(12) UK Patent Application (19) GB (11) 2 425 687 (13) A

(43) Date of A Publication 01.11.2006

(21) Application No: 0508796.0

(22) Date of Filing: 29.04.2005

(71) Applicant(s):
Motorola Inc
(Incorporated in USA - Delaware)
1301 East Algonquin Road, Schaumburg, Illinois 60196, United States of America

(72) Inventor(s):
Stephen J Barrett

(74) Agent and/or Address for Service:
Eltima Consulting
Grove House, Lutyens Close, Chineham Court, BASINGSTOKE, Hampshire, RG24 8AG, United Kingdom

(51) INT CL:
H04B 7/005 (2006.01) H04Q 7/38 (2006.01)

(52) UK CL (Edition X):
H4L LRRTP L213

(56) Documents Cited:
EP 1526652 A1 **EP 1507343 A1**

(58) Field of Search:
UK CL (Edition X) **H4L**
INT CL^7 **H04B, H04L, H04Q**
Other: **Online: WPI, EPODOC**

(54) Abstract Title: **Transmission power control in a hard handover channel**

(57) A cellular communication system (100) comprises base stations (103, 105, 107) which receive signals from a user equipment (101) in a soft handover communication channel which is supported by a plurality of base stations (103, 105, 107) and in a non-soft handover communication channel supported only by a first base station (103) of the plurality of base stations. The base stations (103, 105, 107) are coupled to an RNC (109) which comprises an error processor (203) that determines a characteristic, such as an error rate, of signal components of the signals of the soft handover communication channel transmitted between the user equipment and the first base station. The RNC (109) furthermore comprises a transmission parameter processor (209) which determines a modified transmission parameter for the transmissions of signals from the user equipment (101) in the non-soft handover communication channel in response to the characteristic. The transmission parameter may for example be a transmit power offset or a repetition rate for transmissions in the non-soft handover communication channel. The modified transmission parameter is transmitted to the user equipment (101) in a reconfiguration message.

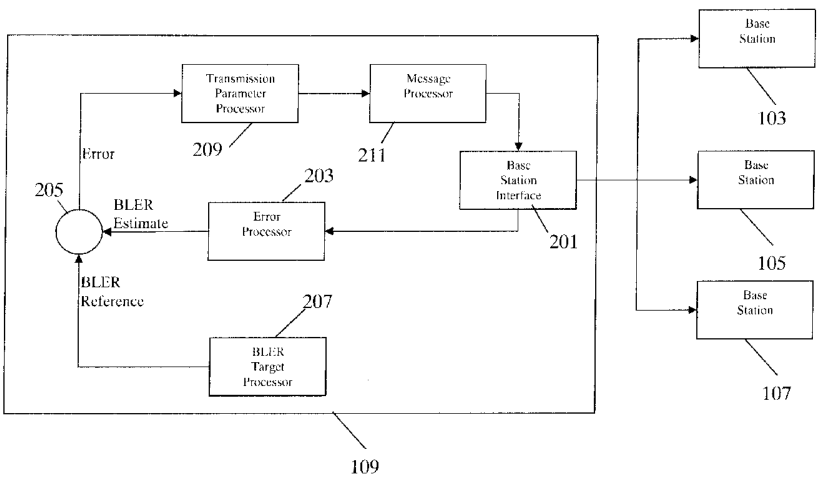

FIG. 2

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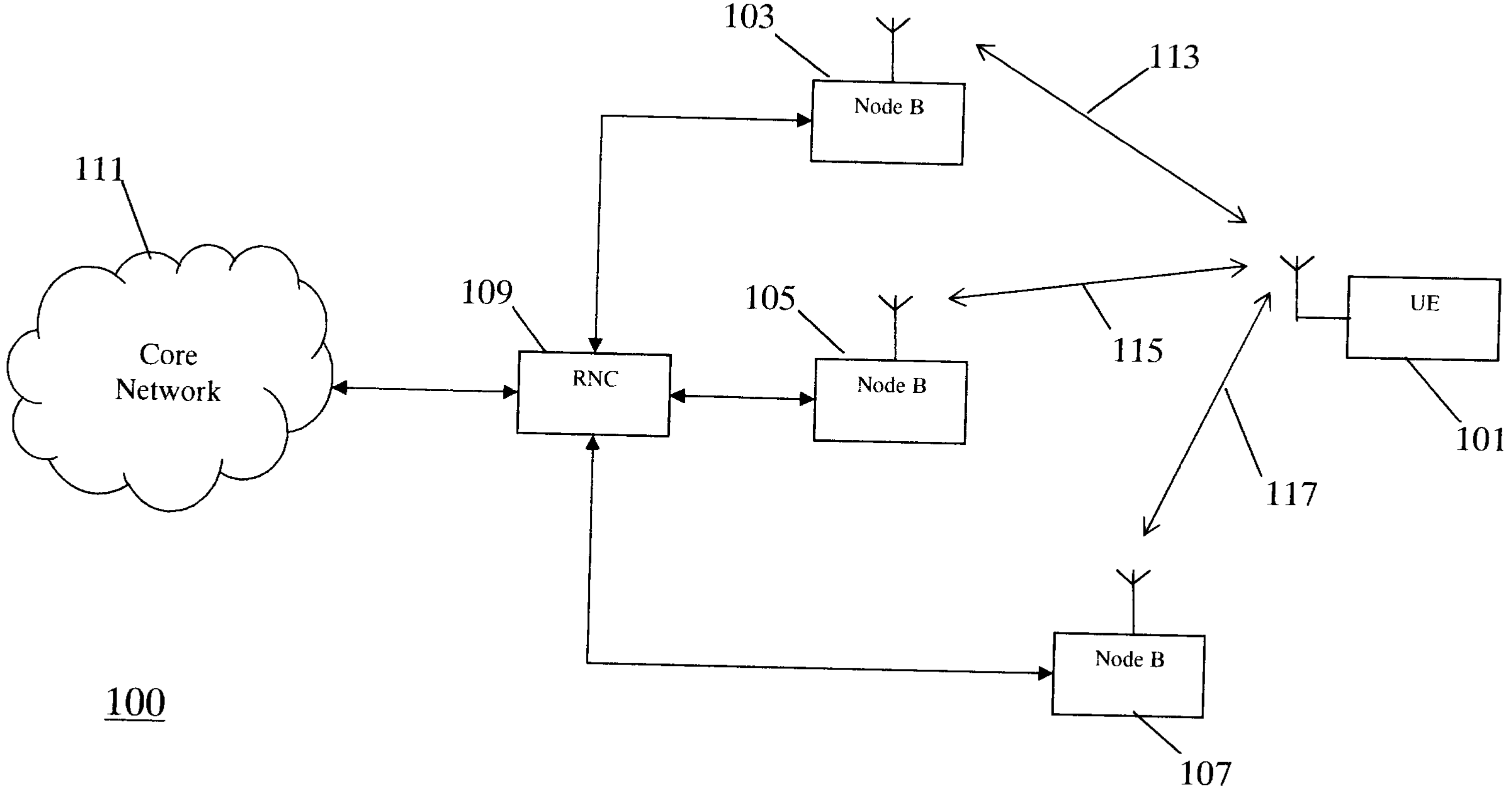
103
Node B
113
111
Core
Network
109
RNC
105
Node B
115
UE
101
117
Node B
107
100

FIG. 1

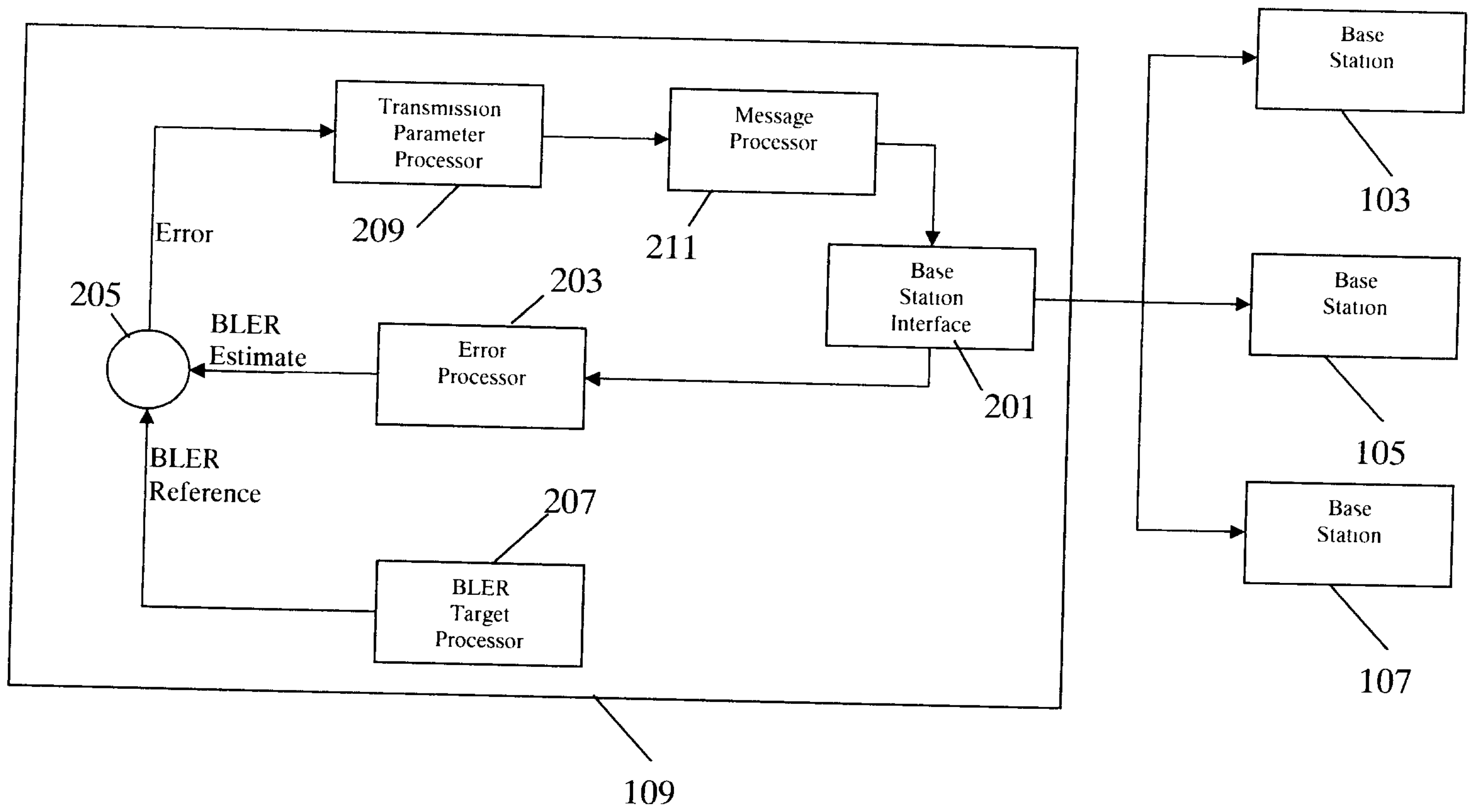
Transmission Parameter Processor
Message Processor
Base Station Interface
Error Processor
BLER Target Processor
Error
BLER Estimate
BLER Reference
Base Station
Base Station
Base Station
209
211
203
205
207
201
109
103
105
107

FIG. 2

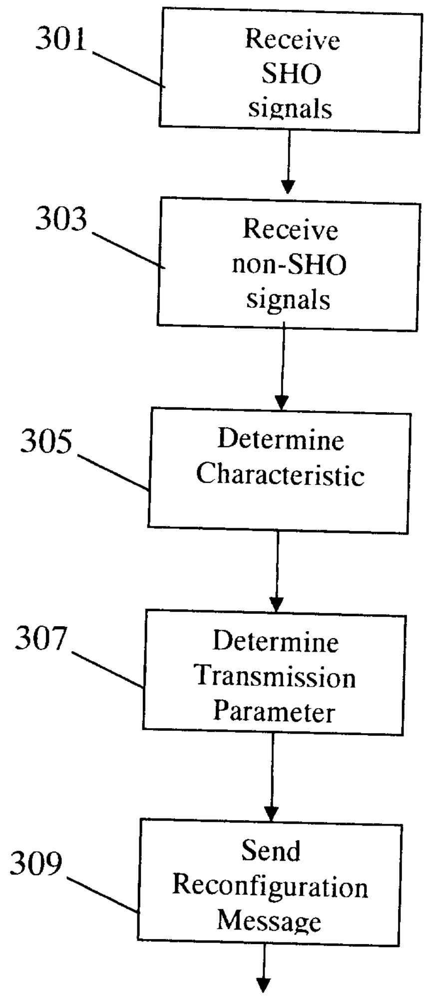
301
Receive SHO signals
303
Receive non-SHO signals
305
Determine Characteristic
307
Determine Transmission Parameter
309
Send Reconfiguration Message

FIG.3

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A CELLULAR COMMUNICATION SYSTEM AND A METHOD OF TRANSMISSION CONTROL THEREFOR

Field of the invention

The invention relates to transmission control in a cellular communication system and in particular, but not exclusively, to transmission control in a 3rd generation cellular communication system.

Background of the Invention

In a cellular communication system, a geographical region is divided into a number of cells served by base stations. The base stations are interconnected by a fixed network which can communicate data between the base stations. A mobile station is served via a radio communication link from the base station of the cell within which the mobile station is situated.

A typical cellular communication system extends coverage over an entire country and comprises hundreds or even thousands of cells supporting thousands or even millions of mobile stations. Communication from a mobile station to a base station is known as the uplink, and communication from a base station to a mobile station is known as the downlink.

The fixed network interconnecting the base stations is operable to route data between any two base stations, thereby enabling a mobile station in a cell to communicate with a mobile station in any other cell. In addition, the fixed network comprises gateway functions for interconnecting to external networks such as the Internet or the Public Switched Telephone Network (PSTN), thereby allowing mobile stations to communicate with landline telephones and other communication terminals connected by a landline. Furthermore, the fixed network comprises much of the functionality required for managing a conventional cellular communication network including functionality for routing data, admission control, resource allocation, subscriber billing, mobile station authentication etc.

The most ubiquitous cellular communication system is the 2nd generation communication system known as the Global System for Mobile communication (GSM). GSM uses a technology known as Time Division Multiple Access (TDMA) wherein user separation is achieved by dividing frequency carriers into 8 discrete time slots, which individually can be allocated to a user. Further description of the GSM TDMA communication system can be found in 'The GSM System for Mobile Communications' by Michel Mouly and Marie Bernadette Pautet, Bay Foreign Language Books, 1992, ISBN 2950719007.

Currently, 3rd generation systems are being rolled out to further enhance the communication services provided to mobile users. The most widely adopted 3rd generation communication systems are based on Code Division Multiple Access (CDMA) technology. Both Frequency Division Duplex (FDD) and Time Division Duplex (TDD) techniques employ this CDMA technology. In CDMA systems, user separation is obtained by allocating different spreading and scrambling codes to different users on the same carrier frequency and in the same time intervals. In TDD, additional user separation is achieved by assigning different time slots to different users in a similar way to TDMA. However, in contrast to TDMA, TDD provides for the same carrier frequency to be used for both uplink and downlink transmissions. An example of a communication system using this principle is the Universal Mobile Telecommunication System (UMTS). Further description of CDMA and specifically of the Wideband CDMA (WCDMA) mode of UMTS can be found in 'WCDMA for UMTS', Harri Holma (editor), Antti Toskala (Editor), Wiley & Sons, 2001, ISBN 0471486876.

In a 3rd generation cellular communication system, the communication network comprises a core network and a Radio Access Network (RAN). The core network is operable to route data from one part of the RAN to another, as well as interfacing with other communication systems. In addition, it performs many of the operation and management functions of a cellular communication system. The RAN is operable to support wireless user equipment over a radio link of the air interface. The RAN comprises the base stations, which in UMTS are known as Node Bs, as well as Radio Network Controllers (RNCs) which control the base stations and the communication over the air interface.

The RNC performs many of the control functions related to the air interface including radio resource management and routing of data to and from appropriate base stations. It further provides the interface between the RAN and the core network. An RNC and associated base stations are collectively known as a Radio Network Subsystem (RNS).

3rd generation cellular communication systems have been specified to provide a large number of different services including efficient packet data services. For example, downlink packet data services are supported within the 3rd Generation Partnership Project (3GPP) release 5 Technical Specifications in the form of the High Speed Downlink Packet Access (HSDPA) service.

In accordance with the 3GPP specifications, the HSDPA service may be used in both Frequency Division Duplex (FDD) mode and Time Division Duplex (TDD) mode.

In HSDPA, transmission code resources are shared amongst users according to their traffic needs. The base station (also known as the Node-B for UMTS) is responsible for allocating and distributing the HSDPA resources amongst the individual calls. In a UMTS system that supports HSDPA, some of the code allocation is performed by the RNC whereas other code allocation, or more specifically, scheduling is performed by the base station. Specifically, the RNC allocates a set of resources to each base station, which the base station can use exclusively for high speed packet services. The RNC furthermore controls the flow of data to and from the base stations. However, the base station is responsible for scheduling High Speed-Downlink Shared CHannel (HS-DSCH) transmissions to the mobile stations that are attached to it, for operating a retransmission scheme on the HS-DSCH channels, for controlling the coding and modulation for HS-DSCH transmissions to the mobile stations and for transmitting data packets to the mobile stations.

HSDPA seeks to provide packet access techniques with a relatively low resource usage and with low latency.

Specifically, HSDPA uses a number of techniques in order to reduce the resource required to communicate data and to increase the capacity of the communication system. These techniques include Adaptive Coding and Modulation (AMC), retransmission with soft combining and fast scheduling performed at the base station.

Although 3rd Generation cellular communication systems support soft handovers wherein transmissions between a mobile station and a plurality of base stations are combined for improved performance, HSDPA communications are designed to involve only a single cell. Accordingly, HSDPA relies on only a single radio link and soft handover of HSDPA signals is not supported. Thus, in an HSDPA enabled cellular communication system some communication channels may support soft handover whereas other communication channels (such as HSDPA channels) do not.

It is important to manage radio links between base stations and communication units such that the resource used by a given communication link is as low as possible. It is therefore important to minimise the interference caused by the communication to or from a mobile station, and consequently it is important to use the lowest possible transmit power. As the required transmit power depends on the instantaneous propagation conditions, it is necessary to dynamically control transmit powers to closely match the conditions. For this purpose, the base stations and mobile stations operate power control loops, where the receiving end reports information on the receive quality back to the transmitting end, which in response adjusts the transmit power.

Specifically, in WCDMA, the uplink power control operates by the base station calculating the signal to interference ratio (SIR), comparing this to a desired uplink SIR threshold and transmitting a power down control signal to the mobile station if the SIR is above the threshold. If the SIR is not above the threshold, the base station transmits a power up control signal.

If a mobile station is in an active soft handover, it may receive transmit power commands from the active base stations. The mobile station will increase the transmit power only if all of the active base stations transmit a power up command. Thus, if one or more of the base stations transmit a power down command, this is an indication that at least one of the base stations of the active set receives the uplink transmission at a sufficiently high quality. In soft handover the transmit power of the mobile station is accordingly selected to ensure that at least one soft handover link is of sufficient quality.

In order to avoid a high complexity, an individual power control loop is not implemented for each physical channel in a cellular communication system. Specifically, for a UMTS cellular communication system, the transmit power commands are determined by the base stations measuring the SIR of the uplink control channel known as the Dedicated Physical Control CHannel (DPCCH). The DPCCH may be operated in soft handover and thus the transmit power of the DPCCH will be controlled to ensure reliable communication to at least one of the base stations of the active set but not necessarily to all of the base stations.

When a mobile station is involved in an HSDPA service, a number of control messages are transmitted from the mobile station to the single base station supporting the HSDPA service. For example, the mobile station may transmit retransmission acknowledge messages (Hybrid ARQ ACK/NACK messages) and indications of the quality of the communication channel (CQI - Channel Quality Indicators). These messages are transmitted on a continuous HSDPA uplink control channel known as the HS-DPCCH (High Speed - Dedicated Physical Control CHannel). The 3GPP Technical Specifications do not allow for a separate power control loop being implemented for this channel. Rather the Technical Specifications prescribe that the HS-DPCCH may use a transmit power which is given as a constant power offset relative to the DPCCH.

However, when the DPCCH is in a soft handover state, this approach frequently results in the HS-DPCCH not being receivable at the base station supporting the HSDPA service. This is due to the propagation conditions from the mobile station to the soft handover base stations typically varying such that the radio links to other base stations of the soft handover are dominant. In such cases, the power control loop for the DPCCH is effectively controlled by the channel characteristics of the dominant link(s). Thus, the transmit power of the mobile station will not ensure that the DPCCH can be received by the HS-DSCH serving base station (only that it can be received by one of the base stations in the soft handover).

Furthermore, unless the power offset between the HS-DPCCH and the DPCCH is sufficiently large, the HS-DPCHH cannot be received by the serving base station either. However, in this case the HS-DPCCH cannot be received by the RAN at all as the HS-DPCCH cannot be in a soft handover state. Setting the power offset sufficiently high to ensure that the HS-DPCCH can be received in all situations results in the transmit power being excessive for most of the time thereby causing increased interference and reduced capacity.

The Technical Specifications allow the RNC to signal to the mobile station to use a different power offset. Furthermore, the transmissions on the HS-DPCCH may be repeated and the RNC may also signal different repetition rates to the mobile station. This may allow the operator of the cellular communication system to select the trade off between excessive resource usage and communication reliability. Providing that the power offsets and repetition factors are set to be sufficiently large for the different conditions that may be experienced, the probability of the HS-DPCCH being received correctly at the serving base station may be improved. However, as the propagation conditions vary significantly, the required power offsets will typically be very high as they must allow for the worst case conditions for each scenario. Thus, although the approach may allow for a further refinement of the power offset it will typically lead to excessive transmit powers and/or lost HS-DPCCH transmissions. For example, if a power offset is selected to provide for acceptable performance for the HS-DPCCH in situations where the DPCCH is in a soft handover with another link being dominant, this will result in an unnecessarily high transmit power if the link to the serving base station is dominant.

Erroneous reception of HS-DPCCH may degrade the performance and efficient HSDPA services significantly. For example, retransmission acknowledgements/ non-acknowledgements (ACK/NACK) are transmitted on the HS-DPCCH and data errors may therefore affect the retransmission scheme resulting in reduced efficiency and increased resource consumption. Furthermore, Channel Quality Indications (CQI) used by HSDPA schedulers at the base station are also transmitted on the HS-DPCCH and errors in the CQIs may result in an inefficient scheduling. This may reduce capacity and degrade the quality of service.

Furthermore, although the 3GPP Technical Specifications allows for an RADIO LINK PARAMETER UPDATE message to be sent from a base station to an RNC as in indication that the HS-DPCCH is not received, such message may not be transmitted until the HS-DPCCH is very weak or has actually been lost thus resulting in a significant delay and data loss. Furthermore, the additional signalling associated with the RADIO LINK PARAMETER UPDATE message will further load the Iub interface between the base station and the RNC.

Hence, an improved system for power control in a cellular communication system would be advantageous and in particular a system allowing increased flexibility, improved resource usage, reduced signalling, reduced data loss, reduced interference, increased battery life, increased communication reliability and/or increased performance of the communication system would be advantageous.

Summary of the Invention

Accordingly, the Invention seeks to preferably mitigate, alleviate or eliminate one or more of the above mentioned disadvantages singly or in any combination.

According to a first aspect of the invention, there is provided a cellular communication system comprising: means for receiving signals from a user equipment in a soft handover communication channel supported by a plurality of base stations; means for receiving signals from the user equipment in a non-soft handover communication channel supported by a first base station of the plurality of base stations; means for determining a characteristic of signal components of the signals of the soft handover communication channel transmitted between the user equipment and the first base station; means for determining a modified transmission parameter for transmissions of signals from the user equipment in the non-soft handover communication channel in response to the characteristic; and means for transmitting a reconfiguration message comprising an indication of the modified transmission parameter to the user equipment.

The invention may allow improved performance and may specifically in some embodiments allow an improved control of the transmissions from user equipment in a non-soft handover communication channel based on a characteristic for transmissions of the soft handover communication channel.

Furthermore, a low complexity implementation may be achieved in many embodiments.

The invention may allow improved performance while complying with the standards of many cellular communication systems. For example, no additional signalling between the user equipment and the base stations or between base stations and RNCs will be necessary.

The invention may increase the reliability of the non-soft handover communication channel and may in particular reduce the error rate of the signals of the non-soft handover communication channel. Alternatively or additionally, the invention may reduce resource consumption such as e.g. the transmit power of the user equipment and may e.g. reduce the interference caused by the user equipment resulting in an improved quality of service and/or increased capacity of the cellular communication system as a whole.

In particular, for a user equipment in a soft handover configuration, the characteristic may be determined for the leg between the user equipment and the base station supporting the non-soft handover communication channel. The characteristics may thus relate to the individual leg of a soft handover configuration which also supports the non-soft handover communication channel.

According to an optional feature of the invention, the characteristic is an error rate. This may provide for a practical implementation and/or high performance. In particular, the error rate for a soft handover leg between the user equipment and the first base station may be a particular accurate indication of the reception quality of the signals in the non-soft handover communication channel at the first base station 105 station. The error rate may for example be a BLock Error Rate (BLER) or a Bit Error Rate.

According to an optional feature of the invention, the modified transmission parameter comprises a repetition characteristic for transmissions of the non-soft handover communication channel. This may provide a particularly advantageous parameter to control the performance and receive quality for signals in the non-soft handover communication channel based on the soft handover communication channel. The feature may e.g. also provide improved backwards compatibility and compliance with existing communication systems. The repetition characteristic may specifically be an indication of a number of times a given message is retransmitted in the non-soft handover communication channel.

According to an optional feature of the invention, the modified transmission parameter comprises a transmission power offset characteristic for transmissions of the non-soft handover communication channel. This may provide a particularly advantageous parameter to control the performance and receive quality for signals in the non-soft handover communication channel based on the soft handover communication channel. The feature may e.g. also provide improved backwards compatibility and compliance with existing communication systems.

According to an optional feature of the invention, the transmission power offset characteristic comprises a transmission power offset between transmissions of the soft handover communication channel and transmissions of the non-soft handover communication channel. This may provide a particularly advantageous parameter to control the performance and receive quality for signals in the non-soft handover communication channel based on the soft handover communication channel. The feature may e.g. also provide improved backwards compatibility and compliance with existing communication systems.

According to an optional feature of the invention, the means for determining a modified transmission parameter is arranged to compare the characteristic to a first threshold and to offset the modified transmission parameter by a first offset if the characteristic is above the threshold.

This may provide a low complexity implementation with efficient performance and improved transmission control. The first offset may be an absolute or relative offset.

For example, a bit error rate of the leg between the user equipment and the first base station for transmissions in the soft handover communication channel may be compared to a threshold, and if the error rate exceeds the threshold, the transmit power for transmissions in the non-soft handover communication channel may be increased.

According to an optional feature of the invention, the means for determining a modified transmission parameter is arranged to compare the characteristic to a second threshold and to offset the modified transmission parameter by a second offset if the characteristic is below the threshold.

This may provide a low complexity implementation with efficient performance and improved transmission control. The second offset may be an absolute or relative offset.

For example, a bit error rate of the leg between the user equipment and the first base station for transmissions in the soft handover communication channel may be compared to the second threshold below a desired error rate, and if the error rate falls below the threshold, the transmit power for transmissions in the non-soft handover communication channel may be decreased.

According to an optional feature of the invention, the cellular communication system further comprises a Radio Network Controller, RNC, the RNC comprising means for determining the characteristic; determining the modified transmission parameter and the means for transmitting the reconfiguration message. This may provide improved performance and may in particular allow an efficient implementation compatible with the distribution of functionality in many cellular communication systems including 3rd Generation Cellular Communication Systems,

According to an optional feature of the invention, the cellular communication system further comprises means for determining a reliability indication for the characteristic and the means for determining the modified transmission parameter as a default modified transmission parameter if the reliability indication is below a threshold. This may provide improved performance and may in particular allow the transmission control to be adapted to the conditions and characteristics of transmissions in the soft handover communication channel.

According to an optional feature of the invention, the means for determining a reliability indication is arranged to determine the reliability indication in response to an activity indication for the signal components. This may allow an accurate and practical determination of the reliability of the characteristic. The activity indication may be an indication of a data volume or transmission frequency for signal components that can be used to determine the characteristic.

According to an optional feature of the invention, the cellular communication system is a 3rd Generation cellular communication system. The invention may provide improved performance in a 3rd Generation cellular communication system, such as a UMTS cellular communication system. In particular, the invention may improve performance of many 3rd Generation cellular communication systems while complying with the Technical Specifications defined by the 3rd Generation Partnership project.

According to an optional feature of the invention, the non-soft handover communication channel is a High Speed Downlink Packet Access (HSDPA) communication channel.

In particular, the non-soft handover communication channel may be a High Speed-Dedicated Physical Control CHannel (HS-DPCCH) channel, the soft handover communication channel may be a Dedicated Physical Dedicated CHannel (DPDCH) channel and the first base station may be operable to transmit an HSDPA signal to the user equipment on a High Speed-Downlink Shared CHannel (HS-DSCH).

The invention may provide improved performance and may in particular provide improved transmission control in a 3rd Generation cellular communication system supporting HSDPA services. The transmission control may be modified to improve performance while complying with the specifications for the cellular communication system and in particular for HSDPA services.

Specifically, in some embodiments, the invention may substantially improve reliability of signals transmitted on the HS-DPCCH while the DPDCH is operating in a soft handover state. Additionally or alternatively, the transmit power of the HS-DPCCH may e.g. be substantially reduced to match the current requirements rather than using a simple power offset based on a worst case assumption.

According to an optional feature of the invention, the reconfiguration message is an RRC PHYSICAL LAYER RECONFIGURATION message. This may provide high performance, practical implementation and/or improved backwards compatibility.

According to a second aspect of the invention, there is provided a Radio Network Controller cellular comprising: means for receiving signals transmitted from a user equipment in a soft handover communication channel supported by a plurality of base stations; means for receiving signals transmitted from a user equipment in a non-soft handover communication channel supported by a first base station of the plurality of base stations; means for determining a characteristic of signal components of the signals of the soft handover communication channel transmitted between the user equipment and the first base station; means for determining a modified transmission parameter for transmissions of signals from the user equipment in the non-soft handover communication channel in response to the characteristic; and means for transmitting a reconfiguration message comprising an indication of the modified transmission parameter to the user equipment.

According to a third aspect of the invention, there is provided method of transmission control in a cellular communication system comprising: receiving signals from a user equipment in a soft handover communication channel supported by a plurality of base stations; receiving signals from the user equipment in a non-soft handover communication channel supported by a first base station of the plurality of base stations; determining a characteristic of signal components of the signals of the soft handover communication channel transmitted between the user equipment and the first base station; determining a modified transmission parameter for transmissions of signals from the user equipment in the non-soft handover communication channel in response to the characteristic; and transmitting a reconfiguration message comprising an indication of the modified transmission parameter to the user equipment.

These and other aspects, features and advantages of the invention will be apparent from and elucidated with reference to the embodiment(s) described hereinafter.

Brief Description of the Drawings

Embodiments of the invention will be described, by way of example only, with reference to the drawings, in which

FIG. 1 is an illustration of a cellular communication system incorporating some embodiments of the invention;

FIG. 2 illustrates an example of a Radio Network Controller in accordance with some embodiments of the invention; and

FIG. 3 illustrates a method of transmission control in a cellular communication system in accordance with some embodiments of the invention.

Detailed Description of Some Embodiments of the Invention

The following description focuses on some embodiments of the invention applicable to a 3rd Generation cellular communication system and in particular to 3rd Generation cellular communication system supporting HSDPA services. However, it will be appreciated that the invention is not limited to this application but may be applied to many other communication systems and services.

FIG. 1 is an illustration of a UMTS cellular communication system 100 incorporating some embodiments of the invention.

In the example of FIG. 1, a user equipment 101 is supported by three base stations (node Bs) 103, 105, 107. The three base stations 103-107 are coupled to a Radio Network Controller (RNC) 109 which is coupled to a core network 111 as is typical for UMTS cellular communication systems. In the example of FIG. 1, the user equipment 101 is in an overlap area between three different cells supported by the three different base stations 103-107. It will be appreciated that although each cell of the current example is supported by a separate base station, individual base stations may in other examples support more than one cell.

The user equipment 101 may typically be a communication unit, a 3rd Generation User Equipment (UE), a subscriber unit, a mobile station, a communication terminal, a personal digital assistant, a laptop computer, an embedded communication processor or any physical, functional or logical communication element which is capable of communicating over the air interface of the cellular communication system.

In the current example, the user equipment 101 is communicating with a serving base station 103 through a first radio link 113 but is also communicating with two other base stations 105, 107 over other radio links 115, 117. Specifically, the user equipment 101 is currently in a soft handover configuration with an active set comprising the three base stations 103-107.

For clarity and brevity, FIG. 1 illustrates only aspects of the communication system required to describe exemplary embodiments of the invention. Similarly, only the functionality and features required to describe the embodiments will be described and it will be apparent to the person skilled in the art that the illustrated elements will be capable of performing other functions and provide features required or desired for the operation of a 3rd Generation cellular communication system as appropriate.

In the example of FIG. 1, the user equipment 101 is currently involved in an HSDPA call supported by a first of the base stations 103. Thus, the user equipment 101 is communicating with the first base station 103 using HSDPA communication channels. In particular, the first serving base station 103 is transmitting data to the user equipment 101 on an HS-DSCH (High Speed - Downlink Shared CHannel). Similarly, an uplink HS-DPCCH (High Speed Dedicated Physical Control CHannel) has been setup to communicate control data from the user equipment 101 to the base station 103 as is known from conventional HSDPA systems. The HSDPA channels cannot be involved in soft handovers but are dedicated communication links between the user equipment 101 and the serving base station 103. Thus, HSDPA channels are non-soft handover communication channels. This facilitates operation for HSDPA services, and for example allows that a fast and individual resource allocation for HSDPA services can be performed by the individual base station 103 in response to fluctuations of the radio link 113 between the base station 103 and the user equipment 101.

The HS-DPCCH is used to transmit various control messages including Hybrid ARQ ACK/NACK and CQI (Channel Quality Indicator) data. The Hybrid ARQ ACK/NACK data comprises acknowledge data used by the Hybrid ARQ retransmission scheme of the HSDPA service whereas the CQI commands are indicative of a quality of the radio link 113 between the serving base station 103 and the user equipment 101. The user equipment 101 measures the current receive quality of a pilot signal of the base station 103 and reports the result by transmitting the CQI commands. Thus, the CQI commands are indicative of the current radio propagation conditions from the base station 103 to the user equipment 101 and are used by the scheduling function of the base station 103 to schedule HSDPA data on the shared HS-DSCH to user equipment experiencing advantageous conditions. Such link adaptation scheduling may result in a substantially improved efficiency of the resource usage and may increase the capacity of the cellular communication system as a whole.

Furthermore, in the example of FIG. 1, a number of non-HSDPA communication channels are set up for the user equipment 101. Specifically, the user equipment 101 is supporting a DPDCH (Dedicated Physical Data CHannel) for user data communication and a DPCCH (Dedicated Physical Control CHannel) which is used to transmit various control data and commands from the user equipment 101 to the fixed network. In the specific example, downlink data channels and uplink control channels are thus setup. Furthermore, these channels are soft handover communication channel wherein the communication may be supported simultaneously by a plurality of base stations.

In the example, the non-HSDPA communication channels are in a soft handover state where the communication between the base stations 101-103 and the user equipment 101 utilise a plurality of propagation channels with the received signals of the plurality of propagation paths being combined by the receiving end (for example by selection combining). Thus, in the example of FIG. 1, the user equipment 101 is in a configuration wherein it is simultaneously supporting HSDPA channels which are not (and cannot be) in a soft handover state and non-HSDPA channels which are in a soft handover state.

It is important to manage radio links between base stations and user equipments such that the resource used by a given communication link is as low as possible. Thus, it is important to minimise the interference caused by the transmission of signals from the communication unit to the base stations and therefore the lowest possible transmit power should be used by the user equipment 101 when transmitting to the base stations 103-107. Accordingly, the base stations 103-107 and user equipment 101 operate power control loops to dynamically control transmit powers to closely match the varying conditions.

Specifically, cellular communication systems such as UMTS operate both an inner power control loop and an outer power control loop. Conventionally, the inner power control loop measures the received signal to noise ratio (SIR) of pilot symbols of the DPCCH, and compares it to a locally stored target SIR. If the measured SIR is less than the target SIR, the base station transmits a power up command and otherwise it transmits a power down command. If the user equipment 101 is in a soft handover, each of the base stations 103-107 in the soft handover transmits a transmit power command to the user equipment 101. Thus, in the example of FIG. 1, the user equipment 101 receives a transmit power command from each of the three base stations 103-107. Only if all of the received transmit power commands are power up commands will the user equipment 101 increase the transmit power. In other words, as long as one of the links 113-117 provides sufficient performance, the transmit power is not increased. Accordingly, the transmit power is controlled such that the dominant link is of sufficient quality whereas other links of the soft handover may provide a poor quality signal.

However, in UMTS communication systems, power control is not operated individually for each communication channel, and in particular the same power control commands are used to control the transmit power of both the DPDCH channel and the HS-DPCCH channel. Specifically, the transmit power for the HS-DPCCH is set to a fixed offset relative to the transmit power for the DPDCH. For example, the HS-DPCCH transmit power may be set to be 10 dB higher than the transmit power of the DPDCH channel. However, in contrast to the DPDCH, the HS-DPCCH cannot be in a soft handover state. Thus, the transmit power control which is based on maintaining acceptable performance for a soft handover communication may be used for a non soft handover communication which may result in acceptable performance. Specifically, if the link to the serving base station is not the dominant link of the DPCCH this may result in the HS-DPCCH not being received (or being received with too many errors) by the base station 103. For example, if the current path loss to the base station 103 is 20dB lower than the path loss to the base station 105, the 10 dB transmit power offset may be insufficient to maintain acceptable performance to the base station 103.

Accordingly, although the 3GPP R5 standards allow for a power offset to be specified between the transmit power of the DPDCH and the HS-DPCCH such that the HS-DPCCH is transmitted at a relatively higher power, this results in an inaccurate setting of the transmit power as it will typically either be too high (if the HS-DPCCH experiences better conditions than assumed when setting the power offset) or too low (if the HS-DPDCH experiences worse conditions than assumed when setting the power offset).

In accordance with some embodiments of the invention, the RNC 109 of FIG. 1 determines an individual characteristic for the soft handover leg between the user equipment 101 and the base station 103 for DPDCH transmissions from the user equipment 101. In particular, an individual error rate is determined for the individual leg rather than for the combined soft handover signal. This individual characteristic is then used to dynamically control a transmission parameter of the transmissions from the user equipment 101 in the HS-DPCCH channel. Specifically, the power control of the HS-DPCCH is continued to be linked to the power control of the DPDCH but the transmission parameter is dynamically changed to vary the margin between the transmissions of the two channels. The margin may be varied to ensure that the reliability of the transmissions in the HS-DPCCH is sufficient even if the radio link between the user equipment 101 and the base station 103 is not the dominant link in the soft handover.

FIG. 2 illustrates a simplified block diagram of the RNC of FIG. 1.

The RNC 109 comprises a base station interface 201 which is coupled to the three base stations 103, 105 and 107. The base stations 103-107 receive signals from the user equipment 101 transmitted both in the DPDCH and the HS-DPCCH channels. The demodulated and decoded signals are forwarded to the base station interface 201 of the RNC 109.

The base station interface 201 is coupled to an error processor 203 which is arranged to determine a characteristic of the signal components of the signals of the soft handover communication channel transmitted between the user equipment 101 and the base station 103. In more detail, the error processor 203 is arranged to determine a BLock Error Rate (BLER) for the signal received in the DPDCH by the serving base station 103. Thus, in the example, the characteristic is an individual characteristic for the soft handover transmissions between the base station 103 and the user equipment 101 rather than of the combined soft handover signal that includes signal components from the plurality of base stations 103-107.

The error processor 203 may specifically determine the BLER from an evaluation of check sum values comprised in the data packets sent from the base station 103 to the RNC 109. Thus, the error processor 203 may perform a CRC (Cyclic Redundancy Checksum) check on all data packets from the base station 103 which relate to the DPDCH of the user equipment 101.

The error processor 203 is coupled to a BLER comparator 205 which is furthermore coupled to a BLER target processor 207. The BLER target processor 207 determines a desired BLER value for the individual leg between the user equipment 101 and the base station 103 for the DPDCH channel. The BLER target processor 207 may in particular determine the desired BLER simply by providing a BLER target which has been received from an external source, such as an Operations and Management Center (OMC). Thus, the BLER comparator 205 compares the BLER estimate from the BLER processor to the BLER reference from the BLER target processor 307 and generates an error signal. Specifically, the BLER comparator 205 may simply determine the error signal as the filtered difference between the BLER estimate and the BLER reference. As another example, the BLER comparator 205 may simple indicate the difference as a binary value indicating if the BLER is higher or lower than the BLER reference.

The BLER comparator 205 is coupled to a transmission parameter processor 209 which determines a modified transmission parameter for transmissions of signals from the user equipment in the non-soft handover communication channel in response to the characteristic.

In the example of FIG. 2, the transmission parameter processor 209 modifies a parameter that will change the margin provided between the transmissions in the non-soft handover communication channel and the soft handover communication channel. Specifically, the transmission parameter processor 209 may modify a transmit power offset or a repetition characteristic for the transmissions in the HS-DPCCH.

As a specific example, the transmission parameter processor 209 may simply determine if the BLER estimate of the error processor 203 is above or below the BLER reference. If the BLER estimate is below the reference, a first transmit power offset is determined and if the BLER estimate is above the reference, a second transmit power offset is determined, where the second transmit power offset is higher than the first. For example, if the BLER estimate for the DPDCH leg between the user equipment 101 and the base station 103 is low (below the reference) a transmit power offset of, say, 6 dB may be used and if the BLER estimate is high (above the reference) a much higher transmit power offset of, say, 20 dB may be used.

As another example, a given increment may be added to the current value of offset being used, eg +1dB, in the case that BLER is too high (or if BLER is too low a given decrement, eg -1dB may be added). This may be implemented using a single threshold value and the updates may for example be made periodically or could e.g. be event driven. In some examples, there might be two thresholds in which case an increment could be made when the BLER is above the first threshold and a decrement made when the BLER is below the second threshold.

Thus, the trade off between the reliability of the HS-DPCCH communication and the resource usage may be dynamically and effectively varied leading to reduced resource usage and/or improved reliability of the HS-DPCCH communication.

As another specific example, if the BLER estimate is below the reference, transmissions in the HS-DPCCH channel may only be transmitted once whereas if the BLER estimate is above the reference, transmissions in the HS-DPCCH channel may be repeated a number of times. Incremental redundancy and error correcting coding may then be used to improve the reliability of the HS-DPCCH communication.

It will be appreciated that more complex algorithms may be used by the transmission parameter processor 209 to determine the transmission parameter. For example, the RNC 109 may use two or more thresholds and may determine e.g. a specific transmit offset for each threshold. As another example, the transmission parameter processor 209 may determine a transmit power offset as a mathematical function of the difference between the BLER estimate and the BLER reference.

The transmission parameter processor 209 is coupled to a message processor 211 which is coupled to the base station interface 201. The message processor 211 receives the modified transmission parameter from the transmission parameter processor 209 and generates a reconfiguration message comprising an indication of the modified transmission parameter. Specifically for a UMTS communication system, the message processor 211 may generate an RRC PHYSICAL LAYER RECONFIGURATION message comprising a transmit power offset and/or a repetition rate to be used for the HS-DPCCH channel.

The message processor 211 feeds the reconfiguration message to the base station interface 201 which transmits it to the base station 103. The base station 103 then transmits the reconfiguration message to the user equipment 101 over the air interface. When the reconfiguration message is received, the user equipment 101 proceeds to transmit on the HS-DPCCH using the prescribed transmission parameters. In particular, the user equipment 101 proceeds to determine the transmit power for the non-soft handover communication channel in response to the power control operation of the soft handover communication channel while applying the modified transmission parameter to provide a desired margin. In particular, the transmit power determined for the soft handover communication channel is offset by the received transmit power offset.

Thus, the described embodiments may allow an efficient communication system which is compatible with the Technical Specifications for UMTS while allowing reduced resource usage and improved reliability of HSDPA communications.

In some embodiments, the RNC 109 may furthermore comprise means for determining the reliability of the determined characteristic. For example, the error processor 203 may determine a reliability for the BLER estimate. The reliability may be determined in response to an activity indication for the soft handover signal components received by the base station 103. E.g., the reliability of a BLER estimate depends on the number of errors that are measured and for a given error rate the number of errors increase for increasing amounts of data. Accordingly, the error processor 203 may determine a number of errors and/or the data amount used to determine the BLER estimate. If one of these values is below a given threshold, the error processor 203 designates the BLER estimate as unreliable. In this case, the transmission parameter processor 209 may determine the transmission parameter as a default value. For example, if less than a given volume of data has been received on the DPDCH from the user equipment 101 to the base station 103, the RNC 109 sets the transmit power offset to a default of 10dB. This approach may provide increased reliability and is particularly advantageous in e.g. HSDPA embodiments where the transmissions from the user equipment 101 may vary substantially.

FIG. 3 illustrates a method of transmission control in a cellular communication system in accordance with some embodiments of the invention. The method is applicable to the RNC 109 of FIG. 2 and will be described with reference to this.

The method initiates in step 301 wherein the RNC 109 receives signals from the user equipment 101 in a soft handover communication channel supported by a plurality of base stations. The signals are specifically DPDCH signals received via base stations 103, 105, 107.

Step 301 is followed by step 303 wherein the RNC 109 receives signals from the user equipment 101 in a non-soft handover communication channel supported by base station 103. The signals are specifically HS-DPCCH signals received via base stations 103.

Step 303 is followed by step 305 wherein the error processor 203 determines a characteristic of signal components of the signals of the soft handover communication channel transmitted between the user equipment and the first base station. Specifically, a BLER estimate is generated specifically for the DPDCH communication between the user equipment 101 and the base station 103.

Step 305 is followed by step 307 wherein the transmission parameter processor 209 determines a modified transmission parameter for transmissions of signals from the user equipment in the non-soft handover communication channel in response to the characteristic. Specifically, a transmit power offset between DPDCH and HS-DPCCH transmissions of the user equipment 101 is determined or a repetition rate for the HS-DPCCH transmissions is determined.

Step 307 is followed by step 309 wherein the message processor generates a reconfiguration message comprising an indication of the modified transmission parameter. The reconfiguration message may specifically be an RRC PHYSICAL LAYER RECONFIGURATION message. The reconfiguration message is transmitted to the user equipment 101 via the base station interface 201 and the base station 103.

It will be appreciated that the above description for clarity has described embodiments of the invention with reference to different functional units and processors. However, it will be apparent that any suitable distribution of functionality between different functional units or processors may be used without detracting from the invention. For example, functionality illustrated to be performed by separate processors or controllers may be performed by the same processor or controllers. Hence, references to specific functional units are only to be seen as references to suitable means for providing the described functionality rather than indicative of a strict logical or physical structure or organization.

The invention can be implemented in any suitable form including hardware, software, firmware or any combination of these. The invention may optionally be implemented at least partly as computer software running on one or more data processors and/or digital signal processors. The elements and components of an embodiment of the invention may be physically, functionally and logically implemented in any suitable way. Indeed the functionality may be implemented in a single unit, in a plurality of units or as part of other functional units. As such, the invention may be implemented in a single unit or may be physically and functionally distributed between different units and processors.

Although the present invention has been described in connection with some embodiments, it is not intended to be limited to the specific form set forth herein. Rather, the scope of the present invention is limited only by the accompanying claims. Additionally, although a feature may appear to be described in connection with particular embodiments, one skilled in the art would recognize that various features of the described embodiments may be combined in accordance with the invention. In the claims, the term comprising does not exclude the presence of other elements or steps.

Furthermore, although individually listed, a plurality of means, elements or method steps may be implemented by e.g. a single unit or processor. Additionally, although individual features may be included in different claims, these may possibly be advantageously combined, and the inclusion in different claims does not imply that a combination of features is not feasible and/or advantageous. Also the inclusion of a feature in one category of claims does not imply a limitation to this category but rather indicates that the feature is equally applicable to other claim categories as appropriate. Furthermore, the order of features in the claims do not imply any specific order in which the features must be worked and in particular the order of individual steps in a method claim does not imply that the steps must be performed in this order. Rather, the steps may be performed in any suitable order. In addition, singular references do not exclude a plurality. Thus references to "a", "an", "first", "second" etc do not preclude a plurality.

CLAIMS

1. A cellular communication system comprising:

means for receiving signals from a user equipment in a soft handover communication channel supported by a plurality of base stations;

means for receiving signals from the user equipment in a non-soft handover communication channel supported by a first base station of the plurality of base stations;

means for determining a characteristic of signal components of the signals of the soft handover communication channel transmitted between the user equipment and the first base station;

means for determining a modified transmission parameter for transmissions of signals from the user equipment in the non-soft handover communication channel in response to the characteristic; and

means for transmitting a reconfiguration message comprising an indication of the modified transmission parameter to the user equipment.

2. The cellular communication system claimed in claim 1 wherein the characteristic is an error rate.

3. The cellular communication system claimed in claim 1 or 2 wherein the modified transmission parameter comprises a repetition characteristic for transmissions of the non-soft handover communication channel.

4. The cellular communication system claimed in any previous claim wherein the modified transmission parameter comprises a transmission power offset characteristic for

transmissions of signals in the non-soft handover communication channel.

5. The cellular communication system claimed in claim 4 wherein the transmission power offset characteristic comprises a transmission power offset between transmissions of the soft handover communication channel and transmissions of the non-soft handover communication channel.

6. The cellular communication system claimed in any previous claim wherein the means for determining a modified transmission parameter is arranged to compare the characteristic to a first threshold and to offset the modified transmission parameter by a first offset if the characteristic is above the threshold.

7. The cellular communication system claimed in claim 5 wherein the means for determining a modified transmission parameter is arranged to compare the characteristic to a second threshold and to offset the modified transmission parameter by a second offset if the characteristic is below the threshold.

8. The cellular communication system of any previous claim further comprising a Radio Network Controller, RNC, the RNC comprising the means for determining the characteristic; the means for determining the modified transmission parameter and the means for transmitting the reconfiguration message.

9. The cellular communication system of any previous claim further comprising means for determining a reliability indication for the characteristic; and wherein the means for

determining is arranged to determine the modified transmission parameter as a default modified transmission parameter value if the reliability indication is below a threshold.

10. The cellular communication system of claim 9 wherein the means for determining a reliability indication is arranged to determine the reliability indication in response to an activity indication for the signal components.

11. The cellular communication system claimed in any previous claim wherein the cellular communication system is a 3rd Generation cellular communication system.

12. The cellular communication system claimed in claim 11 wherein the non-soft handover communication channel is a High Speed Downlink Packet Access (HSDPA) communication channel.

13. The cellular communication system claimed in claim 12 wherein the non-soft handover communication channel is a High Speed-Dedicated Physical Control CHannel (HS-DPCCH) channel.

14. The cellular communication system claimed in any of the claims 11 to 13 wherein the soft handover communication channel is a Dedicated Physical Data CHannel (DPDCH) channel.

15. The cellular communication system claimed in any of the claims 11 to 14 wherein the reconfiguration message is an RRC PHYSICAL LAYER RECONFIGURATION message.

16. A Radio Network Controller cellular comprising:

means for receiving signals transmitted from a user equipment in a soft handover communication channel supported by a plurality of base stations;

means for receiving signals transmitted from a user equipment in a non-soft handover communication channel supported by a first base station of the plurality of base stations;

means for determining a characteristic of signal components of the signals of the soft handover communication channel transmitted between the user equipment and the first base station;

means for determining a modified transmission parameter for transmissions of signals from the user equipment in the non-soft handover communication channel in response to the characteristic; and

means for transmitting a reconfiguration message comprising an indication of the modified transmission parameter to the user equipment.

17. A method of transmission control in a cellular communication system comprising:

receiving signals from a user equipment in a soft handover communication channel supported by a plurality of base stations;

receiving signals from the user equipment in a non-soft handover communication channel supported by a first base station of the plurality of base stations;

determining a characteristic of signal components of the signals of the soft handover communication channel transmitted between the user equipment and the first base station;

determining a modified transmission parameter for transmissions of signals from the user equipment in the non-soft handover communication channel in response to the characteristic; and

transmitting a reconfiguration message comprising an indication of the modified transmission parameter to the user equipment.

Amendments to the claims have been filed as follows

1. A cellular communication system comprising:

means for receiving signals from a user equipment in a soft handover communication channel supported by a plurality of base stations;

means for receiving signals from the user equipment in a non-soft handover communication channel supported by a first base station of the plurality of base stations;

means for determining an error rate of signal components of the signals of the soft handover communication channel transmitted between the user equipment and the first base station;

means for determining a modified transmission parameter for transmissions of signals from the user equipment in the non-soft handover communication channel in response to the error rate; and

means for transmitting a reconfiguration message comprising an indication of the modified transmission parameter to the user equipment.

2. The cellular communication system claimed in claim 1 wherein the modified transmission parameter comprises a repetition characteristic for transmissions of the non-soft handover communication channel.

3. The cellular communication system claimed in any previous claim wherein the modified transmission parameter comprises a transmission power offset characteristic for transmissions of signals in the non-soft handover communication channel.

4. The cellular communication system claimed in claim 3 wherein the transmission power offset characteristic comprises a transmission power offset between transmissions of the soft handover communication channel and transmissions of the non-soft handover communication channel.

5. The cellular communication system claimed in any previous claim wherein the means for determining a modified transmission parameter is arranged to compare the error rate to a first threshold and to offset the modified transmission parameter by a first offset if the error rate is above the threshold.

6. The cellular communication system claimed in claim 4 wherein the means for determining a modified transmission parameter is arranged to compare the error rate to a second threshold and to offset the modified transmission parameter by a second offset if the error rate is below the threshold.

7. The cellular communication system of any previous claim further comprising a Radio Network Controller, RNC, the RNC comprising the means for determining the error rate; the means for determining the modified transmission parameter and the means for transmitting the reconfiguration message.

8. The cellular communication system of any previous claim further comprising means for determining a reliability indication for the error rate; and wherein the means for determining is arranged to determine the modified

transmission parameter as a default modified transmission parameter value if the reliability indication is below a threshold.

9. The cellular communication system of claim 8 wherein the means for determining a reliability indication is arranged to determine the reliability indication in response to an activity indication for the signal components.

10. The cellular communication system claimed in any previous claim wherein the cellular communication system is a 3rd Generation cellular communication system.

11. The cellular communication system claimed in claim 10 wherein the non-soft handover communication channel is a High Speed Downlink Packet Access (HSDPA) communication channel.

12. The cellular communication system claimed in claim 11 wherein the non-soft handover communication channel is a High Speed-Dedicated Physical Control CHannel (HS-DPCCH) channel.

13. The cellular communication system claimed in any of the claims 10 to 12 wherein the soft handover communication channel is a Dedicated Physical Data CHannel (DPDCH) channel.

14. The cellular communication system claimed in any of the claims 10 to 13 wherein the reconfiguration message is an RRC PHYSICAL LAYER RECONFIGURATION message.

15. A Radio Network Controller of a cellular communication system, comprising:

means for receiving signals transmitted from a user equipment in a soft handover communication channel supported by a plurality of base stations;

means for receiving signals transmitted from a user equipment in a non-soft handover communication channel supported by a first base station of the plurality of base stations;

means for determining an error rate of signal components of the signals of the soft handover communication channel transmitted between the user equipment and the first base station;

means for determining a modified transmission parameter for transmissions of signals from the user equipment in the non-soft handover communication channel in response to the error rate; and

means for transmitting a reconfiguration message comprising an indication of the modified transmission parameter to the user equipment.

16. A method of transmission control in a cellular communication system comprising:

receiving signals from a user equipment in a soft handover communication channel supported by a plurality of base stations;

receiving signals from the user equipment in a non-soft handover communication channel supported by a first base station of the plurality of base stations;

determining an error rate of signal components of the signals of the soft handover communication channel transmitted between the user equipment and the first base station;

determining a modified transmission parameter for transmissions of signals from the user equipment in the non-soft handover communication channel in response to the error rate; and

transmitting a reconfiguration message comprising an indication of the modified transmission parameter to the user equipment.

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Application No: GB0508796.0

Claims searched: All

Examiner: Steve Evans

Date of search: 10 October 2005

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
X	1, 16 & 17 at least	EP 1507343 A1 (MATSUSHITA) - Whole document
X	1, 16 & 17 at least	EP 1526652 A1 (EVOLIUM) - Whole document

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H04B; H04L; H04Q

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

Online: WPI, EPODOC