Title of the Invention: Method of operating a communication system

Abstract Title: Communication network inhibits or enables NAS signalling recovery after radio link failure

A communication system comprises a Non Access Stratum (NAS) via which a network and user equipment (UE) communicate, and an Access Stratum (AS) providing physical connections to enable NAS communication between the network and UE. The physical connections include a radio link to the UE. Information is sent from the network to the UE to determine action of the UE in response to the failure of the radio link. Upon detecting a radio link failure (RLF), the UE performs a decided action according to the received information. The decided action may comprise NAS signaling recovery procedure, e.g. triggering a service request, tracking area update (TAU) or routing area update (RAU), dependent upon what information the UE has previously received from the network, i.e. the network may have sent information to inhibit/prevent or enable NAS signaling recovery after a RLF. Hence, network operators may remotely set or configure the UE, in terms of what action it takes after detection of a RLF, in order to 'switch on' or 'switch off' this NAS signaling recovery.

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

This print takes account of replacement documents submitted after the date of filing to enable the application to comply with the formal requirements of the Patents Rules 2007.
UE is in a media session with NW. There is UL data and DL data.
AS is in RRC_connected
NAS is in EMM_connected

AS detects RLF
AS takes action to recover

AS recovery action ends up with
- UE is in another eNB
- NAS in EMM_IDLE

AS recovery action ends up with
- UE is in same eNB
- NAS in EMM_IDLE

UE has UL data to send?
Yes
NAS sends SERVICE_REQUEST to request radio bearers for UL data
NAS moves to EMM_CONNECTED mode
NAS stays in EMM_CONNECTED

No
NAS stays in EMM_IDLE awaits NW action
If NW has DL data NW pages the UE
NAS moves to EMM_CONNECTED mode
FIG. 3

UE is in a media session with NW. There is UL data and DL data.
AS is in RRC_connected
NAS is in EMM_connected

AS detects RLF
AS takes action to recover

AS recovery action ends up with
- UE is in another eNB
- NAS in EMM_IDLE

AS indicated to NAS there has been RLF

On being informed of RLF, NAS sends SERVICE_REQUEST to request radio bearers regardless if needed

NAS moves to EMM_CONNECTED mode

NAS stays in EMM_CONNECTED
UE is in a media session with NW. There is UL data and DL data. AS is in RRC_connected NAS is in EMM_connected

AS detects RLF
AS takes action to recover

AS recovery action ends up with
- UE is in another eNB
- NAS in EMM_IDLE

AS recovery action ends up with
- UE is in same eNB
- NAS in EMM_IDLE

AS indicated to NAS there has been RLF

Is "NAS specific_signalling_for_recovery" indication available?

Yes

Check if "NAS specific_signalling_for_recovery" indication allow is NAS signalling to recover after RLF allowed?

No

Of fig. 2

Yes

On being informed of RLF, NAS sends SERVICE_REQUEST to request radio bearers regardless if needed

NAS moves to EMM_CONNECTED mode

NAS stays in EMM_CONNECTED

FIG. 4
FIG. 5

ATTACH_REQUEST

UE

MME

ATTACH_ACCEPT

["NAS specific_signalling_for_recovery"]

FIG. 6

TRACKING_AREA_UPDATE_REQUEST

UE

MME

TRACKING_AREA_UPDATE_ACCEPT

["NAS specific_signalling_for_recovery"]

FIG. 7

ROUTING_AREA_UPDATE_REQUEST

UE

SGSN

ROUTING_AREA_UPDATE_ACCEPT

["NAS specific_signalling_for_recovery"]
FIG. 8

FIG. 9

RRC signalling to eNB
RRC signalling response from eNB
["NAS specific_signalling_for_recovery"]
Method of Operating a Communication System

Field of the Invention

The present invention relates to communication (telecommunication) systems, and in particular, although not exclusively, to 3GPP telecommunications systems.

Background to the Invention

Communication systems (which may also be described as telecommunications systems) able to provide wireless connections to mobile user equipment (or UE) are well known, and have a variety of configurations. Work is ongoing to develop technical specifications for so-called 3GPP systems.

For the purpose of ease of elaboration and also for readers unfamiliar with terms and abbreviations within the 3GPP, some of the used abbreviation and terms used in this specification are provided here. It must be clearly noted and understood by readers that whilst every attempt has been made to have the terms and abbreviations used in this document to be an exact match with those terms and abbreviations used in 3GPP, the terms and abbreviations here listed are strictly only for the purpose of use relating to this document.

Abbreviations

AS Access Stratum.
CN Core Network
DOI Description Of Invention
eNB Enhanced Node B
EPC Enhanced Packet Core
EPS Enhanced Packet System (For information: eNB + EPC = EPS)
HPLMN Home PLMN
LTE Long Term Evolution (relate most to the Radio Access Network)
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PLMN</td>
<td>Public Land Mobile Network</td>
</tr>
<tr>
<td>PS</td>
<td>Packet Switched</td>
</tr>
<tr>
<td>SAE</td>
<td>System Architecture Evolution (relate most to the EPC)</td>
</tr>
<tr>
<td>SIM</td>
<td>Subscriber Identity Module</td>
</tr>
<tr>
<td>UE</td>
<td>User Equipment</td>
</tr>
<tr>
<td>UMTS</td>
<td>Universal Mobile Telecommunications System</td>
</tr>
<tr>
<td>USIM</td>
<td>UMTS SIM</td>
</tr>
<tr>
<td>VPLMN</td>
<td>Visited PLMN</td>
</tr>
<tr>
<td>RLF</td>
<td>Radio Link Failure</td>
</tr>
<tr>
<td>EMM_IDLE mode</td>
<td>[Extract from 3GPP TS 24.301] A UE is in EMM-IDLE mode when no NAS signalling connection between UE and network exists. The term EMM-IDLE mode used in the present document corresponds to the term ECM-IDLE state used in 3GPP TS 23.401</td>
</tr>
<tr>
<td>EMM_CONNECTED mode</td>
<td>[Extract from 3GPP TS 24.301] A UE is in EMM-CONNECTED mode when a NAS signalling connection between UE and network is established. The term EMM-CONNECTED mode used in the present document corresponds to the term ECM-CONNECTED state used in 3GPP TS 23.401</td>
</tr>
<tr>
<td>RRC_CONNECTED</td>
<td>[Extract from 3GPP TS 36.331] A UE is in RRC_CONNECTED when an RRC connection has been established. If this is not the case, i.e. no RRC connection is established, the UE is in RRC_IDLE state. Note: For more info, see 3GPP TS 36.331</td>
</tr>
<tr>
<td>NAS</td>
<td>Non Access Stratum</td>
</tr>
<tr>
<td>TAU</td>
<td>Tracking Area Update</td>
</tr>
<tr>
<td>RAU</td>
<td>Routing Area Update</td>
</tr>
</tbody>
</table>

Note: For abbreviations relevant to 3GPP please refer to TS 21.905. Should there be a conflict between the abbreviations given here above and abbreviations given in TS 21.905, the abbreviations given in TS 21.905 have precedence if the abbreviations are for 3GPP related terms.

**Terminologies**

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>WiMax</td>
<td>Broadband Wireless Access System being defined under IEEE 802.16e</td>
</tr>
</tbody>
</table>
In the proposed 3GPP systems, communication between the UE and the core network (CN or NW) is in a so-called non-access stratum (NAS) (in other words, communication is at the NAS level) and an access stratum (AS) provides services for the NAS. One such service is that the AS provides, and seeks to maintain, physical connections to enable the NAS layer communication between CN and UE to take place. These physical connections include radio links to the UE (i.e. wireless links). An issue with such systems is, of course, what to do in the event of a radio link failure (RLF). In other words, how should the system respond to a RLF? What steps, if any, should be taken in order to re-establish connection.

The RRC (Radio Resource Control) re-establishment procedure after radio link failure (RLF) or handover failure is not determined yet in 3GPP LTE (Long Term Evolution). A possibility is that after RLF or handover failure detection at the lower layers, the UE may take the following actions:

1. The UE starts a timer T311 and performs cell selection.
2. If the UE finds a suitable E-UTRAN cell (i.e., an accessible cell having sufficient radio quality), the UE initiates the re-establishment procedure by sending the RRC Connection Re-establishment Request message.
3. If the eNB cell receiving the RRC Connection Re-establishment Request was "prepared" (i.e., either was the source cell or a cell that was prepared by the source cell with the UE context through the handover preparation procedure), the re-establishment procedure succeeds.
4. If the eNB cell receiving the RRC Connection Re-establishment Request was not "prepared", the UE is rejected and pushed back to RRC_IDLE. Further connection recovery is left to NAS.
5. If the UE cannot find a suitable E-UTRAN cell, the UE can search UTRAN/GERAN cells. If the UE finds a suitable UTRAN/GERAN cell, the UE goes back to RRC_IDLE. Further connection recovery is left to (UTRAN/GERAN) NAS.
6. If the UE cannot find a suitable cell before T311 expiry, the UE goes back to RRC_IDLE.

In the event that the UE reaches steps 4, 5 or 6, one would expect that the connection would be recovered by the NAS, e.g. by NAS initiating a new NAS Service Request procedure. However, this is only likely if the UE had pending UL (Up Link) data. In the event that there was no pending UL data, but there was DL (Down Link) data in the
network side, the NAS recovery procedure will not be triggered. Hence, one possible option would be to indicate the specific case of radio failure to NAS, so that NAS can initiate the recovery procedure in both cases (i.e. whether or not there was UL data remaining to be sent). Note that after step 5, one would also expect that the NAS will recover the connection by an inter-RAT recovery procedure.

A possibility, involving NAS specific recovery, is that the NAS can, after recovery from RLF (made known to the NAS by the AS) trigger a Service Request or a TAU_Request to ensure that the connection to the network is reestablished.

The main driver for this technique would be that the network might have DL data waiting to send to the UE. At present (that is, according to the current state of 3GPP discussions) the NAS, after RLF, will just stay in IDLE (i.e. an idle mode, or idle state) if there is no UL data to send. Only if the UE has UL data to send will the NAS autonomously perform or trigger a request for radio bearers after recovery from RLF. So, in the event that there is DL, that DL data that will only reach the UE after a paging procedure. That may be unacceptable to certain operators (e.g. because it involves too long a delay).

In addition to the above scenario, another possible scenario is as follows:-

i) cell A and cell B are located within the same TA and both cells are connected to same eNB and MME.

ii) UE is in cell A, in a media session with the network and data exchange is ongoing

iii) There is a radio level failure and RRC attempts to recover

iv) RRC, in an attempt to recover, performs cell reselection onto cell B

v) During this period, there is no UL data pending. There is no TAU, as cell A and cell B are within the same TA.

vi) There is a network equivalent of T311 and that network timer is still running. Until the network equivalent of T311 expires, the MME is not aware that the UE is no longer in cell A.

vii) DL data arrives at the network. The network will pass the DL data to the eNB to deliver through cell A.

In this scenario, even though the UE has recovered itself, it is in a new radio area and the network still thinks the UE is in the old (previous) radio area. So in this scenario the
paging from the NW to deliver DL data will fail and the paging needs to be escalated to paging a wider radio area.

From the above examples and discussion of the identified problems, it will be appreciated that some of these techniques post-RLF may result in an unacceptable service for the user. Hence, a NAS solution (done by triggering Service Request or TAU or RAU) (in other words a NAS specific recovery) after detection of a RLF may provide the means to overcome loss of this possible anticipated DL data, and hence provide improved user services.

On the other hand, however, such automatic use of NAS specific recovery also has disadvantages associated with it, as will be appreciated from the following:

1. The network equivalent of T311 (for sake of description called T311-nw) can be properly configured to allow the NE to know if the UE is no longer in previous radio area (i.e. the S1 connection can be taken down upon expiry of T311-nw). So, subsequent paging will immediately go for a paging in a wider area.

2. The paging and UE responding will only take some 2 or 3 seconds and services will not be severely affected. For GBR services that is likely to be some UL data very soon and that in itself will cause UE to trigger a Service Request. For non-GBR services, that by nature can suffer seconds of interruption.

3. The complexities may not outweigh the gain. The gain may be a matter of 6 to 8 seconds compared to 13 seconds if nothing is done. It could be argued that if T311-nw is set correctly, to 5 seconds, for example, then with 2 – 3 sec of paging delay that will only take 7 to 8 secs, and that is comparable to doing all the complexities to get to 6 to 8 seconds.

4. The performance of NAS signalling, be it Service Request or TAU request or RAU request, is in anticipation of there being DL data to be transmitted to the UE. There is no certainty, however, that there will be DL data.

5. Performing the NAS signalling after detection of a RLF will cause a large signalling spike in certain conditions, for example in the situation where a trainload of users go into and then come out of a tunnel.
Thus, automatic performance of NAS restoration procedures after a RLF can have disadvantages associated with it. Adoption of such a procedure may not suit all operators and all situations.

5 Summary of the invention

It is an aim of certain embodiments of the invention to solve, mitigate or obviate, at least partly, at least one of the problems and/or disadvantages associated with the prior art. Certain embodiments aim to provide at least one of the advantages described below.

10 According to a first aspect of the invention there is provided a method of operating a communication system comprising a network (which, in certain embodiments, may be described as a core network)(NW) and user equipment (UE), a Non Access Stratum (NAS) via which the NW and UE communicate with each other, and an Access Stratum (AS) providing physical connections to enable the NAS communication between the NW and UE to be achieved, the physical connections including a wireless radio link to the UE, the method comprising:

sending information from the NW to the UE to determine at least one action of the UE in response to the failure of a radio link to the UE;

20 detecting a said radio link failure (RLF);

in response to detecting said RLF, deciding on an action to be performed by the UE according to the received information; and

performing, with the UE, the decided action.

25 According to another aspect of the invention there is provided a method of operating a communication system comprising a core network (NW), user equipment (UE), and an Access Network providing physical connections to enable the communication between the NW and UE to be achieved, the physical connections including a wireless radio link to the UE, the method comprising:

20 sending information from the NW to the UE to determine at least one action of the UE in response to the failure of a radio link to the UE;

30 detecting a said radio link failure (RLF);

in response to detecting said RLF, deciding on an action to be performed by the UE according to the received information; and

35 performing, with the UE, the decided action.
It will be appreciated that, in its broadest sense, the inventive method is not limited to any particular action or inaction by the UE. Embodiments of the invention may utilise the concept of remote setting or configuration of the UE (in terms of what action the UE performs in response to a RLF) by the NW.

In certain embodiments the decided action comprises the sending or triggering of a service request.

In certain embodiments the decided action comprises the sending or triggering of a TAU.

In certain embodiments the decided action comprises the sending or triggering of a RAU.

In certain embodiments said deciding on an action comprises deciding whether or not to send or initiate a service request, a TAU, or a RAU.

In certain embodiments the method further comprises storing said information in the UE.

In certain embodiments the method further comprises configuring (which may also be described as setting a configuration of, setting, setting a state of) the UE according to the received information.

In certain embodiments said deciding comprises deciding on an action according to the configuration of the UE.

In certain embodiments said sending comprises sending said information in an ATTACH_ACCEPT message.

In certain embodiments said sending comprises sending said information in a TRACKING_AREA_UPDATE_ACCEPT message.

In certain embodiments said sending comprises sending said information in a ROUTING_AREA_UPDATE_ACCEPT message.

In certain embodiments said sending comprises sending said information in a GUTI_REALLOCATION_COMMAND message.
In certain embodiments said sending comprises sending said information in a message from an eNB to the UE.

In certain embodiments said sending comprises sending said information in a message having a format from a list comprising: SMS; and OMA DM.

In certain embodiments said sending comprises sending said information in a RRC signalling message.

Another aspect of the invention provides a communication system adapted to implement a method in accordance with any of the above aspects.

Another aspect provides user equipment adapted for use in such a communication system.

Yet another aspect provides a computer program comprising instructions arranged, when executed, to implement a method and/or a system as claimed in any claim of this specification.

Another aspect provides machine-readable storage storing a program as claimed in any claim of this specification.

**Brief Description of the Drawings**

Embodiments of the invention will now be described with reference to the accompanying drawings, of which:

Fig. 1 is a schematic representation of a communications system embodying the invention;

Fig. 2 is a flowchart illustrating a known method of operating a communications system;

Fig. 3 is a flowchart illustrating a possible alternative method of operating a communications system;

Fig. 4 is a flowchart illustrating a method of operating a communications system and which embodies the present invention;
Figs. 5 to 9 illustrate the sending of messages in embodiments of the invention; and Figs. 10 and 11 illustrates the SAE/LTE reference architecture, as defined by 3GPP, and in which methods embodying the invention may be implemented.

Description of embodiments of the invention

Referring now to Fig 1, this is a highly schematic representation of a communication system embodying the invention, and in which methods also embodying the invention may be implemented. The system comprises a core network CN, user equipment UE, and an E-UTRAN system sitting/operating between the CN and the UE. Communication between the UE and CN is in a Non-Access Stratum (NAS). An Access Stratum (AS) provides services for the NAS. In particular, the AS provides physical connections to enable the NAS communication between the NW and UE to be achieved, the physical connections including a wireless radio link to the UE (in other words, the AS provides the physical radio interface between the UE and E-UTRAN in this example). The AS also provides the physical link for the NAS/E-UTRAN interface. The system shown in fig. 1 is arranged to perform a method comprising:

- sending information from the NW to the UE to determine at least one action of the UE in response to the failure of a radio link to the UE;
- detecting a said radio link failure (RLF);
- in response to detecting said RLF, deciding on an action to be performed by the UE according to the received information; and
- performing, with the UE, the decided action.

The decided action may, for example, comprise one or more NAS signalling recovery actions or procedures. Whether or not NAS signalling recovery is performed, or at least triggered, may thus be dependent upon what information the UE has previously received from the network. The network may have sent information/a signal to inhibit/prevent NAS signalling recovery after a RLF, or alternatively to enable such action. Thus, certain embodiments provide methods to limit the NAS signalling recovery after a RLF for operators who either do not want it or see it as a disadvantage. These methods provide the network with means to remotely set or configure the UE, in terms of what action it takes after detection of a RLF by the AS. In other words, certain embodiments provide a way to ‘switch on’ switch off’ this NAS signalling recovery after detection of RLF.
As further background to the invention, fig. 2 is a flowchart illustrating a known method. Descriptions of the method steps are contained in the figure and are not repeated here.

Fig. 3 illustrates an alternative method, in which NAS specific recovery is automatically performed after a RLF. In this figure only the triggering of the SERVICE_REQUEST is illustrated. Fig. 3 thus illustrates a technique for a NAS specific recovery by NAS signalling. What is clear from fig. 3 is that it results in the UE unconditionally triggering SERVICE_REQUEST. This will bring about the unwarranted and undesirable signalling load. To couple with this disadvantage, this way of NAS specific recovery is done in anticipation that there will be DL data, which might not be the case at all. So allocated radio resources will be wasted.

In contrast to the methods shown in figs 2 and 3, embodiments of the invention are able to allow networks and operators to have a choice as to whether there will be this NAS specific recovery. In giving the network and the operator the choice, the network operator can choose if he wishes to risk the disadvantages of NAS specific recovery.

Fig. 4 illustrates a method embodying the invention and which provides a solution to the problem of restricting unnecessary Service Request after RLF. The solution consist of the following:-

> The network provides an indication to the UE whether the UE can perform NAS specific recovery after recovery from RLF.

> For the sake of description, let's called this indication "NAS specific_signalling_for_recovery"

> The UE checks for network indication "NAS specific_signalling_for_recovery" to ascertain if UE can perform NAS specific recovery after recovery from RLF.

> If UE does not get the indication "NAS specific_signalling_for_recovery" that NAS specific recovery is allowed or if the indication "NAS specific_signalling_for_recovery" from the network is that UE is not allowed to perform NAS specific recovery after recovery from RLF, then NAS will not perform NAS specific recovery after recovery from RLF.
If UE gets the indication "NAS specific_signalling_for_recovery" that NAS specific recovery is allowed, then UE can trigger NAS specific recovery after recovery from RLF.

Figure 4 thus shows an embodiment in which an Indication to allow or disallow NAS specific recovery is provided to the UE by the NW.

In embodiments of the invention, the NW can provide the information (indication) to the UE in a variety of ways. Some methods of providing this "NAS_specific_signalling_for_recovery" indication are shown in figs. 5 to 8. These illustrate ways of providing the information for decision-making purposes (e.g. the indication of need for NAS signaling recovery). In the Attach Accept, TAU Accept, RAU Accept, GUTI Reallocation and all appropriate NAS signaling provides the "NAS specific_signalling_for_recovery". These indications will indicate to the UE whether the NAS signaling to recover connection to NW after RLF is to be done. In other words, the information can be included in/ sent with any of these Attach Accept, TAU Accept, RAU Accept, GUTI Reallocation messages.

Certain embodiments comprise the providing of the Indication at the AS level.

In both the methods below, this indication given at AS level is conveyed to NAS through implementation specific means and will not be described further.
In certain embodiments the Indication is provided over Broadcast channels.

In certain embodiments the Indication is provided by AS signalling. For example, in certain embodiments RRC signalling provide the "NAS specific_signalling_for_recovery" indication to the AS of the UE. The AS of the UE will pass this "NAS specific_signalling_for_recovery" indication up to NAS whether NAS signalling to recover the connection is required after detecting RLF. The internal As to NAS communications are subject to implementation dependencies and are not discussed in further detail here. An example of such sending of the information as part of RRC signalling is shown in fig. 9.

In certain embodiments the information (e.g. the Indication) is provided to the UE through OTA mechanisms. By OTA mechanisms an indication can be provide to UE. Such OTA mechanism, which may be used in embodiments, include (but not limited to) the following:-
- SMS
- OMA DM

It will be appreciated from the above that certain NAS restoration procedures following Radio Link Failure (RLF) indication from the AS may not involve the UE first returning to Idle mode. In certain embodiments, the UE may return to IDLE, but in alternative embodiments it does not. A possible reason for not returning to idle mode is that there are circumstances (e.g. Guaranteed Bit Rate Downlink streamed video via UDP) in which the UE will have no data to send in the Uplink direction, and so will not immediately send Service Request to re-establish the dedicated EPC Bearer following RLF. In that case it could be argued that, as the UE would return to Idle mode, it would be necessary for the network to page the UE (potentially via a cell in which the UE is no longer present) and then for the UE to re-establish the RRC connection before the downlink data flow can resume. This could lead to unacceptable data interruption times for GBR services and unsatisfactory user experience. Furthermore, paging might not reach the UE if the UE has moved to another cell and NW is not (yet) informed. So paging escalation is needed, adding a further few seconds of delay.

A concern is that if the UE automatically invokes NAS restoration procedures on receiving the RLF indication from the AS, this could lead to a spike in signalling to the network if a large group of users in the same cell loses coverage and then all attempt
restoration procedures at the same time. One example is that of a train load of users entering and leaving a tunnel. It is very hard for the NAS to determine what kind of service was actually in use at RLF. The RABM can know that but the RABM has not an indication of RLF. So the one that does know the RLF does not know the service used, while the one that does know the service in use does not know a RLF has occurred.

Certain embodiments of the invention give the operators (the network, or core network) a chance to control whether the UE should automatically attempt NAS restoration procedures on detection of RLF from the AS, and provide that this indication may be communicated to the UE via system information broadcast, explicit NAS signalling, or OTA provisioning.

It will be appreciated that certain embodiments of the invention are 3GPP specific. However, embodiments may also relate to other wireless systems that effectively comprise both an Access Network and a Core Network. The Non-Access Stratum is essentially a generic term to describe the stratum that encapsulates the layer 3 (and in some cases layer 4) protocols used for communication between the UE and the Core Network. Likewise, the Access Stratum is a generic term used to describe the stratum that encapsulates the Layer 2 / Layer 3 protocols used for communication between the UE and the Access Network and between the Access Network and the Core Network.

3GPP TS 23.101 defines the Access Stratum as "...the functional groupings consisting of the parts in the infrastructure and in the user equipment and the protocols between these parts being specific to the access technique (i.e. the way the specific physical media between the User Equipment and the Infrastructure is used to carry information). The access stratum provides services related to the transmission of data over the radio interface and the management of the radio interface to the other parts of UMTS. The access stratum includes the following protocols:

- Mobile Termination - Access Network. This protocol supports transfer of detailed radio-related information to co-ordinate the use of radio resources between the MT and the access network.
- Access Network - Serving Network. This protocol supports the access from the serving network to the provided by the access network. It is independent of the specific radio structure of the access network."
The Non-Access Stratum is defined implicitly in TS 23 110 (UMTS access stratum services and functions) where it is used to describe the boundaries of the Access Stratum.

Other methods embodying the invention are implemented in systems comprising UE, Core Network (CN) and Access Network (AN). In such embodiments, the CN sends the information to the UE to determine the course of action on detection of Radio Link Failure and the RLF is detected by the UE based on communication (or lack thereof) between it and the AN.
As further background to the invention, figs 10 and 11 illustrate SAE/LTE Reference Network Architecture

Figure 10 below – extracted from 23.401 – gives an illustration of the SAE/LTE reference architecture as defined by 3GPP.

Highlighted in Figure 10 is also the 2G GSM/GPRS system (GERAN + SGSN) and the 3G UMTS system (UTRAN + SGSN). By that one is able to the see the "link-up" from/to the 3GPP 2G and 3G system and 3GPP's SAE/LTE.

The ideas, methods and claims described in the main part of this document refers to EPC and EPS and in particular refers to possible Interworking Functions within the EPC.

To help visualize the scope of EPC, Figure 11 is provided. For Figure 11, it should be noted that EPC also encompasses the HSS.

It will be appreciated that embodiments of the present invention can be realized in the form of hardware, software or a combination of hardware and software. Any such software may be stored in the form of volatile or non-volatile storage such as, for example, a storage device like a ROM, whether erasable or rewritable or not, or in the form of memory such as, for example, RAM, memory chips, device or integrated circuits or on an optically or magnetically readable medium such as, for example, a CD, DVD, magnetic disk or magnetic tape or the like. It will be appreciated that the storage devices and storage media are embodiments of machine-readable storage that are suitable for storing a program or programs comprising instructions that, when executed, implement embodiments of the present invention. Accordingly, embodiments provide a program comprising code for implementing a system or method as claimed in any one of the claims of this specification and a machine-readable storage storing such a program.

Still further, such programs may be conveyed electronically via any medium such as a communication signal carried over a wired or wireless connection and embodiments suitably encompass the same.

Throughout the description and claims of this specification, the words “comprise” and “contain” and variations of the words, for example “comprising” and “comprises”, means “including but not limited to”, and is not intended to (and does not) exclude other moieties, additives, components, integers or steps.
Throughout the description and claims of this specification, the singular encompasses the plural unless the context otherwise requires. In particular, where the indefinite article is used, the specification is to be understood as contemplating plurality as well as singularity, unless the context requires otherwise.

Features, integers, characteristics, compounds, chemical moieties or groups described in conjunction with a particular aspect, embodiment or example of the invention are to be understood to be applicable to any other aspect, embodiment or example described herein unless incompatible therewith.

It will be also be appreciated that, throughout the description and claims of this specification, language in the general form of "X for Y" (where Y is some action, activity or step and X is some means for carrying out that action, activity or step) encompasses means X adapted or arranged specifically, but not exclusively, to do Y.
CLAIMS

1. A method of operating a communication system comprising a network (NW) and user equipment (UE), a Non Access Stratum (NAS) via which the NW and UE communicate with each other, and an Access Stratum (AS) providing physical connections to enable the NAS communication between the NW and UE to be achieved, the physical connections including a wireless radio link to the UE, the method comprising:

   sending information from the NW to the UE to determine at least one action of the UE in response to the failure of a radio link to the UE;

   detecting a said radio link failure (RLF);

   in response to detecting said RLF, deciding on an action to be performed by the UE according to the received information; and

   performing, with the UE, the decided action.

2. A method of operating a communication system comprising a core network (NW), user equipment (UE), and an Access Network providing physical connections to enable the communication between the NW and UE to be achieved, the physical connections including a wireless radio link to the UE, the method comprising:

   sending information from the NW to the UE to determine at least one action of the UE in response to the failure of a radio link to the UE;

   detecting a said radio link failure (RLF);

   in response to detecting said RLF, deciding on an action to be performed by the UE according to the received information; and

   performing, with the UE, the decided action.

3. A method in accordance with claim 1 or claim 2, wherein the decided action comprises the sending or triggering of a service request.

4. A method in accordance with any preceding claim, wherein the decided action comprises the sending or triggering of a TAU.

5. A method in accordance with any preceding claim, wherein the decided action comprises the sending or triggering of a RAU.
6. A method in accordance with any preceding claim, wherein said deciding on an action comprises deciding whether or not to send or initiate a service request, a TAU, or a RAU.

7. A method in accordance with any preceding claim, further comprising storing said information in the UE.

8. A method in accordance with any preceding claim, further comprising configuring the UE according to the received information.

9. A method in accordance with claim 8, wherein said deciding comprises deciding on an action according to the configuration of the UE.

10. A method in accordance with any preceding claim, wherein said sending comprises sending said information in an ATTACH_ACCEPT message.

11. A method in accordance with any preceding claim, wherein said sending comprises sending said information in a TRACKING_AREA_UPDATE_ACCEPT message.

12. A method in accordance with any preceding claim, wherein said sending comprises sending said information in a ROUTING_AREA_UPDATE_ACCEPT message.

13. A method in accordance with any preceding claim, wherein said sending comprises sending said information in a GUTI_REALLOCATION_COMMAND message.

14. A method in accordance with any preceding claim, wherein said sending comprises sending said information in a message from an eNB to the UE.

15. A method in accordance with any preceding claim, wherein said sending comprises sending said information in a message having a format from a list comprising: SMS; and OMA DM.
16. A method in accordance with any preceding claim, wherein said sending comprises sending said information in a RRC signalling message.

17. A communication system adapted to implement a method in accordance with any preceding claim.

18. User equipment adapted for use in a communication system as defined by claim 17.

19. A computer program comprising instructions arranged, when executed, to implement a method as claimed in any preceding claim and/or a system as claimed in any preceding claim.

20. Machine-readable storage storing a program as claimed in claim 19.

21. A method of operating a communication system, a communication system, user equipment, a computer program, or machine-readable storage substantially as hereinbefore described with reference to the accompanying drawings.
**Patents Act 1977: Search Report under Section 17**

**Documents considered to be relevant:**

<table>
<thead>
<tr>
<th>Category</th>
<th>Relevant to claims</th>
<th>Identity of document and passage or figure of particular relevance</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>1-8, 14, 16-20</td>
<td>EP 1418777 A1 (MELCO MOBILE COMM EUROP) see especially par.0028, 0069-0073</td>
</tr>
<tr>
<td>A</td>
<td>-</td>
<td>EP 1903824 A2 (INNOVATIVE SONIC)</td>
</tr>
<tr>
<td>A</td>
<td>-</td>
<td>WO 2006/118717 A1 (MOTOROLA)</td>
</tr>
<tr>
<td>A</td>
<td>-</td>
<td>WO 2008/086460 A2 (QUALCOMM)</td>
</tr>
</tbody>
</table>

**Categories:**

- **X**: Document indicating lack of novelty or inventive step
- **Y**: Document indicating lack of inventive step if combined with one or more other documents of same category.
- **&**: Member of the same patent family
- **A**: Document indicating technological background and/or state of the art.
- **P**: Document published on or after the declared priority date but before the filing date of this invention.
- **E**: Patent document published on or after, but with priority date earlier than, the filing date of this application.

**Field of Search:**

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC:

- Worldwide search of patent documents classified in the following areas of the IPC
  - H04Q: H04W

The following online and other databases have been used in the preparation of this search report:

- Online: EPODOC, WPI

**International Classification:**

<table>
<thead>
<tr>
<th>Subclass</th>
<th>Subgroup</th>
<th>Valid From</th>
</tr>
</thead>
<tbody>
<tr>
<td>H04W</td>
<td>0076/02</td>
<td>01/01/2009</td>
</tr>
</tbody>
</table>