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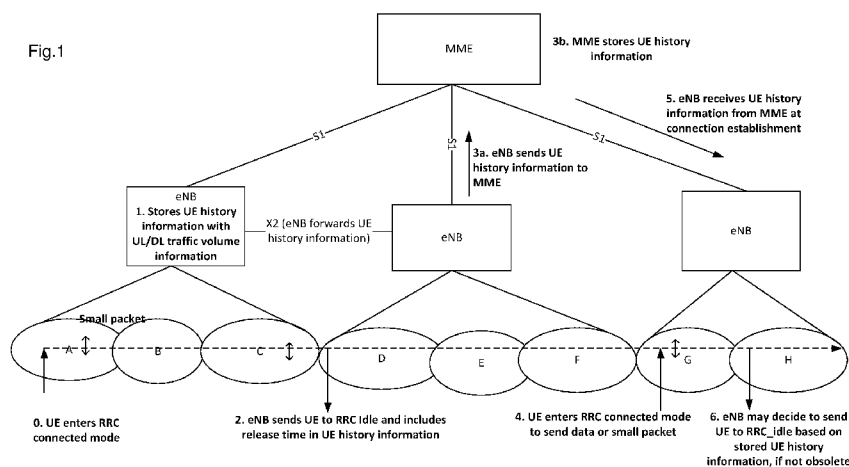
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1317179.8 27 September 2013 (27.09.2013) GB(71) Applicant: **VODAFONE IP LICENSING LIMITED**
[GB/GB]; Vodafone House, The Connection, Newbury,
Berkshire RG14 2FN (GB).(72) Inventors: **GOLAUP, Assen, Mahaboob, Khan**; c/o
Vodafone IP Licensing Limited, Patents Team, Babbage
House, The Connection, Newbury Berkshire RG14 2FN
(GB). **PUDNEY, Christopher, David**; c/o Vodafone IP
Licensing Limited, Patents Team, Babbage House, The
Connection, Newbury Berkshire RG14 2FN (GB). **KU-
LAKOV, Alexej**; c/o Vodafone IP Licensing Limited, Pat-
ents Team, Babbage House, The Connection, Newbury
Berkshire RG14 2FN (GB).(74) Agent: **BOULT WADE TENNANT**; Verulam Gardens,
70 Grays Inn Road, London, Greater London WC1X 8BT
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(57) Abstract: Interaction between a mobile terminal and one or more eNBs of a cellular communications network is configured. History information is stored at an eNB from the one or more eNBs of the cellular communications network that is serving the mobile terminal. The history information comprises information indicative of an uplink and/or downlink network traffic quantity for the mobile terminal. An interaction parameter is configured for communication between the mobile terminal and the one or more eNBs of the cellular communications network based on the stored history information.

NETWORK OPTIMISATION FOR SMALL PACKET TRANSMISSION

Technical Field of the Invention

The present invention concerns a method of configuring interaction between a
5 mobile terminal and one or more eNodeBs (eNBs) of a cellular communications
network and a corresponding eNB.

Background to the Invention

The generation of small data packets at intermittent time intervals, such as
10 smartphone background traffic or machine type communication traffic, may result in
UE being kept by the network in DRX connected mode rather than being sent to
RRC (Radio Resource Control) idle mode. Such an approach will prevent the UE
having to intermittently set up a connection to the network to send a small data
packet if network releases the connection after each small packet transfer. The
15 RAN2 study on enhancements for diverse data applications, documented in TR
36.822, highlights the trade-off in network signalling between keeping the UE in RRC
connected mode and moving the UE to RRC idle after packet transmission.

A UE in RRC Connected mode has to perform handover (whether there is
user plane data to transfer or not) and the rate of handover typically increases if the
20 UE mobility is high and the network is made up of small cells. Each handover would
result in an additional 34 bytes in uplink signalling on the radio interface and 100
bytes in downlink signalling on the radio interface according to TR 36.822.

However, sending a UE too quickly to RRC Idle can also create a signalling
problem, especially if UE has to frequently setup the connection again to send a
25 small packet. According to TR 36.822, each RRC Connection setup/release creates
around 60-70 bytes signalling on the uplink and 120-193 bytes on the downlink.
Setting the RRC state (or more generally, configuring the UE's method of interaction
with the eNB) appropriately is therefore a challenge.

A first known approach to dealing with this issue uses a traffic inactivity timer.
30 An eNB may implement a traffic inactivity timer which monitors whether UE has no
traffic to send during a certain time, for example 10s and then release the RRC
Connection. This approach may function well provided that the UE is not generating

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traffic (typically small packets) periodically, for instance every 30s, in which case, it would be better to keep the UE in RRC Connected mode. However, eNB cannot predict the UE traffic behaviour which varies from one UE to another. Traffic inactivity timer is typically set as the same value for all UEs in the cell.

5 A second known approach employs a power preference indication from the UE. This is discussed in 3GPP working groups and uses a 'power preference indication' bit from the UE which indicates to the network whether the UE would benefit from being sent to RRC Idle or should be kept in RRC Connected mode. This approach impacts the UE and it is not certain that all UEs will support the feature.
10 Moreover, UEs are able to set the bit in any way they wish, for instance, to get preferential access to network resources and hence, this solution is not a good approach for the operator.

 A third known approach releases the RRC Connection before handover. With this approach, the eNB keeps the UE in RRC Connected mode until it receives a
15 trigger for handover. If the UE is not actively transmitting data or has been quiet for a long time, network sends the UE to idle to reduce the handover signalling load. This solution does not however help with reducing the UE battery consumption since UE might be kept in connected mode unnecessarily.

 All existing approaches to configuring the RRC state therefore have difficulties
20 and an approach that improves on handover signalling rate, UE battery consumption and appropriately setting the number of connected mode UEs in the system is desirable.

Summary of the Invention

25 Against this background, it has been recognised that history information stored at a base station (specifically, an eNB) that is serving a mobile terminal (UE) can comprise network traffic quantity information, such as the volume, size or frequency of uplink or downlink traffic with the UE. This information may be determined and stored on the basis of the interaction between the UE and eNB
30 and/or relate to the UE's interaction with one or a plurality of previous eNBs and received from elsewhere. It may be used to affect the way that the eNB and UE

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interact, in particular the way that the Radio Resource Control (RRC) state of the UE is set or adjusted.

This builds on the existing specified feature in 3GPP called 'UE history information' (as specified in TS 36.300, TS 36.413 and TS 36.423). According to this feature, an eNB logs information on the last visited cell of the UE including its cell identity, the time UE stayed in the cell and the cell type. This information is added to information gathered for previously visited cells by the UE and forwarded to the target eNB at handover over the 3GPP LTE X2 interface or 3GPP LTE S1 interface.

It has been found desirable for the network to be aware of how much data a UE is generating, how often the UE is generating the data and also how mobile the UE is when deciding whether to keep the UE in an RRC connected state or send the UE to an RRC Idle state.

The proposed invention provides an eNB with appropriate information on the UE traffic pattern behaviour and UE mobility behaviour so that the eNB can make an improved, informed decision of whether to keep a UE in RRC Connected mode (with the implications of increased handover signalling rate, increased battery consumption and increased number of connected mode UEs in the system) or send the UE to RRC idle (where mobility is not visible to the network, UE battery consumption is less and network resources are not consumed) with the potential consequence that UE might have to frequently go back to connected mode if the eNB makes the wrong decision of sending the UE to RRC Idle.

In particular, there may be provided a method of configuring interaction between a mobile terminal and one or more eNBs of a cellular communications network, the method comprising: storing history information at an eNB from the one or more eNBs of the cellular communications network that is serving the mobile terminal, the history information comprising information indicative of an uplink and/or downlink network traffic quantity for the mobile terminal; and configuring an interaction parameter for communication between the mobile terminal and the one or more eNBs of the cellular communications network based on the stored history information.

Further generic examples (which can be combined with each other and/or with any other features or examples discussed herein) will now be discussed. In a

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cellular communications network comprising one or more eNBs and at least one terminal connected to a serving cell on a serving eNB, having been previously connected to one or more cells of the same or other eNBs, there may be provided a method of determining whether the serving eNB should release the terminal from an RRC connected state to an RRC idle state. The method comprises: on the serving eNB, retrieving information indicative of the volume and/or size and/or frequency of uplink and/or downlink network traffic generated by the terminal whilst connected to one or more previously visited/connected cells, and using said retrieved information to estimate/predict whether the terminal will be sending and/or receiving network traffic within a predetermined period of time and, if not, to release the terminal from an RRC connected state to an RRC idle state.

Preferably, the serving cell logs information indicative of the volume and/or size and/or frequency of uplink and/or downlink network traffic generated by the terminal whilst connected to the serving cell and adds the information to the history information of the terminal on traffic volume generation behaviour which is transferred at handover to a second eNB, if the connection is not released.

Optionally, the history information indicative of the volume and/or size and/or frequency of uplink and/or downlink network traffic generated by the terminal whilst connected to the one or more other eNBs is transmitted to an MME before/during/after the terminal is transferred from an RRC connected state to an RRC idle state, but desirably before the link between the eNB and the MME is released.

In a cellular communications network comprising one or more eNBs and at least one terminal connected to a serving cell of one of a serving eNB having been previously connected to one or more cells of the serving eNB or other eNBs, there may be provided in another aspect, a method of preserving terminal history information indicative of the network traffic history of the terminal comprising: before/during/after transferring/releasing the terminal from an RRC connected state to an RRC idle state, sending the terminal history information to an MME to which the serving eNB is connected.

In a cellular communications network comprising one or more eNBs and at least one terminal connected to a serving cell of the serving eNB having been

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previously connected to one or more cells of the serving or other eNBs, there may be provided in another aspect, a method of retrieving/receiving terminal history information indicative of the network traffic history of the terminal comprising: during/after transferring the terminal from an RRC idle state to an RRC connected state for the purpose of sending data to/from the terminal, retrieving/receiving the terminal history information from an MME to which the eNB of the serving cell is connected. Optionally, the serving eNB uses the terminal history information to decide whether or not to transfer the terminal from an RRC connected state to an RRC idle state after the transfer of network traffic between the serving eNB and the terminal. The terminal history information may comprise one or more absolute times at which the terminal was previously transferred/released to an RRC idle state in the last visited cell and/or absolute time at which the the terminal was previously transferred to an RRC connected state.

Brief Description of the Drawings

The invention may be put into practice in a number of ways, and preferred embodiments will now be described by way of example only and with reference to the accompanying drawings, in which:

Figure 1 schematically illustrates the principles of UE history information handling for controlling UE RRC state transitions; and

Figure 2 depicts a schematic plot of packet size against time.

Detailed Description of Preferred Embodiments

Some novel aspects of the invention are outlined below:

1) Enhancement of UE history information to contain uplink and downlink traffic volume. The granularity of the information can be on a per cell basis or on the level of size of packets and time of transmission of those packets in the last visited cell. Advantageously, the traffic volume information can be coded in an optimised way by signalling the range of the traffic volume information rather than absolute values.

2) eNB stores the absolute time at which the RRC connection is released in the UE history information.

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3) eNB forwards the UE history information to the MME during the RRC connection release procedure, for instance in S1 AP: UE context release request

4) MME stores the UE history information

5) The next time UE enter RRC Connected mode, the MME downloads the stored UE history information to the eNB, for instance in S1 Initial context setup request message.

6) If eNB considers the UE history information as valid, for example, based on time of last RRC Connection release, it adds information on the current cell on which UE connected again to the log. This includes the time at which UE connected to the cell and optionally the time at which the UE releases the connection (if eNB decides to do so). This is in addition to other information on uplink/downlink traffic volume, cell id, traffic type etc.

In general, this may be considered a method of configuring and/or storing data relating to interaction between a mobile terminal and one or more eNBs of a cellular communications network. The method comprises storing history information at an eNB from the one or more eNBs of the cellular communications network that is serving the mobile terminal, the history information comprising information indicative of an uplink and/or downlink network traffic quantity for the mobile terminal.

Advantageously, the method further comprises configuring an interaction parameter for communication between the mobile terminal and the one or more eNBs of the cellular communications network based on the stored history information.

Preferably, the step of configuring an interaction parameter takes place at the eNB serving the mobile terminal. It will further be understood that (in another aspect), there is provided a UE, eNB, MME or another network entity configured to operate in accordance with any method described herein.

The method may be implemented by means of a computer program, which will cause the steps to be carried out when operated by a processor (or other logic). The computer program may be stored on a computer readable medium.

Any combination of specific features may be provided from any of the aspects discussed herein, even if that combination is not explicitly disclosed. Moreover, any part or combination of parts of this aspect may be combined with any other aspect discussed herein.

Enhanced UE History Information handling to optimise small packet transmission

3GPP has specified UE history information to contain information about last visited cells, the time UE stayed in those cells, cell type and the cause of handovers.

- 5 The main motivation for this feature is to allow the eNB receiving the information to optimise the handover procedure, especially to avoid ping-pong handovers.

However, UE history information can also be enhanced to help an eNB decide whether to keep a UE in RRC connected or whether to release the connection following the transfer of a small packet. As described in above, it is desirable for the
10 eNB to know whether the UE is generating small packets, how often those packets are being generated and also the mobility state of the UE.

For example, UE history information might indicate that the UE has done several cell transitions (with different cell ids) in a short time, which can indicate that UE is moving at high speed. An eNB may decide to release the RRC connection
15 based on this information, but it should only do so if it is confident that the UE is not consistently generating a lot of data or it is not generating small packets of data at short time intervals, such as shorter than the cell dwell time, which would require UE to constantly set up an RRC connection.

The eNB might implement a traffic inactivity timer, which should ideally not
20 expire as long as UE has an on-going data transfer and keeping the UE in RRC connected (even though it is moving at high speed) in this situation would then be justified. What the eNB is not aware of is how often a UE will be sending a small packet of data when the interval is longer than the traffic inactivity timer but perhaps still short enough to cause a number of RRC state transitions whilst UE is in a cell.
25 To address this problem, the UE history information should be enhanced to capture the amount of traffic generated by the UE in last visited cells on the uplink and downlink.

In general terms (specifically the method of configuring interaction discussed above), the uplink and/or downlink network traffic quantity may comprise a volume
30 and/or size and/or frequency of uplink and/or downlink network traffic in respect of the mobile terminal. The uplink and/or downlink network traffic quantity may be stored on a per cell basis or in terms of packet size and time of transmission or

reception. This data can also be quantised and/or sampled at an appropriate level. In particular, the information indicative of an uplink and/or downlink network traffic quantity for the mobile terminal may be represented by a range (rather being recorded as the measured value). Optionally, the history information further

5 comprises one or more of: a time at which the uplink and/or downlink network traffic quantity was generated; an aggregated network traffic volume at the cell level; and a time duration for which the mobile terminal was connected to a cell of an eNB from the one or more eNBs of the cellular communications network. In the preferred embodiment, the uplink and/or downlink network traffic quantity comprises a volume
10 and/or size of uplink and/or downlink network traffic in respect of the mobile terminal and this is stored together with a timestamp of when the network traffic quantity was generated or an aggregated network traffic volume at the cell level stored with the time duration of the mobile terminal in a cell, A specific implementation will be detailed below as an example only.

15 Referring to Figure 1, there is illustrated the principles of how the uplink and downlink traffic volume information could be used to help an eNB decide when to send UE to RRC_Idle and how the UE history information of the UE can be preserved when UE is sent to RRC_Idle mode for a temporary amount of time before it enters RRC connected mode again to send more data.

20 According to Figure 1, the following sequence of events can be foreseen for the collection and use of UE history information:

0. UE enters RRC Connected mode to send data. This can be normal user data or a small packet (background traffic) generated by an application or the
25 operating system. eNB keeps UE in DRX connected mode after expiry of a traffic inactivity timer.
1. eNB logs the amount of data transferred on the uplink and downlink, in addition to other already specified information, such as cell Id and Time UE stayed in cell etc. The traffic volume may either be logged on a per cell basis
30 or in terms of packet size and time at which packet is transferred (see below).

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2. If UE selects a cell that is controlled by another eNB, the UE history information is forwarded over X2 interface (as per already specified 3GPP procedures)
3. After collecting information for a few cells, an eNB can analyse the traffic volume pattern generated in previous cells to come to the conclusion that the UE will not be sending or receiving data soon. eNB then decides to release the UE to RRC_idle mode.
4. According to current specifications, sending the UE to RRC_Idle would result in a loss of UE history information. However, it is desirable that the UE history information which contains the UE past behaviour on traffic generation is kept for some time (actual time may be predetermined, fixed or dynamically varying), so that it can be used to correctly determine the most appropriate RRC state for a UE by the next eNB which UE connects to. The proposed approach is:
 - a. For eNB to include the UE history information in the S1 signalling sent to MME at release of the RRC connection
 - b. for MME to store that information until the next time UE enters RRC connected mode from RRC idle.
5. A UE will re-enter RRC Connected mode after some time if there is more data to send/receive. This would typically be the case if the UE is generating background traffic.
6. During the connection setup procedure, the UE history information is pushed down to the eNB in appropriate S1 signalling by the MME.
7. The eNB may use the received information to decide when to subsequently release the connection to idle (After the current packet transmission). However, eNB has to be aware of when was the last time that the UE was sent to RRC_idle, and hence whether the UE history information is valid. This can be achieved by an eNB including the absolute time at which the RRC Connection is released in a particular cell in the UE history information, before forwarding it to the MME. In this way, an eNB subsequently receiving the information can decide whether it is relevant or whether to restart collecting UE history information (and disregard information from MME). Similarly, it is

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desirable for eNB to subsequently include the last time at which UE entered connected mode from RRC_idle as part of the visited cell information where UE entered connected mode.

5 In general terms, the following additional preferable or optional additional features of the generalised method discussed above may therefore be considered. For example, the method may further comprise generating history information for the mobile terminal, based on communication between the mobile terminal and the eNB that is serving the mobile terminal. In other words, the UE history information may
10 be based on the information resulting from the UE's interaction with that eNB and/or cell serving it. Advantageously, the generated history information is stored in the step of storing.

However, that need not necessarily be the case. For instance, the method may further comprise: communicating to the eNB that is serving the mobile terminal
15 (such as, receiving at that eNB), previous history information for the mobile terminal from a network entity (for example, at handover). In other words, the UE history may be based on information from another cell/eNB or even multiple cells and/or eNBs. It need not even comprise any information relating to the UE's interaction with the currently serving eNB. Nevertheless, the step of storing history information
20 optionally comprises combining the previous history information with history information in relation to communication between the mobile terminal and the eNB that is serving the mobile terminal.

In order to preserve the UE history information for use with other eNBs, the generated or stored history information for the mobile terminal may be
25 communicated to a network entity, for example if an RRC connection for the mobile terminal is released. The network entity from which the eNB receives history information and/or to which the eNB communicates the history information may be another eNB from the one or more eNBs or a radio access network or core network entity of the cellular communications network. A particular option for this network
30 entity (as discussed herein) is a Mobility Management Entity (MME). In that case, the step of communicating (that is, passing the history information between the

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serving eNB and MME) preferably forms part of a context setup or release procedure.

A particular advantage of the expanded stored UE history, relates to the enhanced determination or prediction that may be made on the basis of such information, especially with regard to a network traffic pattern and/or level with respect to that UE. For example, the step of configuring an interaction parameter beneficially comprises predicting whether the mobile terminal will be sending and/or receiving network traffic within a predetermined period of time based on the stored history information. Such a prediction or estimation may have numerous advantages, in terms of changing the UE's parameters at the eNB and/or MME and/or another network entity based on historical data communication quantity information. Particular benefits may ensue when the interaction parameter is a RRC state (such as, idle or connected). This may be implemented in a number of ways.

The step of configuring an interaction parameter may comprise releasing the mobile terminal from an RRC connected state to an RRC idle state if the step of predicting indicates that mobile terminal will not be sending and/or receiving network traffic within a predetermined period of time. The step of communicating the generated or stored history information (to the network entity) may take place before/during/after the step of releasing the mobile terminal from an RRC connected state. Preferably, the step of communicating the generated or stored history information is performed before the connection to the MME is released. In the preferred embodiment, the history information for the mobile terminal further comprises at least one (absolute) time at which the RRC state of the mobile terminal was previously changed. This may further be used in the step of predicting whether the mobile terminal will be sending and/or receiving network traffic within a predetermined period of time. The time at which the RRC state of the mobile terminal was previously changed may comprise one or both of: the time when the mobile terminal was (last) released to an RRC idle state (for example in the last visited cell); and the time when then terminal was (last) transferred to an RRC connected state.

Additional Information for UE history information

As described above, it is proposed that UE history information is enhanced to contain the following Information:

- 1) Uplink and Downlink Traffic Volume
- 5 2) Absolute time when UE was last sent to RRC_idle in the last visited cell in connected mode and timestamp of when UE last entered connected mode.

Uplink and Downlink Traffic Volume

There are two approaches to log the uplink and Downlink traffic Volume:

- 10 In the first, the eNB monitors the size of packets, together with the time at which they were received and include those in the UE history information. This means that for a given visited cell, the traffic volume information will be a log of packet sizes and the corresponding times at which these were received. The packet arrival time can be considered as the time when buffer size for UE traffic becomes
- 15 non empty and the packet size is the amount of data transferred between this time and the time at which the buffer for the UE becomes empty again.

- Referring to Figure 2, there is depicted a schematic plot of packet size against time, to show logging of packet size with time of packet arrival. With this approach, the UE history information for traffic volume will consist of a number of entries
- 20 indicating the packet arrival time and size of packet. The table below shows example packet arrival times and sizes.

Time	Packet size (bytes)
12:12:05	200
12:13:05	200
12:14:05	200

- The main issue with this approach is that the UE history information size can
- 25 quickly become significant and this information will have to be transported between eNBs at handover and also sent to MME at RRC Connection Release.

The second, simpler approach would be for a source eNB to log the volume of data sent on the uplink and downlink for the UE whilst it is in the cell, that is on a per cell basis and include that information at handover.

Traffic analysis of light background traffic generated by smart phones (as detailed in 3GPP TR 36.822) indicates that a small packet size on the uplink typically ranges between 0 and 400 bytes, with sizes up to 1500 bytes being rare. On the downlink, small packet sizes can range from 0 to 1500 bytes.

Thus, the format of how this information can be reported in the UE history information can be even further simplified by an indication of whether the amount of data transferred is one of the following:

- 1) 0 bytes
- 2) Less than X bytes
- 3) Between X and Y bytes
- 4) More than Y bytes

The actual thresholds may be determined by experimentation and/or analysis, but as an example, X could be 400 bytes and Y could be 1500 bytes based on traffic analysis results on background traffic in 3GPP TR 36.822. The proposed changes to the content of the UE history information specified in TS 36.413 and TS 36.423 to include UL and DL traffic volume are detailed below, with the assumption of 'X' referred to above of 400 bytes and 'Y' of 1500 bytes.

Absolute time when UE released to RRC Idle in last visited cell in connected mode and last entered connected mode.

An absolute time format is already defined in TS 36.331 for the purpose of Minimisation of Drive Test feature and can be re-used for indicating the time at which eNB releases the RRC connection or last time UE entered connected mode. The format used in TS 36.331 is YY-MM-DD HH:MM:SS and uses BCD encoding. The first/ leftmost bit of the bit string contains the most significant bit of the most significant digit of the year and so on. A simplified format like DD:HH:MM:SS could also be appropriate.

The proposed changes to the content of the UE history information specified in TS 36.413 and TS 36.423 to include a time stamp of when eNB releases UE to

RRC Idle and time stamp of when UE entered connected mode are detailed in the Appendix A with the assumption of a time format similar to that used in TS 36.331.

Use of Enhanced UE History Information

- 5 After collecting the traffic volume information for a few cells, UE history information might look, as an example, as follows:

Cell Id	Time UE stayed in cell (seconds)	UL data volume (bytes)	DL data volume (bytes)	RRC Connection Release time	RRC Connection setup time
1	24	More than 1500 bytes	More than 1500 bytes		2013:10:10:17:33:23
2	15	Less than 400 bytes	Between 400 and 1500 bytes		
3	76	0	0		
4	59	0	0		
5	45	0	0		
6	20	Less than 400 bytes	Between 400 and 1500 bytes		

Example of content of UE history Information with UL and DL Traffic Volume

- 10 The eNB may use the information to deduce that after sending user data in cell 1, UE has been generating background traffic approximately every three minutes (based on information about time UE stayed in each cell) and hence that UE is not expected to be transferring data within the next three minutes. The eNB may additionally deduce that this is a fast moving UE doing about one handover every minute and hence it would be beneficial to send this UE to RRC idle mode. This
15 decision can help save on handover signalling and also UE battery power by sending UE to RRC idle with a low risk that UE will have more data to send immediately after release.

- When eNB decides to send UE to RRC Idle, it includes the time at which the RRC connection is released in the UE history information. A further instance of the
20 UE history information might be the following:

Cell Id	Time UE stayed in cell (seconds)	UL data volume (bytes)	DL data volume (bytes)	RRC Connection Release time	RRC Connection setup time
1	24	More than 1500 bytes	More than 1500 bytes		2014:10:10:17:33:23

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2	15	Less than 400 bytes	Between 400 and 1500 bytes		
3	76	0	0		
4	59	0	0		
5	45	0	0		
6	20	Less than 400 bytes	Between 400 and 1500 bytes		
7	1	0	0	2014:10:10:17:37:23	

As part of the normal UE release procedure, eNB sends S1: UE Context Release message to MME. This message is enhanced to carry the UE history information. The MME stores the UE history information and associates it with a unique UE identity.

5 Assuming UE is following same mobility and traffic pattern, UE will enter connected mode after going through a few cells in RRC Idle and establish a new RRC Connection and data bearer to send the small packet traffic. During the RRC Connection establishment procedure, the MME identifies the UE (based on its identity) and include the stored UE history information in the S1: UE CONTEXT
10 SETUP REQUEST message. This message is enhanced to carry the UE history information as described in the Appendix.

When the eNB receives the UE history information, it can deduce from the time stamp of the last time UE was released to RRC Idle, whether the information is still valid for the ongoing session or has to be discarded. If, for example, the UE is
15 connecting after three minutes, the eNB can still assume that the previous UE behaviour pattern applies. The source eNB might use the traffic inactivity timer to confirm that UE has no more than 400 bytes to send and then release the connection to RRC Idle instead of sending the UE to Long DRX. If the UE decides to keep the stored UE history information, it adds the information of the time at which
20 the UE connected to the current cell, in addition to other information it would include when the UE leaves the cell.

If the UE is being sent to RRC_idle before handover, the release time of the connection is included.

25

Cell Id	Time UE stayed in cell (seconds)	UL data volume (bytes)	DL data volume (bytes)	RRC Connection Release time	RRC Connection setup time
1	24	More than 1500 bytes	More than 1500 bytes		2014:10:10:17:33:23
2	15	Less than 400 bytes	Between 400 and 1500 bytes		
3	76	0	0		
4	59	0	0		
5	45	0	0		
6	20	Less than 400 bytes	Between 400 and 1500 bytes		
7	1	0	0	2014:10:10:17:37:23	
10	5	Less than 400 bytes	Between 400 and 1500 bytes	2014:10:10:17:40:28	2014:10:10:17:40:23

Example of content of UE history Information with UL and DL Traffic Volume, time of RRC connection release and RRC Connection setup.

Proposed Signalling Changes to 3GPP specifications

5 TS 36.413: S1 AP signalling

9.2.1.43a Last Visited E-UTRAN Cell Information

The Last Visited E-UTRAN Cell Information contains information about a cell that is to be used for RRM purposes.

IE/Group Name	P r e s e n c e	R a n g e	IE type and reference	Semantics description	C r i t i c a l i t y	Assigned Criticality
Global Cell ID	M		E-UTRAN CGI 9.2.1.38		-	
Cell Type	M		9.2.1.66		-	
Time UE stayed in Cell	M		INTEGER (0..4095)	The duration of the time the UE stayed in the cell in seconds. If the UE stays in a cell more than 4095s, this IE is set to 4095.	-	
Time UE stayed in Cell Enhanced Granularity	O		INTEGER (0..40950)	The duration of the time the UE stayed in the cell in 1/10 seconds. If the UE stays in a cell more than 4095s, this IE is set to 40950.	Y E S	ignore
HO Cause Value	O		9.2.1.3	The cause for the handover from the E-UTRAN cell.	Y E S	ignore
UL Traffic Volume	O		Enumerated (0,LessThan400, Between400And1500,MoreThan1500)	The uplink traffic volume generated in last visited cell. 'LessThan400' means less than 400 bytes of data transferred etc.	Y E S	ignore
DL Traffic Volume	O		Enumerated (0,LessThan400, Between400And1500,MoreThan1500)	The downlink traffic volume generated in last visited cell. 'LessThan400' means less than 400 bytes of data transferred etc.	Y E S	ignore
Time UE Released to Idle	O		BIT STRING (SIZE(48))	Absolute time in a format YY-MM-DD HH:MM:SS and using BCD encoding. The first/leftmost bit of the bit string contains the most significant bit of the most significant digit of the year and so on.	Y E S	ignore
Time UE entered Connected Mode	O		BIT STRING (SIZE(48))	Absolute time in a format YY-MM-DD HH:MM:SS and using BCD encoding. The first/leftmost bit of the bit string	Y E S	ignore

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				contains the most significant bit of the most significant digit of the year and so on.		
--	--	--	--	--	--	--

TS 36.423: X2 AP Signalling

9.2.40 Last Visited E-UTRAN Cell Information

The Last Visited E-UTRAN Cell Information contains information about a cell

5 that is to be used for RRM purposes.

IE/Group Name	Presence	IE type and reference	Semantics description	Criticality	Assigned Criticality
Global Cell ID	M	ECGI 9.2.14		-	-
Cell Type	M	9.2.42		-	-
Time UE stayed in Cell	M	INTEGER (0..4095)	The duration of the time the UE stayed in the cell in seconds. If the UE stays in a cell more than 4095s, this IE is set to 4095.	-	-
Time UE stayed in Cell Enhanced Granularity	O	INTEGER (0..40950)	The duration of the time the UE stayed in the cell in 1/10 seconds. If the UE stays in a cell more than 4095s, this IE is set to 40950.	YES	ignore
HO Cause Value	O	9.2.6	The cause for the handover from the E-UTRAN cell.	YES	ignore
UL Traffic Volume	O	Enumerated (0,LessThan400,Between400And1500,MoreThan1500)	The uplink traffic volume generated in last visited cell. 'LessThan400' means less than 400 bytes of data transferred etc.	YES	ignore
DL Traffic Volume	O	Enumerated (0,LessThan400,Between400And1500,MoreThan1500)	The downlink traffic volume generated in last visited cell. 'LessThan400' means less than 400 bytes of data transferred etc.	YES	ignore
Time UE Released to Idle	O	BIT STRING (SIZE(48))	Absolute time in a format YY-MM-DD HH:MM:SS and using BCD encoding. The first/ leftmost bit of the bit string contains the most significant bit of the most significant digit of the year and so on.	YES	ignore

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9.1.4.5 UE CONTEXT RELEASE REQUEST

This message is sent by the eNB to request the release of the UE-associated S1-logical connection over the S1 interface.

Direction: eNB --> MME

5

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.2.1.1		YES	ignore
MME UE S1AP ID	M		9.2.3.3		YES	reject
eNB UE S1AP ID	M		9.2.3.4		YES	reject
Cause	M		9.2.1.3		YES	ignore
GW Context Release Indication	O		9.2.1.84		YES	reject
UE History Information	O		9.2.1.42		YES	ignore

9.1.4.1 INITIAL CONTEXT SETUP REQUEST

This message is sent by the MME to request the setup of a UE context.

Direction: MME --> eNB

10

IE/Group Name	P r e s e n c e	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.2.1.1		YES	reject
MME UE S1AP ID	M		9.2.3.3		YES	reject
eNB UE S1AP ID	M		9.2.3.4		YES	reject
UE Aggregate Maximum Bit Rate	M		9.2.1.20		YES	reject
E-RAB to Be Setup List		1			YES	reject
>E-RAB to Be Setup Item IEs		1 .. <max number of E-RABs>			EACH	reject
>>E-RAB ID	M		9.2.1.2		-	
>>E-RAB Level QoS Parameters	M		9.2.1.15	Includes necessary QoS parameters.	-	
>>Transport Layer Address	M		9.2.2.1		-	
>>GTP-TEID	M		9.2.2.2		-	
>>NAS-PDU	O		9.2.3.5		-	
>>Correlation ID	O		9.2.1.80		YES	ignore

IE/Group Name	P r e s e n c e	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
UE Security Capabilities	M		9.2.1.40		YES	reject
Security Key	M		9.2.1.41	The KeNB is provided after the key-generation in the MME, see TS 33.401 [15].	YES	reject
Trace Activation	O		9.2.1.4		YES	ignore
Handover Restriction List	O		9.2.1.22		YES	ignore
UE Radio Capability	O		9.2.1.27		YES	ignore
Subscriber Profile ID for RAT/Frequency priority	O		9.2.1.39		YES	ignore
CS Fallback Indicator	O		9.2.3.21		YES	reject
SRVCC Operation Possible	O		9.2.1.58		YES	ignore
CSG Membership Status	O		9.2.1.73		YES	ignore
Registered LAI	O		9.2.3.1		YES	ignore
GUMMEI	O		9.2.3.9	This IE indicates the MME serving the UE.	YES	ignore
MME UE S1AP ID 2	O		9.2.3.3	This IE indicates the MME UE S1AP ID assigned by the MME.	YES	ignore

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IE/Group Name	P r e s e n c e	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Management Based MDT Allowed	O		9.2.1.83		YES	ignore
Management Based MDT PLMN List	O		MDT PLMN List 9.2.1.89		YES	ignore
UE History Information	O		9.2.1.42		YES	ignore

Range bound	Explanation
maxnoofE-RABs	Maximum no. of E-RAB allowed towards one UE, the maximum value is 256.

CLAIMS

1. A method of configuring interaction between a mobile terminal and one or more eNBs of a cellular communications network, the method comprising:

5 storing history information at an eNB from the one or more eNBs of the cellular communications network that is serving the mobile terminal, the history information comprising information indicative of an uplink and/or downlink network traffic quantity for the mobile terminal; and

10 configuring an interaction parameter for communication between the mobile terminal and the one or more eNBs of the cellular communications network based on the stored history information.

2. The method of claim 1, wherein the uplink and/or downlink network traffic quantity comprises a volume and/or size and/or frequency of uplink and/or downlink
15 network traffic in respect of the mobile terminal.

3. The method of claim 1 or claim 2, wherein the history information further comprises one or more of: a time at which the uplink and/or downlink network traffic quantity was generated; an aggregated network traffic volume at the cell level; a time
20 duration for which the mobile terminal was connected to a cell of an eNB from the one or more eNBs of the cellular communications network.

4. The method of any preceding claim, wherein the information indicative of an uplink and/or downlink network traffic quantity for the mobile terminal is represented
25 by a range.

5. The method of any preceding claim, further comprising:
communicating to the eNB that is serving the mobile terminal, previous history
information for the mobile terminal from a network entity, the step of storing history
30 information comprising combining the previous history information with history information in relation to communication between the mobile terminal and the eNB that is serving the mobile terminal.

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6. The method of any preceding claim, further comprising:
generating history information for the mobile terminal, based on
communication between the mobile terminal and the eNB that is serving the mobile
5 terminal, the generated history information being stored in the step of storing.

7. The method of claim 6, further comprising:
communicating the generated or stored history information for the mobile
terminal to a network entity.

8. The method of any of claims 5 to 7, wherein the network entity is another eNB
from the one or more eNBs or a radio access network or core network entity of the
cellular communications network.

9. The method of claim 8, wherein the network entity is a Mobility Management
Entity, MME, and wherein the step of communicating forms part of a context setup or
release procedure.

10. The method of any preceding claim, wherein the step of configuring an
interaction parameter comprises predicting whether the mobile terminal will be
20 sending and/or receiving network traffic within a predetermined period of time based
on the stored history information.

11. The method of claim 10, wherein the interaction parameter is a Radio
25 Resource Control, RRC, state.

12. The method of claim 11, wherein the step of configuring an interaction
parameter comprises releasing the mobile terminal from an RRC connected state to
an RRC idle state if the step of predicting indicates that mobile terminal will not be
30 sending and/or receiving network traffic within a predetermined period of time.

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13. The method of claim 11 or claim 12, wherein the history information for the mobile terminal further comprises at least one time at which the RRC state of the mobile terminal was previously changed.

5 14. The method of any preceding claim, wherein the step of configuring an interaction parameter takes place at the eNB serving the mobile terminal.

15. An eNB of a cellular communications network, configured to operate in accordance with the method of any preceding claim.

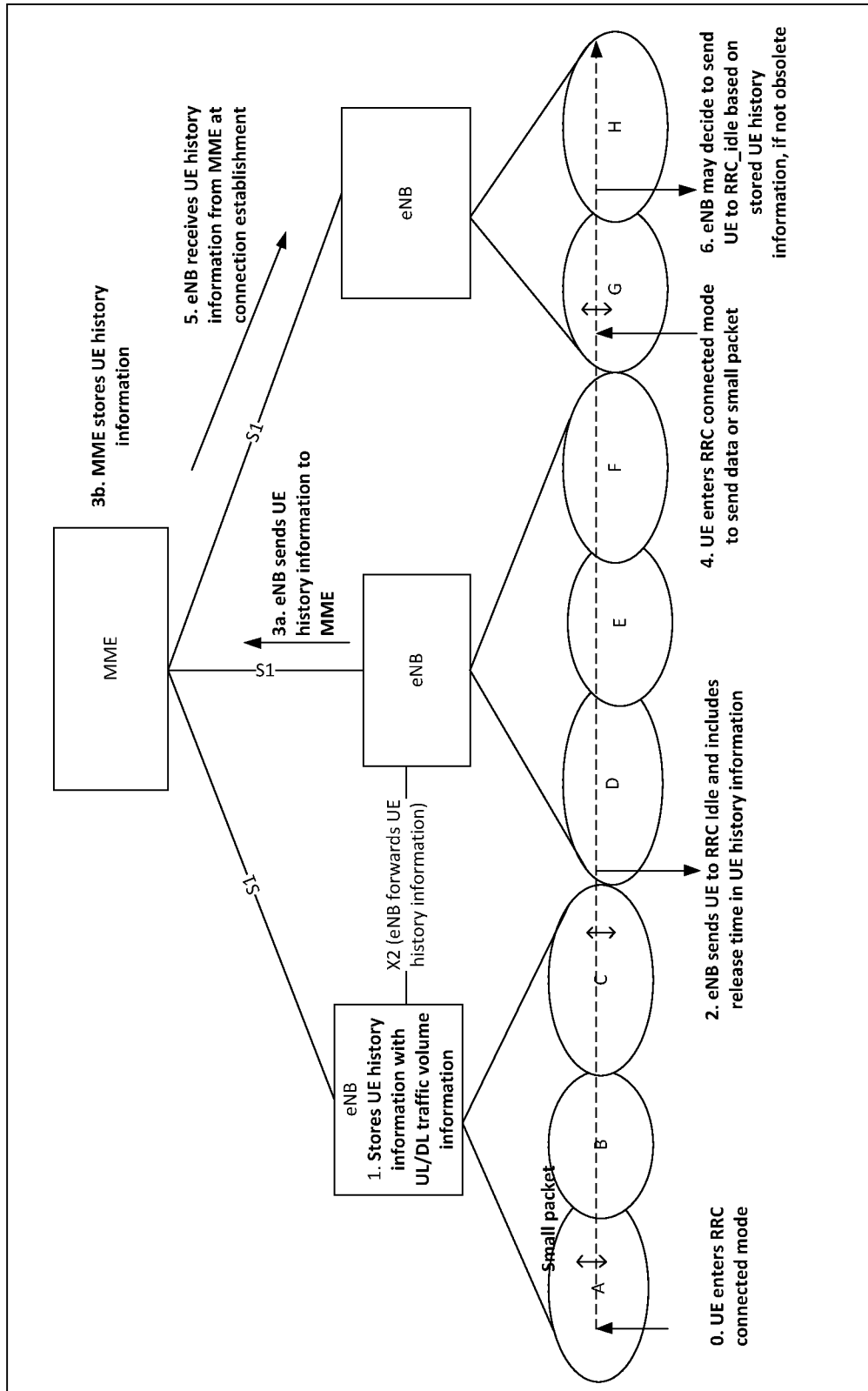


Fig.1

2/2

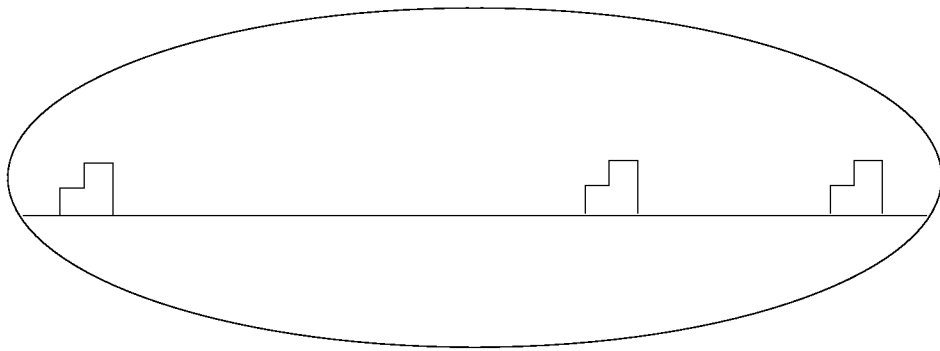


Fig. 2

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2014/052930

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04W76/04
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04W

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X,P	VODAFONE: "RAN enhancement to optimise handling of UEs generating small packets in the network", 3GPP DRAFT; R3-131864, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG3, no. Venice, Italy; 20131007 - 20131011 27 September 2013 (2013-09-27), XP050719962, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/tsg_ran/WG3_Iu/TSGR3_81bis/Docs/ [retrieved on 2013-09-27] the whole document ----- -/-	1-15



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

14 January 2015

Date of mailing of the international search report

02/02/2015

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040,
Fax: (+31-70) 340-3016

Authorized officer

Zembery, Peter

INTERNATIONAL SEARCH REPORT

International application No

PCT/GB2014/052930

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	MEDIATEK INC: "UE assisted eNB parameters tuning for small data transfer", 3GPP DRAFT; R2-131868 DISC UE ASSISTED ENB PARAMETERS TUNING FOR SMALL DATA TRANSFER, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANT , vol. RAN WG2, no. Fukuoka, Japan; 20130520 - 20130524 10 May 2013 (2013-05-10), XP050699904, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_82/Docs/ [retrieved on 2013-05-10]	1,2,6, 10-12, 14,15
A	page 1, line 10 - page 2, line 17	3-5,7-9, 13
X	----- SAMSUNG: "Views on solution for frequent small data transmission", 3GPP DRAFT; R2-132737 RAN CN ASSISTANCE UPDATE, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG2, no. Barcelona, Spain; 20130819 - 20130823 9 August 2013 (2013-08-09), XP050718297, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_83/Docs/ [retrieved on 2013-08-09] page 3, line 14 - page 4, line 10 figure 1 ----- -/--	1-15

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2014/052930

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	ALCATEL-LUCENT ET AL: "Core Network assisted eNodeB parameters tuning", 3GPP DRAFT; S2-133206 23401 CNASSIST, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. SA WG2, no. Xiamen, P.R. China; 20130923 - 20130927 18 September 2013 (2013-09-18), XP050726577, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/tsg_sa/WG2_Arch/TSGS2_99_Xiamen/Docs/[retrieved on 2013-09-18] section 4.3.x.1 CN Assistance Information section 4.3.x.2 RAN Generated Assistance Information figures 4.3.x.3-1 -----	1-15
A	ALCATEL-LUCENT SHANGHAI BELL ET AL: "CN assistance data over S1AP in long connected mode for 5.1.2.3.1", 3GPP DRAFT; R2-132619 CNASSISTEDPARAMETERS V2, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG2, no. Barcelona, Spain; 20130819 - 20130823 9 August 2013 (2013-08-09), XP050718256, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_83/Docs/[retrieved on 2013-08-09] the whole document ----- -/--	1-15

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2014/052930

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	ZTE CORPORATION: "Summary of email discussion [81bis#15] [Joint/MTCe] Initial qualitative analysis of the proposed solutions for SDDTE", 3GPP DRAFT; R2-131708 [81BIS#15] INITIAL QUALITATIVE ANALYSIS OF SDDTE SOLUTIONS, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOL , vol. RAN WG2, no. Fukuoka, Japan; 20130520 - 20130524 13 May 2013 (2013-05-13), XP050700177, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_82/Docs/ [retrieved on 2013-05-13] section 1.5.1 Solution 5a. -----	1-15