Title: NON CONTENTION BASED ACCESS AT HANDOVER FAILURE

Abstract: The present invention relates to a handover process in a cellular telecommunication system. In cellular systems were the communication resources are shared among a plurality of mobile terminals, there is no designated transmission resources maintained in a source cell when a mobile station makes a handover attempt. If the handover fails, the mobile terminal reverts back to the source cell in a random access procedure. The random access is contention based. There is a severe risk of dropped call due to the one or more random access contentions are lost. The present invention solves the problem by designating a source cell specific preamble to the mobile terminal in the handover command. In case the handover fails the mobile terminal accesses the source cell by transmitting the designated preamble on the RACH. The source cell identifies the dedicated preamble as relating to the specific mobile terminal and gives it priority to transmission resources. The access procedure is further shortened because the identification of the mobile terminal need not be verified before the data communication can be started.
NON CONTENTION BASED ACCESS AT HANDOVER FAILURE

TECHNICAL FIELD OF THE INVENTION

The present invention relates to cellular communication, to the handover process where the support of radio communication with a mobile terminal is handed over from one cell to another and in particular to a method in respectively a radio base station and a mobile terminal relating to handover failure.

DESCRIPTION OF RELATED ART

Figure 1 is a view of two cells C1, C2 and a mobile terminal 11. A first of the cells C1 supports the mobile terminal with communication. The mobile terminal 11 approaches the second cell C2, and at some stage the first cell C1, decides that the support of the communication with the mobile terminal shall be handed over to the second cell C2 and initiates the handover process. During the handover process the mobile terminal leaves the first cell C1 that is acting source cell, while the second cell C2 that is entered is acting target cell during the handover process.

The communication in the first cell C1, is controlled by a first radio base station 121, and the communication in the second cell C2 is controlled by a second radio base station 122. In the further description it is assumed that the communication system is a eUTRA system, as is standardized by 3GPP. eUTRA is often named LTE (Long Term Evolution). In eUTRA the radio base stations are named eNB (evolved Node B). The eNBs are connected via X2 interfaces, as is illustrated in figure 1. eUTRA consist of a plurality of eNBs preferably interconnected via X2 interfaces, the eNBs are also connected to core network nodes via a S1 interface. For simplicity only two of the eNBs 121, 122, are disclosed in figure 1. The core network nodes MME (Mobility Management
Entity) and S-GW (Serving Gateway) are roughly indicated in figure 1, since they are of minor importance for the present invention.

Figure 2 is a signalling chart, taken from the standard 3GPP 36.300 V 8.1.0 CH. 10.1.5.1 on the handover procedure. The signalling chart discloses the messages sent between the UE, as is the eUTRA name of the mobile terminal 11, the source and target eNBs, the MME and S-GW.

The source eNB 121 decides on the handover typically based on measurements received from the UE 11, and initiates the handover by sending a handover request to the target eNB, 122. The handover request includes information on the UE 11 identity. Provided the target eNB 122, admits the handover, it designates a preamble to be used by the UE 11, for the specific handover process. The target eNB 122 acknowledge the handover request to the source eNB 121 and provide information of the preamble to use by the UE in the target eNB 122. The source eNB 121 sends a handover command to the UE 11, which includes information on the target cell identity and the target cell preamble. The UE 11 approaches the target cell 122 by sending the target cell preamble on the RACH (Random Access Channel). The target eNB 122, identifies the received preamble as coming from the UE 11 that it is assigned to.

Figure 3, is a signalling diagram illustrating the conveying of the preamble P1, designated by the source cell for the specific handover, by the arrows of:

31. The target eNB 122 sends the designated preamble P1 to the source eNB 121 for further transfer to the UE in the handover command 31.

32. The UE 11 makes a random access 32 to the target cell C2, by transmitting the preamble P1 over the RACH.
The UE 11 receives a random access response 33 from
the target eNB 122, that acknowledge that the preamble P1
is received.

It may happen that the handover to the target cell 122,
fails. The reason may be that either the random access 32
preamble P1, is not detected by the target eNB 122, or the
random access response 33 is not received by the UE 11, as
is illustrated in the signalling diagram of figure 4. In
case of handover failure, the UE 11 shall revert to the
source cell C1 for continued support of the communication.

In cellular communication systems in use at the time eUTRA
is being developed, resources for communication with the
mobile terminal are maintain in the source cell during the
handover process. If the handover fails, the mobile terminal
reverts to the source cell and continues communication with
maintenance of logical and physical resources, such as
temporary identities, queue status of buffers.

A significant difference in e-UTRA, as compared to the prior
systems, is that in case the first UE 11 fails the handover
to the target cell C2, it must contend with other UEs for
getting access back to the target cell C1. The reason the
other UEs make the access attempt may be for call setup, or
registrations.

When the UE 11 does not receive any random access response
from the target cell C2 it shall revert back to the source
cell in a random access process. The random access is a
contention based process and is specified in 3GPP 36.300 v
8.1.0 CH 10.1.5.1. The UE 11 starts the random access
process by selecting a random preamble within a group of
possible preambles. The signalling is further disclosed in
figure 4. The UE sends 44 the randomly selected preamble
over the RACH. The source eNB 121 in return sends a random
access response 45 that includes an identifier of the
preamble used by the UE 11, and a temporary identity of the
UE 11 in the cell. The temporary identifier is named
temporary C-RNTI (Cell Radio Network Temporary Identifier).
Next the UE 11 makes a first scheduled transmission 46 on
UL-SCH (UpLink Synchronisation Channel), and that includes
an UE unique identity. The random access process is finished
by the source eNB sending a contention resolution 47 to the
UE. In case more than one UE selected the same preamble for
random access during the same period only one of them is
addressed in the contention resolution message, by reference
to the unique UE identity.

If the UE is not addressed in the contention resolution
message from the source eNB 121, it has lost the random
access contention. The UE must restart the random access
process again by transmitting a randomly selected preamble
44 over RACH to source eNB 121. The UE waits for a
contention resolution message being addressed to it during a
predefined time period after sending the preamble.
Consequently, even if a contention resolution message has
been addressed to the one of the UEs winning the contention,
the loosing UEs wait until the time period is ended before
they restarts the random access procedure.

SUMMARY OF THE INVENTION

The object of the present invention is to reduce the risk of
dropped call at handover failure.

The essence of the present invention is; a source cell
designates a cell unique preamble to a mobile terminal for
accessing the source cell in case of the handover to a
target cell fails. More specifically it relates to a method
for a radio base station and to a method for a mobile
terminal. According to the first method the radio base
station supports communication with a mobile terminal in a
first cell, and a first identity is associated with the
mobile terminal. The radio base station further designates a preamble for a handover process with the mobile terminal and associates it with the first identity, sends the preamble to the mobile terminal in a handover command, monitors if the preamble is received over the random access channel, and if it is received continues the communication with the mobile terminal assuming the first identity is still valid for the communication with the mobile terminal transmitting the preamble.

According to the second method, a mobile terminal that is supported by communication in a source cell receives a command to perform handover to a target cell, wherein the command includes a source cell preamble. The mobile terminal sends a random access request to the target cell, and if no response is received from the source cell, the mobile terminal sends the preamble over the source cell random access channel.

The invention also relates to a radio base station and a mobile terminal that are arranged for performing respective of the two methods.

Advantages afforded by using a designated preamble for access in the source cell in case of handover failure are:

1. The source eNB can more easily detect that the preamble is received when it expects a designated preamble code, as compared to if an arbitrary among a number of preambles is received.

2. Fast re-establish of communication in the source cell because there is no risk the UE failing handover randomly selects the same preamble as another UE, loses the contention in the RA-process, and need restart the RA-procedure.
3. The delay for re-establishment of communication in target cell is further, decreased, because less signalling is needed between the source cell and the UE to verify the UE identity.

All the advantage contributes in avoiding the risk of dropped call, because they shortens the time until communication can take place in the source cell and that is of outmost importance when the mobile terminal is on the cell edge and the radio quality may rapidly vary between the source and target cells.

DESCRIPTION OF THE DRAWINGS

Figure 1 is a view of cells, an UE, eNBs and connections to and from the eNBs.

Figure 2 is a prior art signalling diagram of the handover process.

Figure 3 is a signalling diagram illustrating the prior art use of a designated preamble in successful handover.

Figure 4 is a signalling diagram of a non successful handover according to the prior art.

Figure 5 is a signalling diagram of non successful handover according to the invention.

Figure 6 is radio base station block diagram.

Figure 7 is a protocol stack of the eUTRA radio interface control plane as terminating in respectively the UE, the eNB and AGW.

Figure 8 is mobile terminal block diagram.
DESCRIPTION OF PREFERRED EMBODIMENTS

The present invention is described in the context of an eUTRA system, because the problem of an UE contend with other UEs in getting access to its source cell in case a handover attempt fails, appears for the first time in the eUTRA. The solution may however be applied also to other future systems.

A first eNB 121, as disclosed in figure 1, supporting a first UE 11 with communication in a first cell Cl, may decide that the first UE 11 shall perform handover to a second cell C2 served by a target eNB 122. The decision is based on measurements provided by the UE 11. The first cell C1 and first eNB 121 the act as source cell and source eNB, while the second cell C2 and second eNB 122 act target cell and target eNB.

Use of preamble for accessing source cell

The source eNB designates a preamble to the first UE 11 to use in case the handover fails and the first UE 11 needs to revert back to the source cell. As long as the source cell preamble is designated to the first UE 11, it shall not be used by any other UE accessing the cell Cl.

Figure 5 is a signaling diagram disclosing the procedure in case of handover failure according to the present invention. The signaling diagram discloses signals with start from top and following downwards:

51. The source eNB sends 51 a handover command to the first UE. The handover command includes the designated source cell preamble P2. The handover command also includes a target cell preamble Pl, and an instruction to make handover to the target cell, as is disclosed in the prior art.
32. The UE 11 is thereby triggered to send the target cell preamble over the target cell RACH, as is also in the prior art. This is performed just as is disclosed in the prior art.

33. For some reason the UE 11 fails to receive any RA-response (Random Access response). It may owe to the target eNB failed to receive the target cell preamble, and did not send any RA-response.

34. The UE 11 access the source cell by sending the source cell preamble P2 over the source cell RACH.

35. The source cell sends a RA-response on DL-SCH (Down Link Shared Channel).

When the source eNB 121 designates the preamble P2 to the first UE, it is saved in a UE specific record named UE context. The UE context includes information associated with the first UE 11 and that is needed for the first eNB 121 to support the communication with the first UE 11. For example the UE context includes a C-RNTI (Cell Radio Network Temporary Identifier) that the eNB 121 has assigned to the first UE 11. The C-RNTI is an identifier of the first UE 11 in the cell, and used to address the first UE in DL communication. The UE context also includes information on all UE identities used for the communication with the specific UE in the cell and information relating to configurations of the radio bearers that has been agreed with the UE.

After the handover command is sent 51 to the UE 11, the source eNB monitors the RACH for the assigned preamble P2 to be received. If it is received 54, the eNB uses the association between the preamble and the UE context to find the C-RNTI of the first UE 11.
The RA-response sent from the source eNB to the first UE, includes an identifier of the source cell preamble P2, and a TA (Timing Advance) value. The RA-response preferably also include the C-RNTI. The source cell preamble P2 identifier ensures only the first UE is addressed by the RA-request. The TA value is used to adjust the uplink transmission timing to compensate for propagation delay. The first UE is synchronized to the source cell when adjusted according to the TA-value.

When the first UE is synchronized to the source cell, communication in the source cell continues using the same C-RNTI and the same configurations of radio bearers and signaling radio bearers as was agreed upon with the UE before the handover attempt. The UE context, includes the agreed bearer configurations. This is the core of the invention.

Preamble

According to 3GPP TS 36.300 V8.1.0 the random access preambles comprise a 5 bit random identity. The bit patterns selected for preambles must be distinguishable from each other. Ideally they should be orthogonal. It is however very hard, if not impossible, to produce a sufficient number of 5 bit preambles that are orthogonal. Less orthogonal preambles will be used.

The orthogonal property is desired because plural random access preambles will be received overlapping in time, and it should be possible to resolve them all. In the contention based random access process, the UE randomly selects one in a set of predefined preambles for transmission on the RACH. In order to avoid collision, when two or more UEs use the same preamble in the same period, the number of preambles for random selection should be high.
With the present invention a sub-set of all preambles available in the cell must be reserved for the eNB to designate to UEs for handover purposes. The sub-set of preambles may be used for assigning to UEs for making a handover when the cell is acting target cell and to other UEs having the cell as source cell when making handover. Important is though that the same preamble is never allocated to two different UE in the same cell during the same time period, whether the cell is acting source or target cell. Therefore, a preamble shall be designated to a specific UE only for a time period, until it must be available for being designated to another UE. Since the number of preambles with good properties is limited, the time period a preamble is designated should only be as long as it may be used. Preferably the source eNB 121 designates it just before informing of it in the handover command sent to the first UE 11. The time period may be ended by the source cell receiving a Release Resource signal from the target eNB, see arrow 16 in figure 2. Alternatively, the handover command sent from the source eNB 121 to the first UE 11, includes information on the period the assignment is valid. When the period is over the preamble is free to be assigned to another UE. In the rare case the first UE fails the handover and need revert to the source cell after the period is ended, it must enter the contention based random access process in the source cell Cl.

**eNB architecture**

Figure 6 is a block diagram illustrating the basic physical blocks of the eNB 121. The block diagram is only for illustrating most important blocks and functions related to the invention and is far from a complete radio base station block diagram. The eNB comprises a radio transceiver 61 connected to an antenna, an S1 interface module 62, and X2 interface module 63 and a processor with connections to the transceiver 61, the S1 interface 62, and the X2 interface.
63. The total eNB is organized for separating the user plane data and a control plane. Accordingly all the internal connections to and from the processor 64 are separated for control plane and for user plane data. In figure 6 connections for the user plane is illustrated by hatched lines, while the control plane connections are illustrated by continuous lines. The processor 64 is a physical processor typically implemented in a CPU and comprising memories for recording data and controlled by software.

Figure 7 illustrates the protocol stacks in the UE, the eNB and the AGW and is published in the 3GPP TS 36.300 V8.1.0. For this invention the RRC (Radio Resource Control) layer is the important one. It is the RRC that controls and builds the UE context when the first UE 11 is in active mode. It is also the RRC layer that assigns the C-RNTI to the first UE 11. It is done the first time the UE enters active mode within the first cell Cl. Active mode may be entered when the first UE registers in the first cell or when the first UE enters the first cell Cl via handover from another cell.

In connection to the C-RNTI is being assigned is also made an authentication of a eUTRA unique identity of the first UE 11.

The RRC module 65 is indicated in the processor 64 with a hatched box. The RRC module 65 is implemented in a combination of hardware and software. There is a memory 66 available for and controlled by the RRC software, for recording the data in UE context. According to the invention the UE context is updated with a post for including the source cell preamble, in case it is being designated for a period. The RRC module 66 decides when a handover is to be performed based on measurements received from the UE 11. It is adapted for assigning the source cell preamble, recording it in the UE context and releasing it when the assignment period is ended. The sub-set of preambles available for the RRC module to assign to a UE is listed in a record 67.
included in the RRC module 65. When a new handover is to be performed the RRC module picks a random one of the preambles in the record 67, and assigns it to the UE for a period. The assigned preamble is deleted from the list, and reentered when the assignment period is ended.

**UE architecture**

Figure 8 is a simplified block diagram of the UE 11. The UE comprises a transceiver 81, and a processor 84, and that are connected to each other. The processor consists of hardware such as processors and memories and of software. At least part of the software is organized according to the protocol stack discloses in figure 7. The RRC layer software functions are indicated by a hatched box 85. A memory 86 for storing the source cell specific preamble is indicated in figure 8. The RRC layer functions 85 are further arranged to store the source specific identities and configuration agreements, during the handover attempt. The RRC layer functions are all arranged to identify the source cell preamble in the handover command, and in case of handover failure, control the random access process is initiated in the source cell by transmission of the source cell preamble.
CIAIMS

1. A method for a radio base station (121) supporting a first mobile terminal (11) with communication in a first cell (Cl), and a first identity is associated with the mobile terminal in the radio base station (121), comprising the steps of,

- transmitting (51) a command to the first mobile terminal to perform handover to a target cell (C2) supported by a target radio base station (122), characterised by:

  - designating a first cell unique first preamble to the mobile terminal, associate it with the first identity and include it in the command, prior to the transmitting step;

  - monitoring if the first preamble is received in the first cell, and if it is,

    - support the first mobile terminal with communication, assuming the first identity is still valid.

2. The method according to claim 1, wherein the first identity is assigned by the radio base station (121) to be unique in the first cell for supporting communication with the first mobile terminal (11) and comprising the further step of,

    - transmitting a random access response, in response to the first preamble being received, wherein the random access response includes the first identity.

3. The method according to claim 1 or 2, wherein the first preamble is designated to the first mobile terminal (11) for use in the first cell (Cl) only.
4. The method according to claim 1, 2 or 3, wherein the first preamble is designated to the first mobile terminal (11) for a time period.

5. The method according to claim 4, wherein the time period is defined by the radio base station (121) and is informed to the mobile terminal (11) in the command (51).

6. The method according to claim 4, wherein the time period is ended when the radio base station (121) receives an instruction to release resources assigned for communication with the first mobile terminal (11).

7. The method according to claim 1 or 2, wherein the command (51) also includes a target cell (C2) specific preamble that is assigned to the first mobile terminal (11).

8. The method according to claim 7 wherein the target cell specific preamble is received from the target cell and included in the command by the radio base station (121).

9. The method according to claim 2 wherein the first identity is a C-RNTI.

10. The method according to claim 1, 2 or 9 wherein the association between the first identity and first preamble is made by recoding in a common record that is specific for the first mobile terminal.

11. A method for a mobile terminal (11) served by a first cell (C1) that acts source cell, comprising the steps of,

   - receiving a command to perform handover to a second cell (C2) acting target cell, characterised in that, the command includes a source cell unique preamble, and by the further steps of:
- transmitting a random access request (32) in the target cell, and if no response (33) on the transmitted random access request is received from the target cell (C2),

- transmitting the source cell unique preamble in the source cell.

12. The method according to claim 11, comprising the further step of:

- receiving a response on the transmitted source cell unique preamble, the response including a first cell unique identity of the mobile terminal.

13. A radio base station (121) arranged to support at least a first mobile terminal (11) with communication in a first cell (C1) and comprising:

- a radio transceiver (61), supporting communication over one or more radio channels;

- an interface (62, 63) for connection to a network;

- a processor (64) with connections to the interface and the radio transceiver, and arranged for controlling the operation of the radio base station (121), and in particular to control a handover command is transmitted to the first mobile terminal, characterised by the processor further comprises;

- means (65, 67) for designating a first cell unique preamble to the first mobile terminal;

- a memory (66) for registering the preamble and associating it with a first identity of the mobile terminal;

- means for monitoring if the preamble is received on a radio channel; and wherein the processor is further
arranged to support continued communication with the first mobile terminal assuming the first identity is still valid for the mobile terminal that transmitted the preamble.

14. The radio base station of claim 13, wherein the processor is further arranged to control random access response is send acknowledging the receipt of the preamble and including the first identity in said response.

15. The radio base station of claim 13 or 14 wherein the processor (64) is further arranged to assign the first identity for it to be unique in the first cell (C1).

16. A mobile terminal comprising a radio transceiver (81), and a processor (84) for controlling the operation of the mobile terminal, the processor further comprising,

- a radio resource unit (85) arranged for controlling a handover operation in response to a command being received via the radio transceiver (81), and characterised by being arranged for identifying and storing a source cell preamble received in the handover command, and in case of handover failure control the mobile terminal to access the source cell by transmitting the source cell specific preamble.
Fig. 5

RA Preamble assignment P1,P2

Source eNB/old cell

Target eNB/new cell

Random Access Preamble P1

Random Access Response

Random Access P2

Random Access Response

Fig. 6
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

INV. H04Q7/38

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

B. FIELDS SEARCHED

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

Electronic database consulted during the international search (name of database and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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D See patent family annex.

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Date of the actual completion of the international search: 7 August 2008

Date of mailing of the international search report: 22/08/2008

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