(12) UK Patent Application (19) GB (11) 2 431 828 (13) A

(43) Date of A Publication 02.05.2007

(21) Application No: **0610213.1**

(22) Date of Filing: **24.05.2006**

(30) Priority Data:
(31) **0522347** (32) **27.10.2005** (33) **GB**

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(51) INT CL:
H04Q 7/38 (2006.01)

(52) UK CL (Edition X):
H4L LRNMD

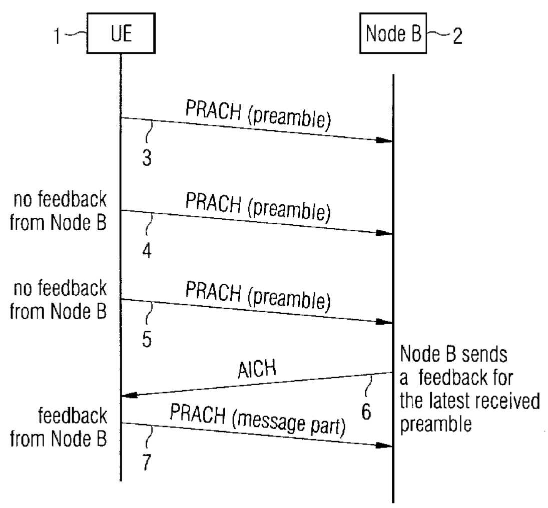
(56) Documents Cited:
GB 2409952 A **WO 2004/100565 A2**
WO 2000/072609 A1

(58) Field of Search:
UK CL (Edition X) **H4L**
INT CL **H04B, H04L, H04Q**
Other: **WPI, EPODOC, TXTUS0, TXTUS1, TXTUS2, TXTUS3, TXTEP1, TXTGB1, TXTWO1, TXTAU1**

(54) Abstract Title: **A method of improving efficiency in a random access procedure**

(57) A method of improving efficiency in a random access procedure between a terminal (1) and a network (2) comprises reading and storing data for a first system information block containing fast changing radio parameters for random access; and setting a flag in a different system information block to indicate whether or not the value of the first system information block is permanently valid.

FIG 1



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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 1995

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FIG 1

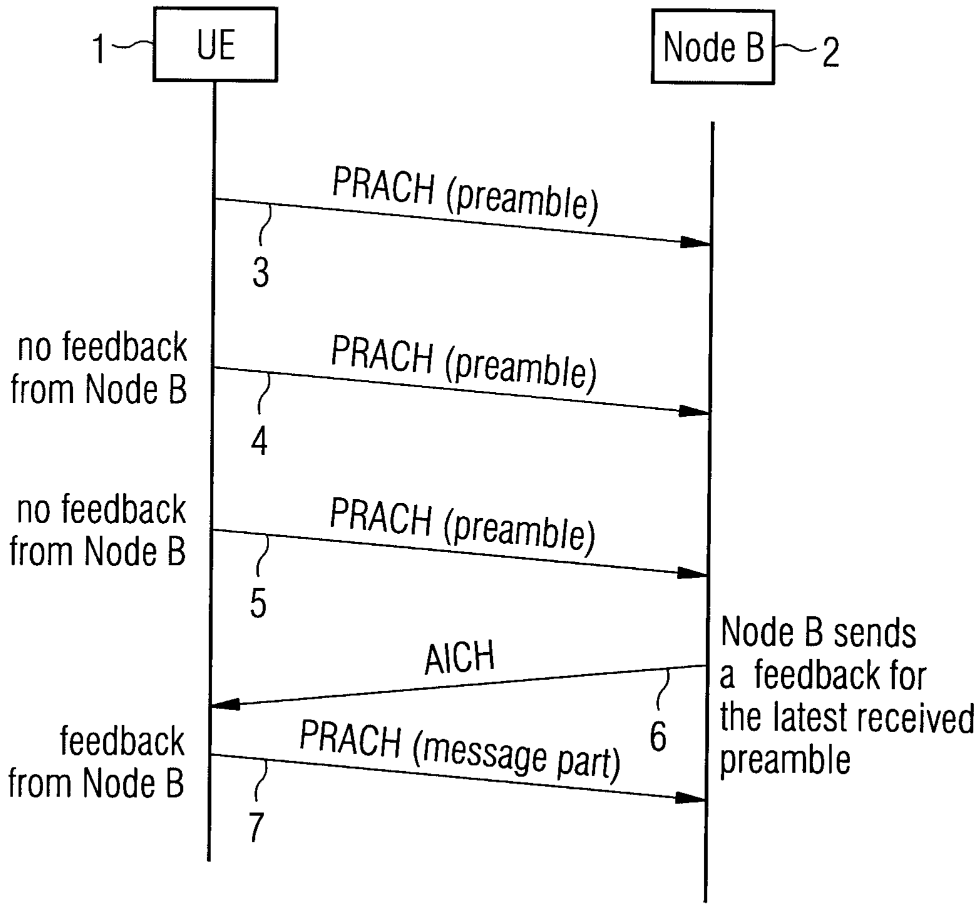

1
UE
Node B
2
PRACH (preamble)
3
no feedback from Node B
PRACH (preamble)
4
no feedback from Node B
PRACH (preamble)
5
AICH
Node B sends a feedback for the latest received preamble
6
feedback from Node B
PRACH (message part)
7

FIG 2A

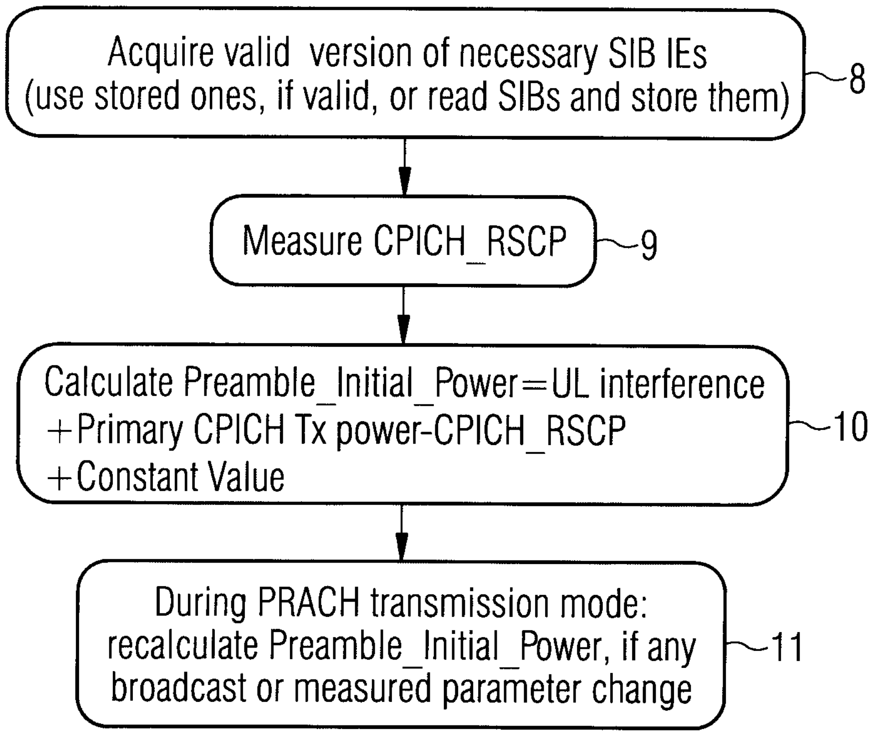

Acquire valid version of necessary SIB IEs (use stored ones, if valid, or read SIBs and store them)
8
Measure CPICH_RSCP
9
Calculate Preamble_Initial_Power=UL interference +Primary CPICH Tx power-CPICH_RSCP +Constant Value
10
During PRACH transmission mode: recalculate Preamble_Initial_Power, if any broadcast or measured parameter change
11

FIG 2B

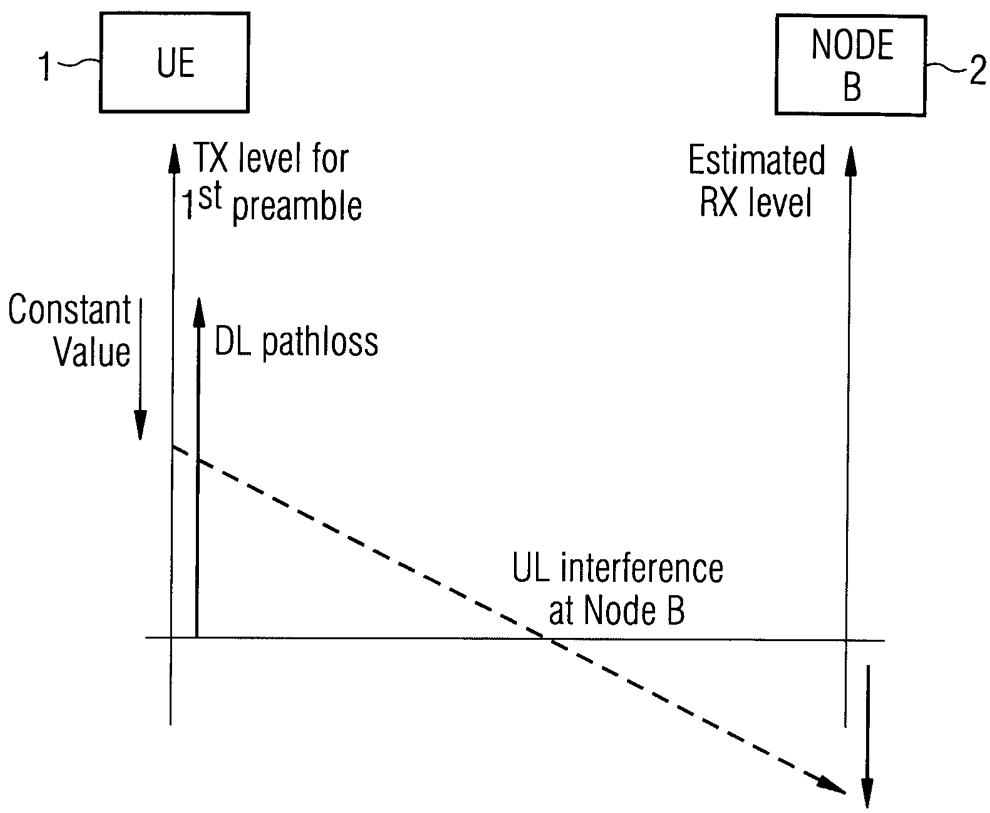

1
UE
NODE B
2
TX level for 1st preamble
Estimated RX level
Constant Value
DL pathloss
UL interference at Node B

FIG 3

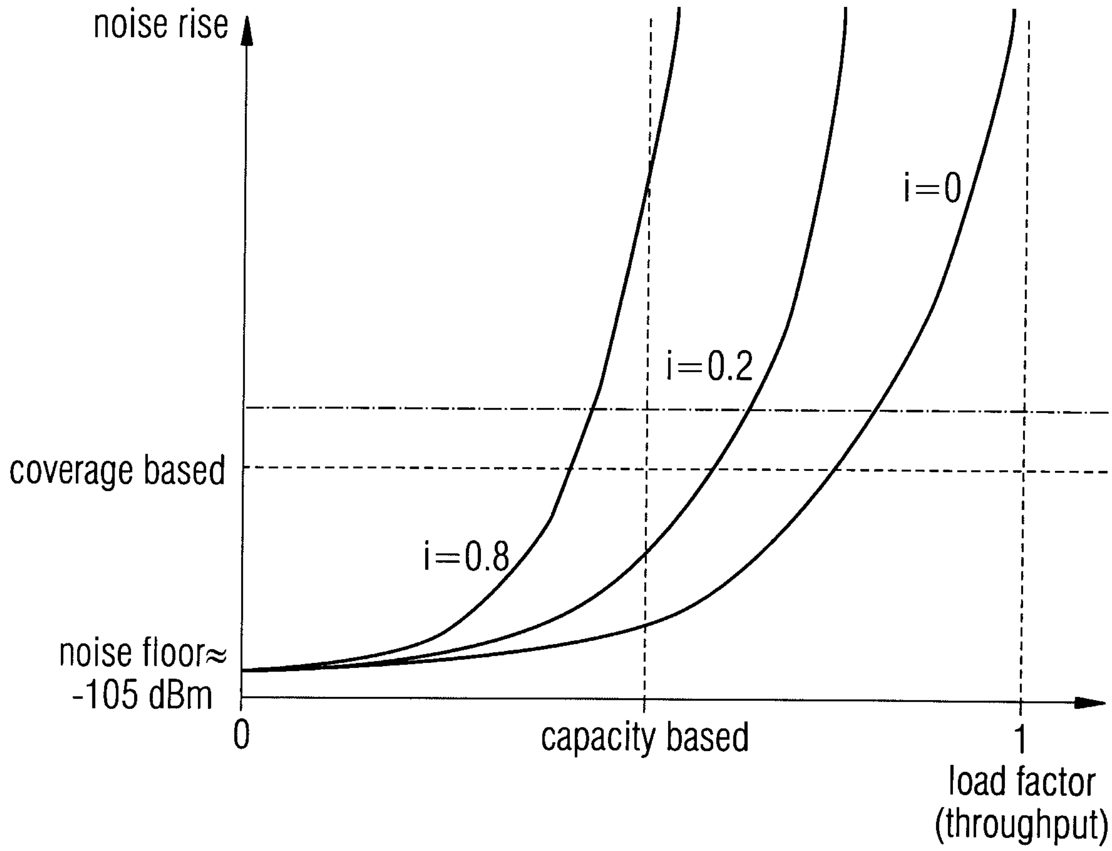

noise rise
coverage based
noise floor≈
-105 dBm
0
capacity based
1
load factor
(throughput)
i=0
i=0.2
i=0.8

FIG 4

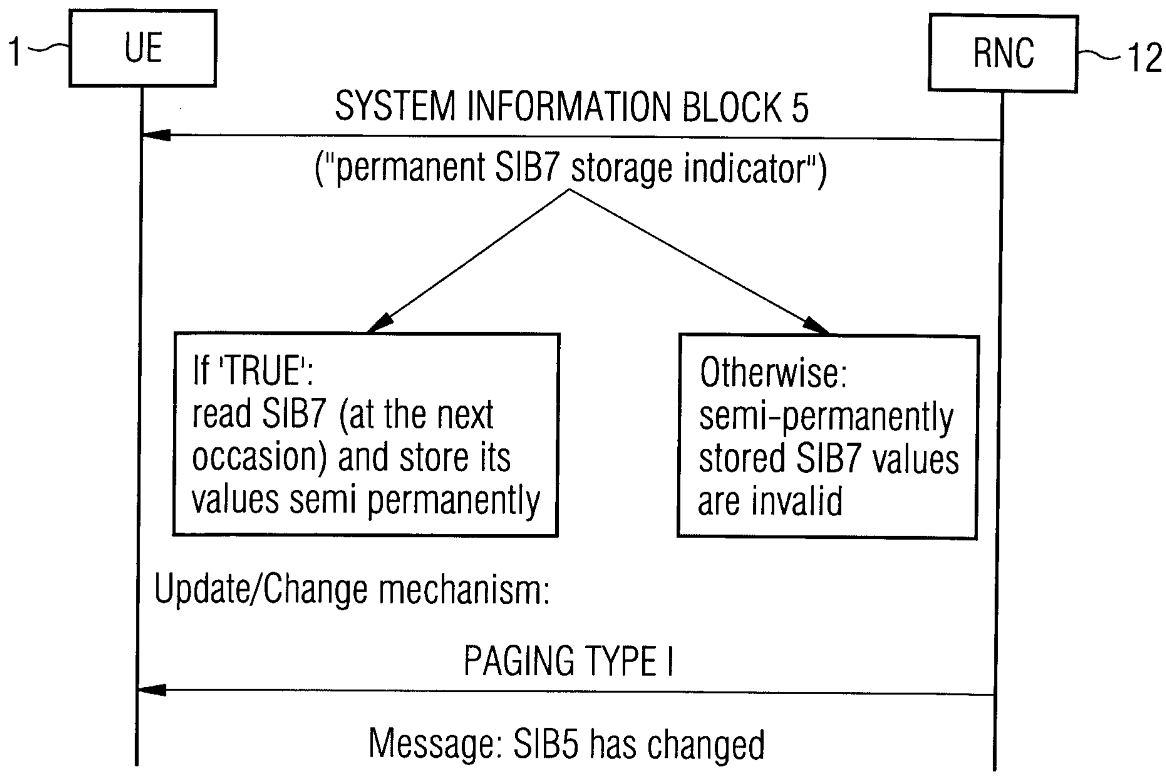
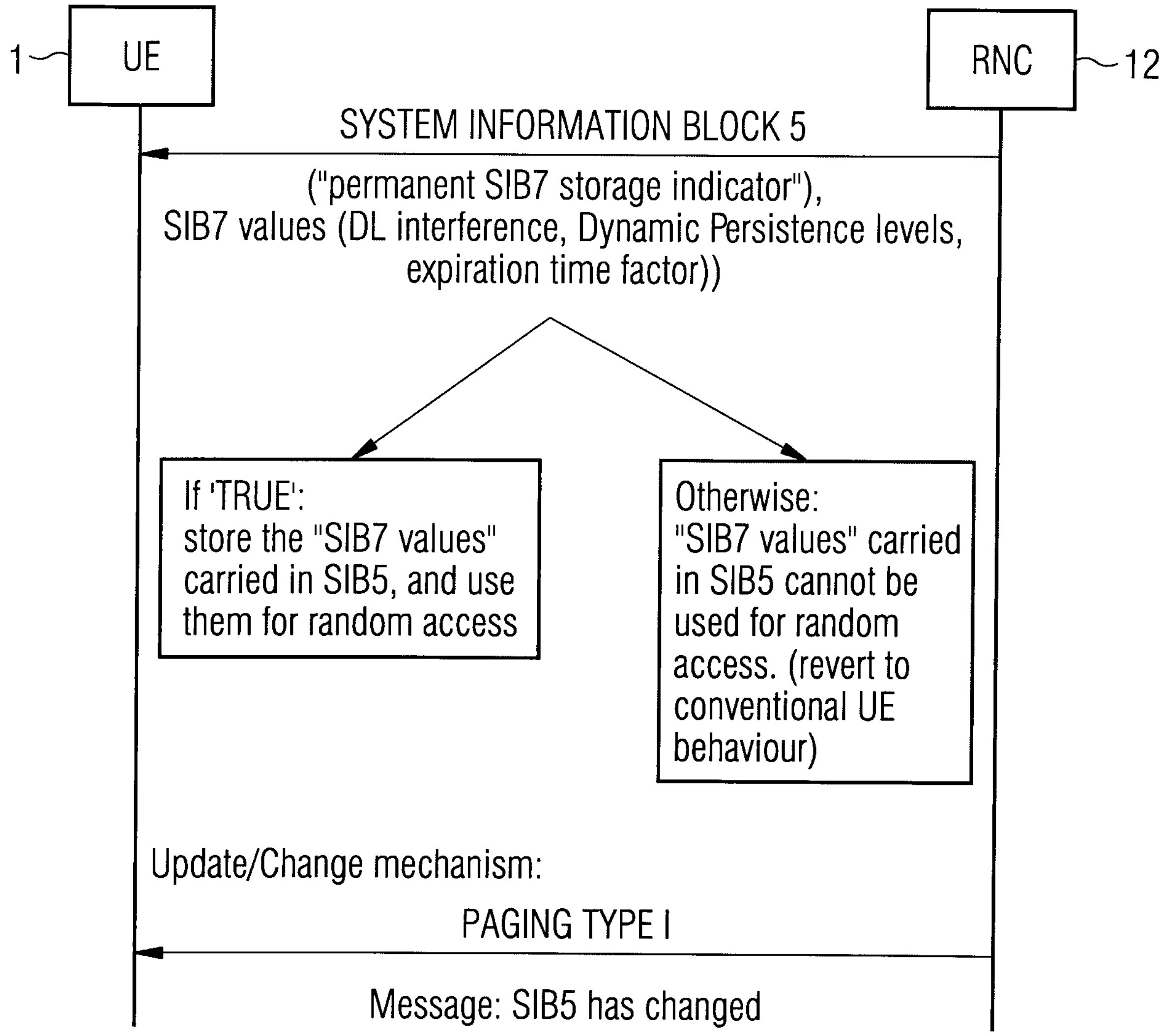

1
UE
RNC
12
SYSTEM INFORMATION BLOCK 5
("permanent SIB7 storage indicator")
If 'TRUE':
read SIB7 (at the next
occasion) and store its
values semi permanently
Otherwise:
semi-permanently
stored SIB7 values
are invalid
Update/Change mechanism:
PAGING TYPE I
Message: SIB5 has changed

FIG 5


1
UE
RNC
12
SYSTEM INFORMATION BLOCK 5
("permanent SIB7 storage indicator"),
SIB7 values (DL interference, Dynamic Persistence levels,
expiration time factor))
If 'TRUE':
store the "SIB7 values"
carried in SIB5, and use
them for random access
Otherwise:
"SIB7 values" carried
in SIB5 cannot be
used for random
access. (revert to
conventional UE
behaviour)
Update/Change mechanism:
PAGING TYPE I
Message: SIB5 has changed

A METHOD OF IMPROVING EFFICIENCY IN A RANDOM ACCESS PROCEDURE

This invention relates to a method of improving efficiency in a random access procedure between a terminal and a network.

Conventionally system information is continuously broadcast to a terminal, or user equipment (UE), such as a mobile phone in a cell and the system information includes a block type. The transmitted parameters control random access procedures and tell the UE how to calculate its initial transmission power.

System information is used to inform a terminal or UE such as a mobile phone camping in one cell of all relevant information about the cell, for example, when and on which physical channel the mobile phone can be paged, which physical channel to use for random access, how to perform measurements and how to perform cell selection and reselection.

The system information is organised in system information blocks (SIB), and each of them carries different types of cell, or network related information. For instance, SIB 11 contains measurement control information.

Most system information is quasi-static, i.e. it changes quite rarely. In UMTS, examples of quasi-static SIBs are SIB11, SIB1, SIB3 and SIB5. If the content of these SIBs has changed, or is going to change, then all UEs camping in the cell are paged. The paging is used to notify all UEs about the change of system information, so that the UEs can read the modified SIB and store its information for later use.

A small number of SIBs contain information which can change quite quickly. Therefore, an expiry timer is included in these SIBs. If the UE stores the information broadcast within one of these SIBs, it is only valid until the expiry of this timer. In UMTS, SIB7 is one of the SIBs, whose information, when stored, is only valid for a limited period of time. However, SIB7 is transmitted infrequently, which can cause delay in the random access procedure. For other systems, such as the 3rd Generation Partnership Project for the Long Term Evolution (3GPP LTE) network, then it is not necessarily SIB7 which is used, but an appropriate system information block is set containing fast changing radio parameters for random access.

The random access procedure consists of a preamble part and a message part. The preamble part is used to indicate to the radio access network, that a UE wants to send a short message (with the message part) to request resources. Code division multiple access (CDMA) allows simultaneous transmission of several entities on a given frequency resource. As a consequence, each user of the radio interface interferes with any other user. Therefore, when the UE starts to send its first physical random access channel (PRACH) preamble, the preamble part, it interferes with any other transmission, which is taking place at the same time.

Therefore, the UE has to be informed as to how it should calculate and set the transmit power for the first PRACH preamble. In UMTS, the values for the transmit power are delivered to the UE in SIB 5 and SIB 7. After sending a preamble, the UE waits for a network response. If there is no response of the network, then the UE sends the next preamble, with a higher transmit power. Thus, the extent of the power rise is part of the SIB5 information. If the first preamble power level used is too low, the random access procedure may fail due to expiry of the maximum number of attempts before a sufficient power has been reached.

In accordance with the present invention, a method of improving efficiency in a random access procedure between a terminal and a network, the method comprising reading and storing data for a first system information block containing fast changing radio parameters for random access; and setting a flag in a different system information block to indicate whether or not the value of the first system information block is permanently valid.

Preferably, on initiation of a random access procedure, the flag in the different system information block is read; and, if the flag is set to indicate that the first system information block is permanently valid, the first system information block is read and a preamble initial power for the random access procedure is determined from the data therein.

Preferably, the data in the first system information block includes uplink interference level; dynamic persistence levels; and an expiration time factor.

Preferably, if the flag in the different SIB is set for the first system information block to be permanently valid, the expiration time factor is set to infinity.

Preferably, a change to the setting of the flag in the different SIB is paged to all terminals in a cell in the network.

Preferably, on receipt of the page, if the flag is set, the terminal reads and stores an updated value of the first system information block.

Preferably, the updated value is taken from one stored in the different system information block.

Preferably, the network is a 3rd Generation Partnership Project for the Long Term Evolution network.

A method of improving efficiency in a random access procedure according to the present invention will now be described with reference to the accompanying drawings in which:

Figure 1 illustrates random access in a typical system in which the method of the present invention is carried out;

Figure 2 illustrates how transmit power of the first PRACH preamble of Fig. 1 is calculated;

Figure 3 is a graph of change in noise rise with load factor relating to the UL interference level required for calculating the PRACH preamble in Fig.2;

Figure 4 illustrates a first example of the method of the present invention; and,

Figure 5 illustrates a second example of the method of the present invention.

Although, the specific examples below are described with respect to existing UMTS systems, this invention is not limited in this way and for 3GPP LTE other SIBs are likely to be used. Throughout this description, the SIB containing fast changing radio parameters is referred to as SIB7 and the other SIB which sets a flag to indicate whether or not the content of the random access SIB is valid is referred to as SIB5 or SIB6, but the particular SIB used for each function depends upon the network concerned and the invention is not limited to using these specific SIBs.

Fig.1 illustrates a typical exchange between a UE 1 and a node B 2 in the process of starting a random access. The UE sends a PRACH preamble at successively higher powers 3, 4, 5 until the node B 2 sends a feedback on the AICH, whereafter the UE can send its PRACH message part 7.

As can be seen from Figs. 2a & 2b, the UE 1 calculates the transmit power for the first preamble based, amongst other things, on the UL interference level. The UL interference level is monitored at the Node B 2, and corresponds to the overall noise level received at the Node B. This depends again on the overall load in the cell, which can change quite frequently. The UE acquires 8 a valid version of necessary SIB information elements (IE) either using stored ones if valid, or by reading and storing the SIBs. The UE then measures 9 the common pilot channel (CPICH) received signal code power (RSCP). The preamble initial power is calculated 10 as uplink interference from SIB7 plus primary CPICH transmit power minus CPICH RSCP plus a constant, from SIB5 or SIB6. This initial power is recalculated 11 during PRACH transmission if any broadcast or measured parameter changes.

Fig.3 illustrates the change in noise rise with load factor, for different values of i, where i = ratio of own cell interference to other cell interference.

The SIB containing the fast changing radio parameters for random access, in this case SIB7, includes information regarding the UL interference level; a list of dynamic persistence levels; and an expiration time factor. In practical networks, the list contains only one dynamic persistence level value which is used as a parameter in an algorithm, with which the UE calculates when it can start sending the PRACH preambles, or when to restart the preamble cycle, if the previous PRACH preamble cycle did not end in a successful transmission of the PRACH message part. If an expiration time factor is not included, then the UE uses a default value of "1times".

Conventionally, a UE reads and stores SIB7, at which time the values are valid and can be immediately used for a maximum period of time calculated as:

$$MAX(32, SIB\_REP * ExpirationTimeFactor) * 10ms,$$

i.e., the stored SIB7 data is valid for at least 320 ms. As a maximum, this information can be stored for 40 seconds, but the exact validity time depends on how often SIB7 is transmitted on the radio interface (=SIB_REP) and the expiration time factor which is included in SIB7.

A problem is that if the UE is to permanently hold valid SIB7 information, then it has to read SIB7 periodically, reducing battery life time significantly and although information in the SIB 7 can change very frequently, generally it does not. Therefore, most UEs read SIB7 only when they have to start a random access and require valid SIB7 data. Depending on the SIB_REP rate, the random access can be significantly delayed.

Different UEs may have different stored SIB7 values because subscribers are mobile. Therefore the UEs have to select the best available cell to camp on, in order to offer mobile services to the subscriber if requested. UEs select a cell to camp on at different times, and their semi-permanently stored SIB7 values depend on the SIB7 value which is broadcast just at the moment that they read it. The controller 12 in UTRAN sets the flag, saying to all UEs should store SIB 7, but if the loading in a cell is very high, then a page is sent to all UEs telling them to read the flag in another SIB, in this example SIB5, which will have been switched so that indefinite storage is now invalid and the UE needs to listen for SIB7 again. SIB5 reads that the flag is set to allow SIB 7 to be stored and carries on with random access procedure as soon as instructed. The RNC 12 fixes what is stored in SIB 5, so they are always the same in the update.

In RAN2#48bis proposals have been made to improve SIB7 provision in order to reduce call set-up delay. One proposes to allow a permanent setting of the SIB7, e.g. having one expiration time factor in SIB7 with value "infinite", and either interpreting the time of the expiration time value 256 as 'infinity' introducing a new value 'infinity'. A problem with this is increased delay in the actual RACH ramp-up. This may be considerable if the UE stored UL interference level is significantly smaller than the current interference level at the Node B. This may even cause the random access to fail. There is also some impact on the noise rise caused when additional preambles are required in the ramp up phase. If the UE stores a much higher UL interference value then currently measured at the Node B, then the UE may become a major source of interference.

If, for example, the UL interference value stored in the UE is 4db lower than the actual measured interference level at the Node B, and when a 1dB preamble-to-preamble power step size is used, then approximately 4 preambles more are required before the Node B can detect the UE properly and return an ACK on the acquisition indication channel (AICH).

The UL interference rise is strongly dependent upon the cell load (and the neighbouring cell interference). The interference rise in relationship to the cell load is calculated with following formula:

$$I = -10 \log(1-q) \text{ [db]},$$

where I = noise rise;

q = cell load in %.

A 50% cell load (q=0.5) leads to a 3dB noise rise, a 75% load (q=.75) to a 6 dB noise rise, a 85% cell load to 8 dB noise rise, and so on.

If a UE camping on a cell, has received its permanent SIB7 information during a low load situation, and the cell load has increased dramatically, then the stored UL interference value will deviate significantly from the actual UL interference. The difference may be so high, that the UE random access fails due to having too low a set number of preambles in a preamble cycle.

Another proposal is to send the SIB7 information "uplink (UL) interference" in a message Paging Type I. If higher layers in the UE command a random access, the UE then scans in parallel the secondary common control physical channel (S-CCPCH), which carries physical channel (PCH) messages and the primary common control physical channel P-CCPCH, which carries the broadcast control channel (BCCH), and gets the SIB7 from the channel, where it was transmitted first. A problem with this is that UL interference is provided in the Node B, and the delivery of this information to the RNC for paging increases the load on the Iub interface and requires upgrades in Node B and RNC.

Thus, in the present invention, under certain conditions, a UE can store the complete random access information semi-permanently and a mechanism is provided in another block to indicate that this is applied. Examples of these mechanisms are shown in Figs. 4 & 5. A first option for this mechanism in Fig. 4 is that a flag is added to another SIB, SIB5, which indicates that the UE can store the currently broadcast information from the random access SIB, SIB7, semi-permanently. The UE stores the SIB7 values and applies them for the random access procedure. The flag is called "permanent SIB7 storage indicator" as shown in Figs 4 & 5. The flag can be Boolean, i.e., if 'TRUE', then permanent storage is allowed, otherwise not and a change of the SIB5 information is paged to all UEs in the cell. When a change is paged, the UE reads SIB5 and if the flag is set to 'FALSE', or if the flag is not included in SIB5, and if the UE has SIB7 information semi-permanently stored, then the stored SIB7 information becomes immediately invalid. However, if the flag is set to 'TRUE', then the UE reads SIB7 (at the next occasion) and stores its values semi-permanently. This also means that if the UE has already SIB7 data stored, then it is replaced by the up to date broadcast values.

If SIB5 says that the information in SIB7 is no longer ok, or that the UEs must update the stored SIB 7, then either an expiry timer is used, or a new permanent store of the value is made accordingly. The derivation of the UE 1 stored SIB7 values can be controlled by a radio network controller (RNC) 12 in the network, because it can force all UEs in the cell to update their semi-permanently stored SIB7 values by paging an SIB5 update.

Another option shown in Fig.5 is to store the parameters in SIB5 and use these directly for SIB7. If all UEs store exactly the same SIB7 values, then as well as a flag being added to SIB5, all parameters of SIB7 are also added. If the flag is set to "TRUE", then the UE 1 uses the SIB7 values carried in SIB5 for random access. Otherwise, it uses the values broadcast in SIB7.

The present invention allows a permanent setting of SIB7, combined with a paging update of SIB7 information to allow resetting the UE stored SIB7 information, if drastic changes in the cell load and therefore in the UL interference has been observed. None of the prior art proposals provide any indication of when SIB7 information has changed.

The SIB5 or SIB6 are extended with an optional 1 bit flag unrestricted SIB7 expiration time, which indicates whether the UE can store SIB7 data permanently. If the flag is not set, then the UE stores the SIB7 information. The SIB7 information is valid for the period of time, given by the "expiration time factor", broadcast in SIB7. If the flag is set then all UEs, which are not in the cell forward access channel (CELL_FACH) state, store the current SIB7 data permanently and UEs in CELL_FACH state only use SIB7 information for random access and behave as specified in UMTS Release 5/6.

For the case where only SIB5 is broadcast, then if the flag is set, all UEs in idle mode and CELL_PCH and UTRAN registration area forward access channel (URA_FACH) store the SIB 7 information quasi-permanently. When SIB5 is broadcast and the flag is set, or SIB6 is broadcast and the flag is not set, then only UEs in the idle mode store the SIB7 information permanently. If SIB5 is broadcast and the flag is not set, or SIB6 is broadcast and the flag is set, then UEs in the URA_PCH and CELL_PCH store the SIB7 information "quasi" permanently. The flag can be either of type Enumerated (TRUE) or BOOLEAN. If BOOLEAN, then "setting the flag" means that "expiration time factor" = TRUE, and "not setting the flag" means either omitting it or "expiration time factor" = FALSE.

Additionally, SIB5 or SIB6 can be extended to carry one UL interference value and dynamic persistence values for the UE to store permanently. This guarantees that all UEs store the same values permanently and therefore the UE behaviour can be well estimated. In this case, if the flag is set, then all UEs, which are not in the CELL_FACH state store the SIB7 information carried on SIB5 or SIB6 permanently; and UEs in CELL_FACH only use SIB7 information for random access and behave as specified in UMTS Release 5/6.

To deactivate, or activate, permanently stored SIB7 data, as long as the UE stored UL interference value does not deviate dramatically from the actual cell's UL interference value (1 to 2 dB), the benefit of accelerated call setup time overcomes the drawbacks caused by increased delay in actual RACH ramp-up, a short term noise rise and an increased preamble collision probability.

If the cell load is increased dramatically, so that the UE stored UL interference value is significantly different from the Node B measured UL interference, or when the UL interference fluctuates strongly, as may happen if there are a small number of enhanced dedicated channel (EDCH) users with highly fluctuating UL data rates, then the flag unrestricted SIB7 expiration time in SIB5 or SIB6 can be changed. In this case, the value tag of SIB5 or SIB6 indicates a modification of system information. If in SIB5/6 the flag unrestricted SIB7 expiration time has changed from set to not-set then the UEs' stored SIB7 information is no longer valid, and all affected UEs have to read the current SIB7 information. If in SIB5/6 the flag unrestricted SIB7 expiration time has changed from non-set to set then all affected UEs have to read the current SIB7 information and store it quasi-permanently. Either SIB7 information is delivered on SIB7 or SIB7 information can be included in SIB 5/6. If included, then the UE stores the SIB7 information delivered on SIB 5/6 quasi-permanently, otherwise it stores SIB7 information delivered on SIB7.

UL interference measurements are done in the Node B. The RNC has to know the UL interference level in order to activate and deactivate the permanent storage of SIB7 information. The RNC either is able to estimate noise level of a cell by the existing Node B measurements which are delivered to it via the node be application part (NBAP), plus knowledge of the granted load; or the Node B measurements reporting to the RNC is extended. For instance, thresholds can be defined. If the UL interference crosses an upper or lower threshold, then this event is reported to the RNC, which then may change the SIB5/6 information. A drawback of this proposal is the need to extend the signalling on the Iub interface.

There are a number of benefits of the present invention, especially when UL interference and dynamic persistence levels are included in SIB5/6. Then the UL interference value stored in the UE can be controlled in such a way that it is less than or equal to the UL interference value monitored at the Node B. In this case, an upper limit for an increased delay in actual RACH ramp-up, a short term noise rise and an increased preamble collision probability can be very accurately determined.

If the UL interference value tends not to change, as it is the case when the load factor ranges between 0 and 50%; if the CELL_DCH load tends to remain the same e.g. 50 voice calls; or if a high number of EDCH users are served most of the time at the calculated received total wideband power (RTWP) level; then there is little need to update the UE stored SIB7 information and so the impact on the UE battery life time is negligible.

In this case then the UE can store the SIB7 information permanently and the call setup time can be improved significantly. In the prior art proposals permanently stored SIB7 information is also used for UE's in the CELL_FACH state. As it is more common for random access to have to be made in this state, the impact of an erroneous UL interference value increases the negative impact of increased delay in actual RACH ramp-up, as well as short term noise rise and an increased preamble collision probability.

This is avoided in the present invention, as UEs in the CELL_FACH state have to relay only SIB 7 information, which is broadcast on the SIB7. In Rel. 99/4, there is an advisory that SIB7 should be updated immediately after the timeout of the expiration time factor, whereas in Rel. 5/6, there is a requirement that SIB7 information is updated immediately after the timeout of the expiration time factor. This stays unchanged in the present invention.

The proposed additions to SIB 5/6 are non-critical. If the UL interference fluctuates significantly within short periods of time, then the use of this solution does not have the same benefits because SIB5/6 have to be updated quite frequently. This can be the case when a small number of packet switched (ps) users have to transmit high amounts of UL data, frequently, e.g. no load, then high load, then no load, and so on. The same may happen if a small number of ps users are located on E-DCH. This scenario is less beneficial for the RACH procedure and thus, the UL interference value can be set at a level, when no ps transmission takes place.

If the RNC can deduce the UL interference level at the Node B from existing Node B measurement reports and the granted load, additional "UL interference" reporting must be introduced. Additions to SIB 5/6 are required. SIB7 contains parameters that control the RACH procedure, including the UL interference, dynamic persistence values and expiration time factor. The UL interference is used to control power level initial RACH preamble and the dynamic persistence level controls how fast RACH transmissions are re-attempted for each access service class.

When designing the UMTS system, these values were regarded as fast changing, henceforth SIB7 information, i.e. UL interference and dynamic persistence values, stored in the UE are only valid for a limited period of time, which is determined by the expiration time factor. If the validity of the UE stored SIB7 information expires, then UEs in the idle mode, CELL_PCH and URA_PCH normally, according to the implementation, do not read the SIB7 because a frequent reading of SIB7 would reduce battery lifetime significantly. UEs in the CELL_FACH state should respond for UMTS Rel. 99/4 and UEs must respond for UMTS Rel. 5/6 and read SIB7, if their stored SIB7 information becomes invalid.

The SIB7 scheduling can have a significant impact to the call setup times: When higher layers in the UE command a random access, and when the UE has no valid SIB7 data stored, then the UE must read the content of SIB7 first. The delay to read SIB7 depends on the repetition factor, with which SIB7 is scheduled on the BCCH. According to the standard, SIB7 could be repeated every 80, 160, 320, 640, 2560, ..., 40960 ms. In many implementations, a repetition factor of 80, 160, and 320 ms is not supported. Frequent repetition of SIB7 is also limited by the need to provide SIB11 (neighbourhood cell information) fast, e.g. for channel type switching, where a huge amount of data has to be transmitted. Use of permanent settings also leads to the collision probability, because an increased number of preambles is required for the random access.

CLAIMS

1. A method of improving efficiency in a random access procedure between a terminal and a network, the method comprising reading and storing data for a first system information block containing fast changing radio parameters for random access; and setting a flag in a different system information block to indicate whether or not the value of the first system information block is permanently valid.

2. A method according to claim 1, wherein, on initiation of a random access procedure, the flag in the different system information block is read; and, if the flag is set to indicate that the first system information block is permanently valid, the first system information block is read and a preamble initial power for the random access procedure is determined from the data therein.

3. A method according to claim 1 or claim 2, wherein the data in the first system information block includes uplink interference level; dynamic persistence levels; and an expiration time factor.

4. A method according to claim 3, wherein, if the flag in the different SIB is set for the first system information block to be permanently valid, the expiration time factor is set to infinity.

5. A method according to any preceding claim, wherein a change to the setting of the flag in the different SIB is paged to all terminals in a cell in the network.

6. A method according to claim 5, wherein on receipt of the page, if the flag is set, the terminal reads and stores an updated value of the first system information block.

7. A method according to claim 6, wherein the updated value is taken from one stored in the different system information block.

8. A method according to any preceding claim, wherein the network is a 3rd Generation Partnership Project for the Long Term Evolution network.

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Application No: GB0610213.1 **Examiner:** Gareth Griffiths

Claims searched: 1 **Date of search:** 15 August 2006

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
A	-	GB2409952 A (NEC)
A	-	WO2004/100565 A2 (SAMSUNG)
A	-	WO00/72609 A1 (ERICSSON)

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	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^{X} :

H4L

Worldwide search of patent documents classified in the following areas of the IPC

H04B; H04L; H04Q

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

WPI, EPODOC, TXTUS0, TXTUS1, TXTUS2, TXTUS3, TXTEP1, TXTGB1, TXTWO1, TXTAU1