or several DRX configuration parameters during the time period when the UE is in transition from the idle mode to the connected mode.

Yet further, the transmitter 11 may be configured to transmit a data message to a radio network node, wherein the data message comprises a request to apply the DRX cycle during the time period when the UE 10 is in transition from the idle mode to the

connected mode. Moreover, the receiver 11 may be configured to receive a data message from the radio network node, the data message comprising an acknowledgement of said request.

- 5 In some embodiments, the memory 13 may also store computer program code, which, when run in the processor 12 causes the UE 10 to retrieve the DRX cycle to be applied during the time period when the UE 10 is in transition from the idle mode to the connected mode. Also, the receiver 11 may be configured to receive a data message from a radio network node, wherein the data message comprises information about the
- 10 DRX cycle. Additionally, or alternatively, the memory 13 may store computer program code, which, when run in the processor 12 causes the UE 10 to retrieve information about the DRX cycle from a memory associated with the UE 10. The memory associated with the UE 10 may be the memory denoted 11. Alternatively, it may be another memory (not shown) of the UE 10. Yet further, it may be another memory (not
- 15 shown) which is external to the UE 10, i.e. not an integral part of the UE 10.

- Furthermore, the memory 13 may store computer program code, which, when run in the processor 12 causes the UE 10 to retrieve the DRX configuration parameters to be applied during the time period when the UE is in transition from the idle mode to the
- 20 connected mode. Also, the receiver 11 may be configured to receive a data message from a radio network node, wherein the data message comprises the DRX configuration parameters. Additionally, or alternatively, the memory 13 may store computer program code, which, when run in the processor 12 causes the UE 10 to retrieve the DRX configuration parameters from a memory associated with the UE.
- 25 Again, the memory associated with the UE 10 may be the memory denoted 11. Alternatively, it may be another memory (not shown) of the UE 10. Yet further, it may be another memory (not shown) which is external to the UE 10, i.e. the memory is not necessarily an integral part of the UE 10.

- 30 Turning to figure 8, an example embodiment of a radio network node 20 will be described. According to this example embodiment, the radio network node 20 comprises an interface module 21. The interface module 21 may comprise a transmitting module (Tx), or transmitter. The interface module 21 may also comprise a receiving module (Rx), or receiver. Alternatively, the interface module 21 may comprise

a transceiving module (Tx/Rx), or transceiver, with both transmission and reception capabilities.

5 The transmitter 21 may be configured to transmit a data message to a user equipment (UE), wherein the data message comprises information about a DRX cycle to be applied by the UE during the time period when the UE is in transition from the idle mode to the connected mode. The *transmitter* 21 may also be configured to transmit a data message to the UE, wherein the data message comprises DRX configuration parameters to be applied by the UE during the time period when the UE is in transition
10 from the idle mode to the connected mode.

The receiver 21 may be configured to receive a data message from a user equipment (UE), wherein the data message comprises a request to apply a DRX cycle during the time period when the UE is in transition from the idle mode to the connected mode. In
15 response, the transmitter 21 may be configured to transmit a data message to the UE, wherein the data message comprises an acknowledgement (ACK) of said request. Alternatively, the transmitter 21 may be configured to transmit a data message to the UE, wherein the data message comprises a negative acknowledgement (NACK) of said request.

20 The radio network node may be an evolved NodeB (eNB). Alternatively, the radio network node may be a Home Subscriber Server (HSS). Alternatively, the radio network node may be a Mobility Management Entity (MME). Yet further, it is conceivable that a distributed solution is utilized. That is, one or several of the eNB, HSS and MME may implement the herein described functionality of the radio network
25 node in a distributed manner.

According to some of the embodiments described throughout this disclosure, it is proposed to apply a DRX cycle during a time period when the UE is in transition from
30 the idle mode to the connected mode. Advantageously, the DRX cycle is temporary and applied only when the UE is in the transition from the idle mode to the connected mode. As soon as the UE is in connected mode, the normal (or, regular) connected mode DRX cycle can be applied in a conventional way. Applying a DRX cycle also in the time period between idle mode and connected mode may provide many

advantages as described hereinabove. For example, this may allow the UE to save power during its transition from idle mode to connected mode. Allowing UEs to save power during the otherwise power-consuming idle-to-connected mode transition signaling procedure may be beneficial to many UEs, particularly (though not
5 exclusively) MTC devices.

In the detailed description hereinabove, for purposes of explanation and not limitation, specific details are set forth in order to provide a thorough understanding of various embodiments described in this disclosure. In some instances, detailed descriptions of
10 well-known devices, components, circuits, and methods have been omitted so as not to obscure the description of the embodiments disclosed herein with unnecessary detail. All statements herein reciting principles, aspects, and embodiments disclosed herein, as well as specific examples thereof, are intended to encompass both structural and functional equivalents thereof. Additionally, it is intended that such equivalents include
15 both currently known equivalents as well as equivalents developed in the future, i.e., any elements developed that perform the same function, regardless of structure. Thus, for example, it will be appreciated that block diagrams herein can represent conceptual views of illustrative circuitry or other functional units embodying the principles of the embodiments. Similarly, it will be appreciated that any flow charts and the like
20 represent various processes which may be substantially represented in computer readable medium and so executed by a computer or processor, whether or not such computer or processor is explicitly shown. The functions of the various elements including functional blocks, may be provided through the use of hardware such as circuit hardware and/or hardware capable of executing software in the form of coded
25 instructions stored on computer readable medium. Thus, such functions and illustrated functional blocks are to be understood as being either hardware-implemented and/or computer-implemented, and thus machine-implemented. In terms of hardware implementation, the functional blocks may include or encompass, without limitation, digital signal processor (DSP) hardware, reduced instruction set processor, hardware
30 (e.g., digital or analog) circuitry including but not limited to application specific integrated circuit(s) [ASIC], and/or field programmable gate array(s) (FPGA(s)), and (where appropriate) state machines capable of performing such functions. In terms of computer implementation, a computer is generally understood to comprise one or more processors or one or more controllers. When provided by a computer or processor or

controller, the functions may be provided by a single dedicated computer or processor or controller, by a single shared computer or processor or controller, or by a plurality of individual computers or processors or controllers, some of which may be shared or distributed. Moreover, use of the term “processor” or “controller” shall also be
5 construed to refer to other hardware capable of performing such functions and/or executing software, such as the example hardware recited above.

Although the various embodiments of this disclosure have been described above with reference to specific embodiments, it is not intended to be limited to the specific form
10 set forth herein. For example, while many of the various embodiments have been described mainly with respect to EPS/LTE, it will come to mind to one skilled in the art having benefit of the teachings presented in the foregoing description and associated drawings that the general principles and concepts described herein can equally possible be utilized in e.g. UMTS/WCDMA/HSPA.

15

SELECTED EXAMPLE EMBODIMENTS

20 The technology disclosed herein thus encompasses without limitation the following example embodiments:

Example embodiment M1: A method performed by a user equipment, UE, wherein the UE is configured to be either in an idle mode or in a connected mode, the method
25 comprising:

applying a discontinuous reception, DRX, cycle during a time period when the UE is in transition from the idle mode to the connected mode.

Example embodiment M2: The method according to example embodiment M1, wherein
30 the DRX cycle is a temporary DRX cycle.

Example embodiment M3: The method according to example embodiment M2, wherein the temporary DRX cycle is applied only when the UE is in transition from the idle mode to the connected mode.

Example embodiment M4: The method according any one of the example embodiments M2-M3, further comprising:

5 ceasing to apply the temporary DRX cycle when the UE has transitioned to the connected mode.

Example embodiment M5: The method according to any one of the example embodiments M1-M4, further comprising:

10 applying one or several DRX configuration parameters during the time period when the UE is in transition from the idle mode to the connected mode.

Example embodiment M6: The method according to any one of the example embodiments M1-M5, further comprising, prior to applying the DRX cycle during the time period when the UE is in transition from the idle mode to the connected mode:

15 transmitting a data message to a radio network node, the data message comprising a request to apply the DRX cycle during the time period when the UE is in transition from the idle mode to the connected mode.

Example embodiment M7: The method according to the example embodiment M6, further comprising, prior to applying the DRX cycle during the time period when the UE is in transition from the idle mode to the connected mode:

20 receiving a data message from the radio network node, the data message comprising an acknowledgement of said request.

Example embodiment M8: The method according to any one of the example embodiments M1-M7, further comprising, prior to applying the DRX cycle during the time period when the UE is in transition from the idle mode to the connected mode:

25 retrieving the DRX cycle to be applied during the time period when the UE is in transition from the idle mode to the connected mode.

30

Example embodiment M9: The method according to example embodiment M8, wherein retrieving the DRX cycle to be applied during the time period when the UE is in transition from the idle mode to the connected mode comprises:

receiving a data message from a radio network node, the data message comprising information about the DRX cycle.

Example embodiment M10: The method according to example embodiment M8,
5 wherein retrieving the DRX cycle to be applied during the time period when the UE is in transition from the idle mode to the connected mode comprises:

retrieving information about the DRX cycle from a memory associated with the UE.

10 Example embodiment M11: The method according to any one of the example embodiments M1-M10, further comprising, prior to applying the DRX cycle during the time period when the UE is in transition from the idle mode to the connected mode:

retrieving DRX configuration parameters to be applied during the time period when the UE is in transition from the idle mode to the connected mode.

15

Example embodiment M12: The method according to example embodiment M11, wherein retrieving the DRX configuration parameters to be applied during the time period when the UE is in transition from the idle mode to the connected mode comprises:

20 receiving a data message from a radio network node, the data message comprising the DRX configuration parameters.

Example embodiment M13: The method according to example embodiment M11, wherein retrieving the DRX configuration parameters to be applied during the time
25 period when the UE is in transition from the idle mode to the connected mode comprises:

retrieving the DRX configuration parameters from a memory associated with the UE.

30 Example embodiment M14: The method according to any of the previous example embodiments, wherein the time period when the UE is in transition from idle mode to connected mode begins when the UE transmits (i.e. sends) an initial Random Access message (see Fig. 1).

Example embodiment M15: The method according to any of the previous example embodiments, wherein the time period when the UE is in transition from idle mode to connected mode ends when the UE transmits (i.e. sends) a RRCConnectionReconfigurationComplete message (see Fig. 1).

5

Example embodiment M16: The method according to any of the previous example embodiments, wherein applying the DRX cycle is started after a transmission or a reception of a data message during the time period when the UE is in transition from idle mode to connected mode (see Fig. 1).

10

Example embodiment M17: The method according to example embodiment M16, wherein applying the DRX cycle is started after a transmission of a RRCConnectionRequest message (see Fig. 1).

15

Example embodiment M18: A method performed by a radio network node, the method comprising:

transmitting a data message to a user equipment, UE, the data message comprising information about a DRX cycle to be applied by the UE during the time period when the UE is in transition from the idle mode to the connected mode.

20

Example embodiment M19: The method according to example embodiment M18, further comprising:

transmitting a data message to the UE, the data message comprising DRX configuration parameters to be applied by the UE during the time period when the UE is in transition from the idle mode to the connected mode.

25

Example embodiment M20: A method performed by a radio network node, the method comprising:

receiving a data message from a user equipment, UE, the data message comprising a request to apply a DRX cycle during the time period when the UE is in transition from the idle mode to the connected mode.

30

Example embodiment M21: The method according to the example embodiment M20, further comprising:

transmitting a data message to the UE, the data message comprising an acknowledgement of said request.

5

Example embodiment U1: A user equipment, UE, configured to be either in an idle mode or in a connected mode, the UE comprising:

a *processor*; and

a *memory* storing computer program code, which, when run in the
10 *processor* causes the UE to apply a discontinuous reception, DRX, cycle during a time period when the UE is in transition from the idle mode to the connected mode.

Example embodiment U2: The UE according to example embodiment U1, wherein the DRX cycle is a temporary DRX cycle.

15

Example embodiment U3: The UE according to example embodiment U2, wherein the *memory* stores computer program code, which, when run in the *processor* causes the UE to apply the temporary DRX cycle only when the UE is in transition from the idle mode to the connected mode.

20

Example embodiment U4: The UE according any one of the example embodiments U2-U3, wherein the *memory* stores computer program code, which, when run in the *processor* causes the UE to cease to apply the temporary DRX cycle when the UE has transitioned to the connected mode.

25

Example embodiment U5: The UE according to any one of the example embodiments U1-U4, wherein the *memory* stores computer program code, which, when run in the *processor* causes the UE to apply one or several DRX configuration parameters during the time period when the UE is in transition from the idle mode to the connected mode.

30

Example embodiment U6: The UE according to any one of the example embodiments U1-U5, further comprising a *transmitter* configured to transmit a data message to a radio network node, the data message comprising a request to apply the DRX cycle

during the time period when the UE is in transition from the idle mode to the connected mode.

5 Example embodiment U7: The UE according to the example embodiment U6, further comprising a *receiver* configured to receive a data message from the radio network node, the data message comprising an acknowledgement of said request.

10 Example embodiment U8: The UE according to any one of the example embodiments U1-U7, wherein the *memory* stores computer program code, which, when run in the *processor* causes the UE to retrieve the DRX cycle to be applied during the time period when the UE is in transition from the idle mode to the connected mode.

15 Example embodiment U9: The UE according to example embodiment U8, wherein the *receiver* is configured to receive a data message from a radio network node, the data message comprising information about the DRX cycle.

20 Example embodiment U10: The UE according to example embodiment U8, wherein the *memory* stores computer program code, which, when run in the *processor* causes the UE to retrieve information about the DRX cycle from a memory associated with the UE.

25 Example embodiment U11: The UE according to any one of the example embodiments U1-U10, wherein the *memory* stores computer program code, which, when run in the *processor* causes the UE to retrieve the DRX configuration parameters to be applied during the time period when the UE is in transition from the idle mode to the connected mode.

30 Example embodiment U12: The UE according to example embodiment U11, wherein the *receiver* is configured to receive a data message from a radio network node, the data message comprising the DRX configuration parameters.

Example embodiment U13: The UE according to example embodiment U11, wherein the *memory* stores computer program code, which, when run in the *processor* causes the UE to retrieve the DRX configuration parameters from a memory associated with the UE.

Example embodiment U14: The UE according to any of the example embodiments U1-U13, wherein the time period when the UE is in transition from idle mode to connected mode begins when the UE transmits (i.e. sends) an initial Random Access message
5 (see Fig. 1).

Example embodiment U15: The UE according to any of the example embodiments U1-U14, wherein the time period when the UE is in transition from idle mode to connected mode ends when the UE transmits (i.e. sends) a
10 RRCConnectionReconfigurationComplete message (see Fig. 1).

Example embodiment U16: The UE according to any of the example embodiments U1-U15, wherein applying the DRX cycle is started after a transmission or a reception of a data message during the time period when the UE is in transition from idle mode to
15 connected mode (see Fig. 1).

Example embodiment U17: The UE according to example embodiment U16, wherein applying the DRX cycle is started after a transmission of a RRCConnectionRequest message (see Fig. 1).
20

Example embodiment N1: A radio network node, comprising:
a *transmitter* configured to transmit a data message to a user equipment, UE, the data message comprising information about a DRX cycle to be applied by the UE during the time period when the UE is in transition from the idle mode to the
25 connected mode.

Example embodiment N2: The radio network node according to example embodiment N1, wherein the *transmitter* is configured to transmit a data message to a user equipment, UE, the data message comprising DRX configuration parameters to be
30 applied by the UE during the time period when the UE is in transition from the idle mode to the connected mode.

Example embodiment N3: The radio network node according to example embodiment N1 or N2, wherein the radio network node comprises one or several of the following: an

evolved NodeB (eNB), a Home Subscriber Server (HSS), a Mobility Management Entity (MME).

Example embodiment N4: A radio network node, comprising:

- 5 a *receiver* configured to receive a data message from a user equipment, UE, the data message comprising a request to apply a DRX cycle during the time period when the UE is in transition from the idle mode to the connected mode.

- 10 Example embodiment N5: The radio network node according to the example embodiment N4, further comprising a *transmitter* configured to transmit a data message to the UE, the data message comprising an acknowledgement of said request

- 15 Example embodiment N6: The radio network node according to example embodiment N4 or N5, wherein the radio network node comprises one or several of the following: an evolved NodeB (eNB), a Home Subscriber Server (HSS), a Mobility Management Entity (MME).

- 20 Modifications and other variants of the described embodiments will come to mind to one skilled in the art having benefit of the teachings presented in the foregoing description and associated drawings. Therefore, it is to be understood that the embodiments are not limited to the specific example embodiments disclosed and that modifications and other variants are intended to be included within the scope of this disclosure. Although specific terms may be employed herein, they are used in a
25 generic and descriptive sense only and not for purposes of limitation.

ABBREVIATIONS

- | | |
|---------|--|
| 3GPP | 3 rd Generation Partnership Project |
| CC | Credit Control |
| 30 DL | Downlink |
| DRX | Discontinuous Reception |
| eNB | eNodeB |
| eNodeB | E-UTRAN NodeB |
| EPS | Evolved Packet System |

	E-UTRA	Evolved Universal Terrestrial Radio Access
	E-UTRAN	Evolved UTRAN
	GPRS	General Packet Radio Service
	GTPv2-C	The control plane part of the GPRS Tunneling Protocol version 2.
5	HLR	Home Location Register
	HSPA	High Speed Packet Access
	HSS	Home Subscriber Server
	IE	Information Element
	IMSI	International Mobile Subscriber Identity
10	IP	Internet Protocol
	IP-CAN	IP Connectivity Access Network
	LTE	Long Term Evolution
	M2M	Machine-to-Machine
	MAC	Medium Access Control
15	MD	Machine Device
	MME	Mobility Management Entity
	MOD	Modulo
	MS	Mobile Station
	Msg	Message
20	MTC	Machine Type Communication
	NAS	Non-Access Stratum
	PCEF	Policy and Charging Enforcement Function
	PCRF	Policy and Charging Rules Function
	PDN	Packet Data Network
25	PDU	Packet Data Unit
	PGW	PDN Gateway
	RA	Random Access
	RRC	Radio Resource Control
30	S1	The interface between the Radio Access Network and the Core network in EPS.
	S1AP	S1 Application Protocol (a control plane protocol used between an eNB and an MME)
	SGSN	Serving GPRS Support Node
	SGW	Serving Gateway

	SI	System Information
	TS	Technical Specification
	UE	User Equipment
	UL	Uplink
5	UMTS	Universal Mobile Telecommunications System
	USIM	Universal Subscriber Identity Module
	UTRAN	Universal Terrestrial Radio Access Network
	WCDMA	Wideband Code Division Multiple Access

CLAIMS

1. A method performed by a user equipment, UE, wherein the UE is configured to be either in an idle mode or in a connected mode, the method comprising:
5 applying (210) a discontinuous reception, DRX, cycle during a time period when the UE is in transition from the idle mode to the connected mode.
2. The method according to claim 1, wherein the DRX cycle is a temporary DRX cycle.
10
3. The method according to claim 2, wherein the temporary DRX cycle is applied (210) only when the UE is in transition from the idle mode to the connected mode.
- 15 4. The method according any one of the claims 1-3, comprising:
 ceasing (230) to apply the temporary DRX cycle when the UE has transitioned to the connected mode.
5. The method according to any one of the claims 1-4, comprising:
20 applying (220) one or several DRX configuration parameters during the time period when the UE is in transition from the idle mode to the connected mode.
- 25 6. The method according to any one of the claims 1-5, comprising, prior to applying (210) the DRX cycle during the time period when the UE is in transition from the idle mode to the connected mode:
 transmitting a data message to a radio network node, the data message comprising a request to apply the DRX cycle during the time period when the UE is in transition from the idle mode to the connected mode.
30
7. The method according to claim 6, comprising, prior to applying the DRX cycle during the time period when the UE is in transition from the idle mode to the connected mode:

receiving a data message from the radio network node, the data message comprising an acknowledgement of said request.

- 5 8. The method according to any one of the claims 1-7, comprising, prior to applying (210) the DRX cycle during the time period when the UE is in transition from the idle mode to the connected mode:

retrieving (410) the DRX cycle to be applied during the time period when the UE is in transition from the idle mode to the connected mode.

- 10 9. The method according to claim 8, wherein retrieving (410) the DRX cycle to be applied during the time period when the UE is in transition from the idle mode to the connected mode comprises:

receiving (411) a data message from a radio network node, the data message comprising information about the DRX cycle.

15

10. The method according to claim 8, wherein retrieving (410) the DRX cycle to be applied during the time period when the UE is in transition from the idle mode to the connected mode comprises:

20 retrieving (412) information about the DRX cycle from a memory associated with the UE.

11. The method according to any one of the claims 5-10, comprising, prior to applying (210) the DRX cycle during the time period when the UE is in transition from the idle mode to the connected mode:

25 retrieving (420) DRX configuration parameters to be applied during the time period when the UE is in transition from the idle mode to the connected mode.

- 30 12. The method according to claim 11, wherein retrieving (420) the DRX configuration parameters to be applied during the time period when the UE is in transition from the idle mode to the connected mode comprises:

receiving (421) a data message from a radio network node, the data message comprising the DRX configuration parameters.

13. The method according to claim 11, wherein retrieving (420) the DRX configuration parameters to be applied during the time period when the UE is in transition from the idle mode to the connected mode comprises:
retrieving (422) the DRX configuration parameters from a memory
5 associated with the UE.
14. A method performed by a radio network node, the method comprising:
transmitting (510) a data message to a user equipment, UE, the data
message comprising information about a DRX cycle to be applied by the UE
10 during the time period when the UE is in transition from the idle mode to the connected mode.
15. The method according to claim 14, comprising:
transmitting (520) a data message to the UE, the data message
15 comprising DRX configuration parameters to be applied by the UE during the time period when the UE is in transition from the idle mode to the connected mode.
16. The method according to claim 14 or 15, comprising: receiving (610) a data
20 message from a user equipment, UE, the data message comprising a request to apply a DRX cycle during the time period when the UE is in transition from the idle mode to the connected mode.
17. The method according to claim 16, comprising:
25 transmitting (620) a data message to the UE, the data message comprising an acknowledgement of said request.
18. A user equipment, UE (10), configured to be either in an idle mode or in a
connected mode, the UE comprising:
30 a *processor* (12); and
a *memory* (13) storing computer program code, which, when run in the *processor* causes the UE (10) to apply a discontinuous reception, DRX, cycle during a time period when the UE is in transition from the idle mode to the connected mode.

19. The UE (10) according to claim 18, wherein the DRX cycle is a temporary DRX cycle.
- 5 20. The UE (10) according to claim 19, wherein the *memory* (13) stores computer program code, which, when run in the *processor* (12) causes the UE (10) to apply the temporary DRX cycle only when the UE is in transition from the idle mode to the connected mode.
- 10 21. The UE (10) according any one of the claims 18-20, wherein the *memory* (13) stores computer program code, which, when run in the *processor* (12) causes the UE (10) to cease to apply the temporary DRX cycle when the UE has transitioned to the connected mode.
- 15 22. The UE (10) according to any one of the claims 18-21, wherein the *memory* (13) stores computer program code, which, when run in the *processor* (12) causes the UE to apply one or several DRX configuration parameters during the time period when the UE is in transition from the idle mode to the connected mode.
- 20 23. The UE (10) according to any one of the claims 18-22, comprising a *transmitter* (11) configured to transmit a data message to a radio network node, the data message comprising a request to apply the DRX cycle during the time period when the UE is in transition from the idle mode to the connected mode.
- 25 24. The UE (10) according to claim 23, comprising a *receiver* (11) configured to receive a data message from the radio network node, the data message comprising an acknowledgement of said request.
- 30 25. The UE (10) according to any one of the claims 18-24, wherein the *memory* (13) stores computer program code, which, when run in the *processor* (12) causes the UE to retrieve the DRX cycle to be applied during the time period when the UE is in transition from the idle mode to the connected mode.

26. The UE (10) according to claim 25, wherein the *receiver* (11) is configured to receive a data message from a radio network node, the data message comprising information about the DRX cycle.
- 5 27. The UE (10) according to claim 25, wherein the *memory* stores computer program code, which, when run in the *processor* causes the UE (10) to retrieve information about the DRX cycle from a memory associated with the UE.
- 10 28. The UE (10) according to any one of the claims 22-27, wherein the *memory* (13) stores computer program code, which, when run in the *processor* (12) causes the UE (10) to retrieve the DRX configuration parameters to be applied during the time period when the UE is in transition from the idle mode to the connected mode.
- 15 29. The UE (10) according to claim 28, wherein the *receiver* (11) is configured to receive a data message from a radio network node, the data message comprising the DRX configuration parameters.
- 20 30. The UE (10) according to claim 28, wherein the *memory* (13) stores computer program code, which, when run in the *processor* (12) causes the UE (10) to retrieve the DRX configuration parameters from a memory associated with the UE.
- 25 31. A radio network node (20), comprising:
a *transmitter* (21) configured to transmit a data message to a user equipment, UE, the data message comprising information about a DRX cycle to be applied by the UE during the time period when the UE is in transition from the idle mode to the connected mode.
- 30 32. The radio network node (20) according to claim 31, wherein the *transmitter* (31) is configured to transmit a data message to a user equipment, UE, the data message comprising DRX configuration parameters to be applied by the UE during the time period when the UE is in transition from the idle mode to the connected mode.

33. The radio network node (20) according to claim 31 or 32, comprising:
a *receiver* (21) configured to receive a data message from a user
equipment, UE, the data message comprising a request to apply a DRX cycle
5 during the time period when the UE is in transition from the idle mode to the
connected mode.
34. The radio network node (20) according to claim 33, comprising a *transmitter*
configured to transmit a data message to the UE, the data message comprising
10 an acknowledgement of said request
35. The radio network node (20) according to any of the claims 31-34, wherein the
radio network node comprises one or several of the following: an evolved
NodeB (eNB), a Home Subscriber Server (HSS), a Mobility Management Entity
15 (MME).