(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
7 August 2008 (07.08.2008)

PCT

(10) International Publication Number
WO 2008/092908 A2

(51) International Patent Classification: Not classified

(21) International Application Number:
PCT/EP2008/051150

(22) International Filing Date: 30 January 2008 (30.01.2008)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
200710063175.7 30 January 2007 (30.01.2007) CN

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(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MT, NL, NO, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— *without international search report and to be republished upon receipt of that report*

(54) **Title:** METHOD, SYSTEM, RELAY STATION AND BASE STATION FOR TRANSMITTING DATA IN MOBILE COMMUNICATION

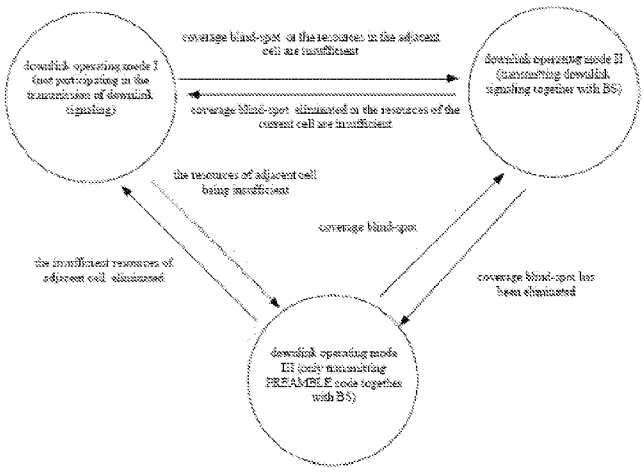


Fig 6

(57) **Abstract:** The present invention provides a data transmission method in mobile communication for a cell having one base station and more than one relay station, the method comprises switching the relay stations between at least two operating modes of signaling transmission under the control of the base station. The present invention also provides a system for transmitting data in mobile communication in a cell having one base station and more than one relay station, wherein when transmitting an uplink signaling or a downlink signaling, the relay stations switch between at least two operating modes under the control of the base station. The present invention also provides a relay station and a base station. By using the method, network, relay station, and base station of the present invention, the data transmission in multiple modes can be achieved, so as to achieve a flexible relay scheme.

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Description

Method, System, Relay Station and Base Station for Transmitting Data in Mobile Communication

Technology Field

The present invention relates to a wireless cellular network technology, particularly to a method for transmitting data in mobile communication and to a system, a relay station and a base station for transmitting data in mobile communication.

Background Art

It has become a hot topic of wireless cellular communication to integrate multi-hop capability by deploying relay stations (RS). For example, IEEE has established recently a relay workgroup in order to introduce RS into systems based on IEEE 802.16.

Currently, it is widely accepted that deploying RSs in wireless cellular systems can broaden coverage range, enhance the capacity of a cell, reduce the transmission power at the user station/mobile station (SS/MS) side, and prevent serious shielding. A feasible scheme is to organize a cellular system under the control of a base station (BS), in which all activities in the cell are under the common control of the BS, the BS sends signals to all SS/MSs and is responsible for answering the signaling requests from the SS/MSs.

However, the mode for transmitting signaling in current RSs is simplex; therefore, it is difficult to adjust a relay scheme according to practical conditions.

Contents of the present invention

The present invention provides a method for transmitting data in mobile communication, in which when transmitting uplink signaling or downlink signaling, an RS can be switched among

different operating modes so as to achieve flexible relay schemes.

The present invention also provides a system for transmitting data in mobile communication, in which flexible relay schemes are achieved by switching an RS between different operating modes for transmitting signaling.

The present invention further provides an RS for transmitting data in mobile communication, which switches between different operating modes for transmitting signaling so as to adapt to different network environments or conditions.

The present invention further provides a BS for transmitting data in mobile communication, which controls the RS so as to switch between different operating modes for transmitting signaling so as to adapt to different network environments or conditions.

The object of the present invention is achieved by the following technical scheme:

a method for transmitting data in mobile communication, being applied in a cell having one base station and more than one relay station; wherein under the control of said base station, said relay stations switch between at least two operating modes when transmitting an uplink signaling or a downlink signaling.

On the one hand, during the transmission of the downlink signaling, said relay stations switch between an operating mode of not participating in the transmission of the downlink signaling and an operating mode of jointly transmitting the downlink signaling with the base station.

Wherein when the base station detects a coverage blind-spot in the cell, after having negotiated with the relay station close to the coverage blind-spot in the cell, it instructs the relay station to switch from the operating mode of not participating in the transmission of the downlink signaling into the operating mode of jointly transmitting the downlink signaling with the base station.

Wherein the situation in which the base station detects the occurrence of the coverage blind-spot in the cell can be confirmed according to the following process:

the base station detects that a difference between an initial ranging parameter of more than one user station/mobile station and a measurement parameter reported by the relay stations is larger than a preset difference threshold.

Wherein when the relay station detects a coverage blind-spot in the cell, after having negotiated with the base station, it switches from the operating mode of not participating in the transmission of the downlink signaling into the operating mode of jointly transmitting the downlink signaling with the base station.

Wherein the situation in which said relay station detects the occurrence of the coverage blind-spot in the cell is confirmed according to the following process:

said relay station detects during its idle time slot that more than one user station/mobile station is attempting to connect to a radio access point of another cell, but the signal quality from the user stations/mobile stations received by said relay station is above a preset signal quality threshold.

Wherein when the base station confirms that the coverage blind-spot in the cell has been eliminated, after having negotiated with the relay station that transmits the downlink signaling jointly with the base station in the cell, it instructs the relay station to switch back to the operating mode of not participating in the transmission of the downlink signaling.

Wherein the steps for the base station to confirm, by long-term learning, the elimination of the coverage blind-spot in the cell comprise:

the base station reducing step by step the signaling transmitting power of the relay station that transmits the downlink signaling jointly with the base station in the cell and observes the responses from the user stations/mobile stations, and if after the transmitting power has been reduced to a normal transmission power, the user stations/mobile

stations are still capable of receiving normally, then the base station determines that the coverage blind-spot in the cell has been eliminated.

Wherein when a network confirms that the wireless resource of a cell is currently sufficient and that of an adjacent cell is insufficient, by instructing the base station in the cell to negotiate with the relay station in the cell close to the adjacent cell, it makes the relay station switch from the operating mode of not participating in the transmission of the downlink signaling into the operating mode of jointly transmitting the downlink signaling with the base station; or

when the network confirms that the wireless resource of a cell is currently insufficient and that of an adjacent cell is sufficient, by instructing the base station in the cell to negotiate with the relay station in the cell close to the adjacent cell, it makes the relay station switch from the operating mode of jointly transmitting the downlink signaling with the base station into the operating mode of not participating in the transmission of the downlink signaling.

Wherein when said relay station is in the operating mode of jointly transmitting the downlink signaling with the base station,

said relay station receives a downlink signaling pre-transmitted by the base station before a transmission time; and

at the transmission time, the relay station and the base station transmit said downlink signaling to the user stations/mobile stations simultaneously.

Wherein during the transmission of the downlink signaling, said relay station can switch between three operating modes of not participating in the transmission of the downlink signaling, jointly transmitting the downlink signaling with the base station, and jointly transmitting a preamble code with the base station.

Wherein when the network confirms that the wireless resource of an adjacent cell of one cell is insufficient, by instructing the base station in the cell to negotiate with the relay station in the cell close to the adjacent cell, it can

make the relay station switch from the operating mode of not participating in the transmission of the downlink signaling into the operating mode of jointly transmitting the preamble code with the base station; or

when the network confirms that the wireless resource of an adjacent cell of one cell is sufficient, by instructing the base station in the cell to negotiate with the relay station in the cell close to the adjacent cell, it can make the relay station switch from the operating mode of jointly transmitting the preamble code with the base station into the operating mode of not participating in the transmission of the downlink signaling.

Wherein, when the base station detects that a coverage blind-spot appears in the cell, after having negotiated with the relay station close to the coverage blind-spot, it can instruct the relay station to switch from the operating mode of jointly transmitting the preamble code with the base station into the operating mode of jointly transmitting the downlink signaling with the base station; or

when the base station confirms that the coverage blind-spot in the cell has been eliminated, after having negotiated with the relay station in the cell that jointly transmits the downlink signaling with the base station, it can instruct said relay station to switch from the operating mode of jointly transmitting the downlink signaling with the base station into the operating mode of jointly transmitting the preamble code with the base station.

On the other hand, when transmitting uplink signaling, the process for said relay station to switch between at least two operating modes can comprise:

said relay station switching between an operating mode of transmitting the whole uplink signaling after having performed digital baseband processing on it, and an operating mode of transmitting delay-sensitive uplink signaling after having stored it and transmitting delay-insensitive uplink signaling after having performed digital baseband processing on it.

Wherein when said base station makes a judgement that the current time-delay requirement is relatively high, after having negotiated with said relay station, it instructs the relay station to switch from the operating mode of transmitting the whole uplink signaling after having performed digital baseband processing on it into the operating mode of transmitting delay-sensitive uplink signaling after having stored it and transmitting delay-insensitive uplink signaling after having performed digital baseband processing on it; or

when the base station makes a judgement that the current time-delay requirement is relatively low or a requirement for transmission quality is relatively high, after having negotiated with said relay station, it instructs the relay station to switch from the operating mode of transmitting delay-sensitive uplink signaling after having stored it and transmitting delay-insensitive uplink signaling after having performed digital baseband processing on it into the operating mode of transmitting the whole uplink signaling after having performed digital baseband processing on it.

Wherein when said relay station is in the operating mode of transmitting delay-sensitive uplink signaling after having stored it,

said relay station can receive information about an uplink signaling gap and an amplified gap preset by the base station for transmitting a delay-sensitive signaling on an uplink subframe; and

said relay station receives the delay-sensitive uplink signaling within said uplink signaling gap, and transmits said delay-sensitive uplink signaling within said amplified gap.

Wherein the process for said base station to pre-set the amplified gap can comprise:

said base station dividing the more than one relay stations in the cell into groups, and reserving a different amplified gap in the uplink subframe for the relay stations in each group; and

said relay stations transmitting the received delay-sensitive signaling within their respective amplified gaps.

Wherein the process for said base station to pre-set the amplified gap can comprise:

said base station assigning N different amplified gaps for M relay stations in the cell, reserving one or several of the N amplified gaps for each of the relay stations, wherein M is a positive integer, and N is an integer; and

said relay station transmitting the received delay-sensitive signaling within the one or several of the N amplified gaps reserved for it by the base station.

Wherein said relay station extracts said uplink signaling gap and said amplified gap from an information unit in a received downlink mapping signaling DL-MAP of the base station.

Wherein said delay-sensitive uplink signaling can comprise a channel quality indicator channel (CQICH) of a physical layer (PHY), an acknowledgement channel (ACKCH), and an uplink signaling transmitted in a CDMA ranging field, or any combination thereof.

Wherein said delay-sensitive uplink signaling can occupy one or several continuous time slots in the uplink subframe.

Wherein during the transmission of the uplink signaling, said relay station can switch between an operating mode of transmitting the whole uplink signaling after having performed digital baseband processing on it, an operating mode of transmitting delay-sensitive uplink signaling after having stored it and transmitting delay-insensitive uplink signaling after having performed digital baseband processing on it, and an operating mode of transmitting the whole uplink signaling after having stored it.

Wherein, when said relay station is in the operating mode of transmitting the whole uplink signaling after having performed digital baseband processing on it, if the base station makes a judgement that a current time-delay requirement is increased to a first time-delay threshold, by negotiating with said relay station, the base station instructs the relay station to switch to the operating mode of transmitting the whole uplink signaling after having stored it; if the base station makes a judgement that the current time-delay

requirement is increased to a second time-delay threshold, by negotiating with said relay station, the base station instructs the relay station to switch to the operating mode of transmitting delay-sensitive uplink signaling after having stored it and transmitting delay-insensitive uplink signaling after having performed digital baseband processing on it;

when the relay station is in the operating mode of transmitting delay-sensitive uplink signaling after having stored it and transmitting delay-insensitive uplink signaling after having performed digital baseband processing on it, if the base station makes a judgement that the current time-delay requirement is increased to the first time-delay threshold, by negotiating with the relay station, the base station instructs the relay station to switch to the operating mode of transmitting the whole uplink signaling after having stored it; if the base station makes a judgement that the current time-delay requirement is reduced to below the second time-delay threshold or a quality requirement is increased to a first quality threshold, by negotiating with the relay station, the base station instructs the relay station to switch into the operating mode of transmitting the whole uplink signaling after having performed digital baseband processing on it;

when the relay station is in the operating mode of transmitting the whole uplink signaling after having stored it, if the base station makes a judgement that the current time-delay requirement is reduced to below the first time-delay threshold, by negotiating with the relay station, the base station instructs the relay station to switch into the operating mode of transmitting delay-sensitive uplink signaling after having stored it and transmitting delay-insensitive uplink signaling after having performed digital baseband processing on it; if the base station makes a judgement that the current time-delay requirement is reduced to below the second time-delay threshold or the quality requirement is raised to the first quality threshold, by negotiating with the relay station, the base station instructs the relay station to switch to the operating mode of transmitting the whole uplink

signaling after having performed digital baseband processing on it; and

said time-delay requirement corresponding to said first time-delay threshold is higher than the time-delay requirement corresponding to said second time-delay threshold.

The method can also comprise:

said relay station performing an initial negotiation with said base station when it is initiated and reporting all operating modes it supports for signaling transmission; and

said base station designating an initial operating mode for said relay station, and controling said relay station to operate in the designated initial operating mode.

The method can further comprise:

said relay station reporting to the base station when it detects that a wired connection is established between itself and a backbone network; and

after said base station has decided to make use of the wired connection between the relay station and the backbone network, it instructs said relay station to forward data via the wired connection between the relay station and the backbone network.

Wherein, when the relay station detects the existence of the wired connection between itself and the backbone network, it can initially negotiate with the base station, and reports the existence of the wired connection between itself and the backbone network.

Wherein said base station can decide whether or not to use the wired connection according to the load in the cell and/or the quality of the wired connection;

if the load in the cell is relatively small and/or the quality of the wired connection is relatively poor, it decides not to use the wired connection; and if the load in the cell is relatively large and/or the quality of the wired connection is relatively good, it decides to use the wired connection.

Wherein said relay station forwards business data and signaling via the wired connection between itself and the backbone network according to QoS requirements.

Wherein when said relay station forwards data through the wired connection between itself and the backbone network, wireless connections for said relay station to communicate with user stations/mobile stations in the cell and wireless connections for said relay station to communicate with the base station when necessary are both controlled by the base station.

According to another aspect of the present invention, the present invention also discloses a system for transmitting data in mobile communication, said mobile communication process involving more than one cell, and said cells comprising one base station and more than one relay station, wherein under the control of said base station, said relay stations switch between at least two operating modes when transmitting an uplink signaling or a downlink signaling.

On the one hand, when transmitting downlink signaling, said relay stations can switch between an operating mode of not participating in the transmission of the downlink signaling and an operating mode of jointly transmitting the downlink signaling with the base station.

Or, said relay stations can switch among three operating modes of not participating in the transmission of the downlink signaling, jointly transmitting the downlink signaling with the base station, and jointly transmitting a preamble code with the base station.

On the other hand, when transmitting uplink signaling, said relay stations switch between an operating mode of transmitting the whole uplink signaling after having performed digital baseband processing on it, and an operating mode of transmitting delay-sensitive uplink signaling after having stored it and transmitting delay-insensitive uplink signaling after having performed digital baseband processing on it.

Or, said relay stations switch between three operating modes of transmitting the whole uplink signaling after having performed digital baseband processing on it, of transmitting delay-sensitive uplink signaling after having stored it and transmitting delay-insensitive uplink signaling after having

performed digital baseband processing to it, and of transmitting the whole uplink signaling after having stored it.

In addition, the present invention also discloses a relay station positioned in a cell of a wireless cellular network for transmitting data in mobile communication, comprising an RF transceiving and processing unit, and also comprising a negotiating unit and a control unit;

said negotiating unit sends an operating mode switching instruction to the control unit after having negotiated with a base station in said cell; and

said control unit controls the RF transceiving and processing unit so as to switch between at least two operating modes for transmitting signaling according to the mode switching instruction sent from the negotiating unit.

Wherein the operating modes of said signaling transmission can comprise a downlink operating mode I of not participating in the transmission of a downlink signaling and a downlink operating mode II of transmitting jointly with the base station; and

said control unit can comprise:

a downlink mode controller for instructing the RF transceiving and processing unit to stop transmitting the downlink signaling, after the negotiating unit has sent it an instruction to switch the operating mode into the downlink operating mode I; and for instructing the RF transceiving and processing unit to receive a downlink signaling pre-transmitted from the base station before a transmission time and to transmit said downlink signaling to a user station/mobile station jointly with the base station at the transmission time after the negotiating unit has sent it an instruction to switch the operating mode into the downlink operating mode II.

Wherein, said RF transceiving and processing unit comprises an RF receiver, an RF transmitter, and a baseband processing module; and

in the operating mode II for transmitting the downlink signaling, said RF receiver receives a pre-transmission of the downlink signaling transmitted from the base station before the

transmission time, said baseband processing module performs digital baseband processing on said downlink signaling, and said RF transmitter transmits the downlink signaling jointly with the base station at the transmission time.

Wherein said signaling transmission of the operating modes can comprise a downlink operating mode I of not participating in the transmission of a downlink signaling, a downlink operating mode II of jointly transmitting with the base station, and a downlink operating mode III of transmitting a preamble code jointly with the base station; and

said control unit comprises:

a downlink mode controller, for instructing the RF transceiving and processing unit to stop transmitting the downlink signaling after the negotiating unit has sent it an instruction to switch the operating mode into the downlink operating mode I; for instructing the RF transceiving and processing unit to receive a downlink signaling pre-transmitted from the base station before a transmission time and to transmit the downlink signaling to a user station/mobile station jointly with the base station at the transmission time after the negotiating unit has sent it an instruction to switch the operating mode into the downlink operating mode II; and for instructing the RF transceiving and processing unit to transmit the preamble code to the user station/mobile station jointly with the base station at the transmission time after the negotiating unit has sent it an instruction to switch the operating mode into the downlink operating mode III.

Said relay station can also comprise:

a monitoring unit, for reporting to the base station and instructing the negotiating unit to negotiate with the base station when it detects a coverage blind-spot in the cell.

Wherein the operating modes of said signaling transmission comprise an uplink operating mode I of transmitting the whole uplink signaling after having performed digital baseband processing on it, and an uplink operating mode II for the relay station to transmit delay-sensitive uplink signaling after having stored it and to transmit delay-insensitive uplink

signaling after having performed the digital baseband processing on it; and

said control unit can comprise:

an uplink mode controller, for instructing the RF transceiving and processing unit to transmit the whole uplink signaling after having performed the digital baseband processing on it after the negotiating unit has sent it an instruction to switch to the uplink operating mode I; and for instructing the RF transceiving and processing unit, after the negotiating unit has sent it an instruction to switch to the uplink operating mode II, to receive the delay-sensitive uplink signaling at an uplink signaling gap set by the base station, to transmit the delay-sensitive uplink signaling at an amplified gap reserved by the base station for the relay station after having stored it, and to receive the delay-insensitive uplink signaling, and transmit the delay-insensitive uplink signaling after having performed the digital baseband processing on it.

Wherein said RF transceiving and processing unit comprises an RF receiver, an RF transmitter, a storage module, and a baseband processing module;

in the uplink operating mode I, said RF receiver receives the uplink signaling, said baseband processing module performs digital baseband processing on the whole uplink signaling, and said RF transmitter transmits the whole uplink signaling; and

in the uplink operating mode II, said RF receiver receives the delay-sensitive uplink signaling within the uplink signaling gap set by the base station, said storage module stores the delay-sensitive uplink signaling, said RF transmitter transmits the delay-sensitive uplink signaling within the amplified gap reserved by the base station; said RF receiver receives the delay-insensitive uplink signaling, said baseband processing module performs the digital baseband processing on the delay-insensitive uplink signaling, and said RF transmitter transmits the delay-insensitive uplink signaling.

Wherein, said RF transceiving and processing unit can further comprise:

a first switch having a first port and a second port, wherein when the first port is opened, an output terminal of said storage module is connected to an input terminal of the RF emitter, and when the second port is opened, an output terminal of said baseband processing module is connected to the input terminal of the RF emitter;

a second switch having a first port and a second port, wherein when the first port is opened, the RF receiver is connected to an antenna, and when the second port is opened, the RF emitter is connected to the antenna;

in the uplink operating mode I, the first switch only opens the second port, and the whole uplink signaling is transmitted by the RF transmitter after having performed the digital baseband processing by the baseband processing module;

in the uplink operating mode II, within said uplink signaling gap, the second switch only opens the first port, and after the storage module has stored the delay-sensitive uplink signaling received by the RF transceiver, the storage module stores the delay-sensitive uplink signaling; within said amplified gap, the first switch only opens the first port and the second switch only opens the second port, the RF emitter fetches the delay-sensitive uplink signaling from the storage module and transmits it; within other uplink subframe gaps, the second switch opens the first port and the first switch opens the second port, the RF receiver receives the delay-insensitive uplink signaling, the baseband processing module outputs the delay-insensitive uplink signaling to the RF transmitter after having performed the digital baseband processing on it, the second switch opens the second port, and the RF transmitter transmits the delay-insensitive uplink signaling.

Wherein said negotiating unit is also used to conduct an initial negotiation with the base station when the relay station is initiated, to report its supported operating modes for signaling transmission, and to inform the control unit

after having received an instruction on the initial operating mode returned from the base station.

Wherein the operating modes of said signaling transmission can also comprise an uplink operating mode I of transmitting the whole uplink signaling after having performed digital baseband processing on it, an uplink operating mode II of transmitting the delay-sensitive uplink signaling after having stored it and transmitting the delay-insensitive uplink signaling after having performed the digital baseband processing on it, and an uplink operating mode III of transmitting the whole uplink signaling after having stored it; and

said control unit comprises:

an uplink mode controller, for instructing the RF transceiving and processing unit, after the negotiating unit has sent it an instruction to switch to the uplink operating mode I, to transmit the whole uplink signaling after having performed the digital baseband processing to it; for instructing the RF transceiving and processing unit, after the negotiating unit has sent it an instruction to switch to the uplink operating mode II, to receive the delay-sensitive uplink signaling within an uplink signaling gap set by the base station, after having stored the delay-sensitive uplink signaling to transmit the same within an amplified gap reserved by the base station for the relay station, to receive the delay-insensitive uplink signaling and to transmit it after having performed the digital baseband processing; and for instructing the RF transceiving and processing unit, after the negotiating unit sends it an instruction to switch to the uplink operating mode III, to store and then transmit the whole uplink signaling.

Said relay station further comprises an interface unit, wherein

said negotiating unit is also used to report to the base station that a wired connection exists between the relay station and a backbone network when the relay station is initiated, and to inform the control unit after having received

an instruction returned from the base station about whether or not to use the wired connection; and

said control unit comprises a wired connection controller for controlling said interface unit so as to forward data by using the wired connection, after having received an instruction returned from the base station to use the wired connection.

According to yet another aspect of the invention, the present invention further discloses a base station for transmitting data in mobile communication, positioned in a cell of a multi-hop wireless cellular network, comprising an RF transceiving and processing unit, wherein it further comprises a negotiating unit and a control unit;

said negotiating unit sends an instruction to switch operating mode to the relay station and the control unit after having negotiated with a relay station in the cell; and

said control unit controls said relay station so as to switch between at least two operating modes of signaling transmission via the RF transceiving and processing unit according to the instruction to switch operating mode sent from the negotiating unit.

Wherein, said control unit can comprise:

a pre-transferring module, for instructing the RF transceiving and processing unit to send a downlink signaling to be transmitted to the relay station being in the operating mode of jointly transmitting downlink signaling with the base station before a transmission time.

Said base station also comprises:

a monitoring unit, for reporting to the network when it detects a coverage blind-spot in the cell, or when it receives a report from the relay station that a coverage blind-spot appears in the cell, and at the same time instructing the negotiating unit to negotiate with the relay station.

Wherein said control unit can comprise:

an uplink allocation module, for determining an uplink signaling gap in which the delay-sensitive uplink signaling is located in an uplink subframe; for reserving an amplified gap

for transmitting the delay-sensitive uplink signaling for the relay station in the operating mode of transmitting delay-sensitive uplink signaling after having stored it and transmitting delay-insensitive uplink signaling after having performed digital baseband processing on it; and then informing said relay station of the determined uplink signaling gap and the amplified gap via the RF transceiving and processing unit.

Wherein said negotiating unit is also used to select an operating mode and then inform the relay station of it after having received a report about the operating modes it supports sent from the relay station when it is initiated.

Wherein said negotiating unit is also used to decide, after having received a report from the relay station when it is initiated that a wired connection exists between the relay station and a backbone network, whether or not to use the wired connection and then inform the relay station.

It can be seen from the above technical solution that, when the RS of the present invention performs the transmission of uplink signaling or downlink signaling, it can switch between different operating modes for transmitting signaling, so as to achieve flexible relay schemes. Since the RS can switch between the two operating modes of not participating in the transmission of downlink signaling and jointly transmitting the downlink signaling with the BS, it is able to meet at the same time the demand of high spectrum-efficiency within a cell and the demand of powerful system coverage, and it is helpful in achieving the load equilibrium between adjacent cells. Since the RS is able to switch between the two operating modes of transmitting the whole uplink signaling after having performed digital baseband processing on it and of transmitting delay-sensitive uplink signaling after having stored it and transmitting delay-insensitive uplink signaling after having performed digital baseband processing on it, delay demands other than uplink signaling can be achieved, and when the delay demand is high, digital baseband processing will not be performed on delay-sensitive uplink signaling so as to reduce the delay to a minimum.

Further, the present invention can also make use of the wired connection between the RS and a backbone network to forward data directly without the need to forward data via the BS, so as to reduce the cell load and to make it possible for the cell to accommodate more SS/MSs under the presupposition of not requiring additional wireless resources.

Description of the accompanying drawings

In order to make the above-mentioned and other features and advantages of the present invention clearer to those skilled in art, the preferred embodiments of the present invention will be described in detail by reference to the accompanying drawings, in which:

Figure 1 is a schematic view of the composition of a wireless cellular network;

Figure 2a is a schematic structure view of an RS according to the present invention, for switching between at least two operating modes for transmitting signaling;

Figure 2b is a schematic structure view of a BS according to the present invention for controlling the RS to switch between at least two operating modes for transmitting signaling;

Figure 3 illustrates the status machine of an RS switching between two downlink operating modes for transmitting downlink signaling;

Figure 4 is a schematic view showing the load equilibrium between cells by switching the RS between two downlink operating modes;

Figure 5a is a schematic structure view of an RS switching between two downlink operating modes according to a first embodiment;

Figure 5b is a schematic structure view of a BS for controlling an RS to switch between two operating modes according to the first embodiment;

Figure 6 illustrates the status machine of an RS switching among three downlink operating modes for transmitting downlink signaling;

Figure 7 illustrates the physical layer (PHY) frame structure of a system based on IEEE 802.16;

Figure 8 illustrates the status machine of an RS switching between two uplink operating modes for transmitting uplink signaling;

Figure 9a is a schematic structure view of an RS switching between two uplink operating modes according to a third embodiment;

Figure 9b is a schematic structure view of a BS for controlling the RS to switch between two uplink operating modes according to the third embodiment;

Figure 10 illustrates the configurations of three uplink subframes;

Figure 11 illustrates the status machine of an RS switching among three uplink operating modes for transmitting uplink signaling;

Figure 12 is a schematic composition view of a cell comprising an RS having a direct connection to a backbone network;

Figure 13a is a schematic structure view of the RS according to a fifth embodiment, which switches between at least two operating modes for transmitting signaling and has a wired connection to a backbone network; and

Figure 13b is a schematic structure view of the BS according to the fifth embodiment, for controlling the RS to switch between at least two operating modes for transmitting signaling, and having a wired connection to a backbone network.

Embodiments

To further clarify the objects, technical schemes and advantages of the present invention, the present invention is further described in detail with reference to the accompanying drawings and embodiments. It needs to be pointed out that the embodiments described here are merely for the purposes of illustrating the present invention; they are not to be understood as limiting the present invention.

A BS and more than one RS are deployed in a cell of a

wireless cellular network, in which under the control of the BS the RS switches between different operating modes for transmitting signaling to realized flexible relay schemes. Fig. 1 is a schematic view of the composition of a wireless cellular network. It can be seen in Fig. 1 that the cell comprises a BS, an RS1, an RS2, an MS1 and an MS2. Among them one or both of RS1 and RS2 are configured to be able to switch between different operating modes. If there exists in the cell an RS that does not support the switching between different operating modes, it will transmit signaling still in a single operating mode, and the BS can control respectively all the RSs within the cell.

Fig. 2a illustrates the structure of the RS according to the present invention that switches between at least two operating modes for transmitting signaling. It can be seen in Fig. 2a that, the RS according to the present invention comprises an RF transceiving and processing unit, a negotiating unit and a control unit.

Wherein the RF transceiving and processing unit performs the basic functions, such as RF receiving, digital baseband processing, RF transmitting, etc.; the negotiating unit sends an instruction to switch operating mode to the control unit after having negotiated with the BS of the cell; and the control unit controls the RF transceiving and processing unit to switch between at least two operating modes for transmitting signaling according to the instruction to switch operating mode sent from the negotiating unit.

Fig. 2b illustrates the structure of the BS according to the present invention for controlling the RS to switch between at least two operating modes for transmitting signaling. It can be seen from Fig. 2b that the BS according to the present invention comprises an RF transceiving and processing unit, a negotiating unit and a control unit.

Wherein the RF transceiving and processing unit performs the basic functions, such as RF receiving, digital baseband processing, RF transmitting, etc.; the negotiating unit sends an instruction to switch operating mode to the RS and the

control unit after having negotiated with the RS of the cell; and the control unit controls the RS to switch between at least two operating modes for transmitting signaling through the RF transceiving and processing unit according to the instruction to switch operating mode sent from the negotiating unit.

The transmitted signaling comprises uplink and downlink signaling, therefore different signaling transmission modes can comprise different modes for transmitting downlink signaling and different modes for transmitting uplink signaling. This will be described in detail hereafter through several embodiments.

First embodiment

According to the first embodiment of the present invention, a BS and more than one RS are deployed in a cell, according to the environments and the conditions of the network, and under the control of the BS said RS is able to switch between different operating modes for transmitting downlink signaling, for example between a downlink operating mode I and a downlink operating mode II. In the downlink operating mode I, the RS only forwards data and does not participate in the transmission of downlink signaling, and the whole downlink signaling is uniformly transmitted by the BS; in the downlink operating mode II, the RS not only forwards business data, but also participates in the transmission of the downlink signaling, that is to say, the RS transmits the downlink signaling jointly with the BS. To achieve the object that the RS and the BS jointly transmit the downlink signaling, it is necessary to reserve some of the wireless resources for the BS to pre-transfer to the RS the downlink signaling to be transmitted jointly.

When the RS is in the downlink operating mode I, its signaling consumption is small, but its performance will be relatively poor if there exists a coverage blind-spot around it; when the RS is in the downlink operating mode II, its signaling consumption is large, but its performance is relatively good if there exists a coverage blind-spot around it.

It is described in detail below, when the RS is transmitting downlink signaling, under what circumstances it is necessary for it to switch operating mode.

Fig. 3 illustrates the status machine of the RS switching between downlink operating modes for transmitting downlink signaling. It can be seen in Fig. 3 that, when a coverage blind-spot appears in the current cell or the wireless resources of adjacent cell are insufficient, so it needs to attract more SS/MSs into the current cell, the switch from the downlink operating mode I to mode II is triggered; and when the coverage blind-spot is eliminated or the wireless resources of the current cell are insufficient, the switch from the downlink operating mode II to the downlink operating mode I is triggered.

As described above, the RS is triggered to switch from the downlink operating mode I to the downlink operating mode II when the coverage problem appears in the cell, and this coverage problem can be detected either by the RS or by the BS.

Switching triggered by an RS detection: the RS can monitor, by making use of an idle time slot, the communication status of a radio access point (RAP) connecting the SS/MSs to other cells. When the RS find that some SS/MSs are always trying to connect to the RAP of other cells, but the quality of the signals received by the RS and sent from these SS/MSs is relatively high, for example higher than a preset threshold of signal quality, in other words, these SS/MSs will be able to obtain service of better quality if they were connected to the cell to which the RS belongs, the RS reports to the network through the BS at this time and prepares to execute the switching from the downlink operating mode I to the downlink operating mode II.

Switching triggered by a BS detection: when the BS finds out that the parameters of an initial ranging measurement being performed by some SS/MSs are significantly different from the measurement results reported by the RS, for example, an SS/MS is making its initial measurement of the distance from it to the BS by using its maximum power, but this SS/MS is close to

an RS, the BS will report to the network if the difference is greater than a preset difference threshold, and at the same time it negotiates with the RS so as to switch the downlink operating mode of the RS.

It should be noted that, detections conducted by the RS and the BS have their own advantages, the advantage of the detection by the RS lies in that it can discover the coverage worsening within the region covered originally by several RAPs, while the advantage of the detection by the BS lies in that it can discover the coverage problem within the region covered previously by one RAP.

Contrary to it, when the coverage blind-spot disappears, the RS is triggered to switch from the downlink operating mode II to the downlink operating mode I. For example, when it is concluded by long-term learning that the RS is safe enough in the downlink operating mode I, the RS is triggered to switch from the downlink operating mode II into the downlink operating mode I so as to reduce the consumption of the signaling and the occupation of the resources. The practical way to realize this can be: reducing step by step the transmitting power of downlink control signaling and observing the responses from the SS/MSs, if during a relatively long time span all SS/MSs are able to receive and recognize the downlink control signaling transmitted by the RS in a normal transmitting power, then it can be concluded that the downlink operating mode I is safe enough to the RS.

Moreover, as described above, when it is necessary to achieve load equilibrium between adjacent cells, the RS can also be triggered to switch between the downlink operating mode I and the downlink operating mode II. For example, if the wireless resources of a cell B are insufficient while that of its adjacent cell A are still sufficient, it is usually considered to attract more SS/MSs into the cell A, and at this time, the RS in the cell A, which is close to the cell B, can be triggered to switch from the downlink operating mode I into the downlink operating mode II; whereas, when the wireless resources of the cell A are insufficient and that of its

adjacent cell B are in surplus, the RS in the cell A, which is in the downlink operating mode II, can be triggered to switched into the downlink operating mode I so as to avoid overloading the cell B.

In addition, in some cases, it is necessary for the network to regulate the cells' covering area irregularly, so that the regulation by switching the downlink operating modes of RS can meet the requirement of more precise load equilibrium. As shown in Fig. 4, a cell comprises two RSs: RS1 and RS2, at the upper part of Fig. 4, RS1 is in the downlink operating mode I, and RS2 is in the downlink operating mode II, if here the network wishes that the cell attract more SS/MSs from a cell to its left and at the same time a cell to its right attract more SS/MSs from this cell, then it is possible to instruct the two RSs to switch their downlink operating modes. The real covering area of the cell after the network having instructed these two RSs to switch their downlink operating modes is shown in the lower part of Fig. 4; it can be seen there, that the mode switching of the RSs results in irregular change of covering area, the covering area to the right of the cell becomes smaller and that to the left of the cell becomes larger.

Furthermore, when initiated, the RS can have an initial negotiation with the BS to report the two downlink operating modes it supports for transmitting downlink signaling; the BS confirms the downlink operating mode of said RS and controls said RS to operate in the determined downlink operating mode.

Hereinbelow, the switching of an RS between two downlink operating modes and the structure of a BS for controlling the RS to switch between two downlink operating modes is explained.

Fig. 5a is a schematic structure view of an RS switching between two downlink operating modes according to a first embodiment of the present invention. As shown in Fig. 5a, in this embodiment, the RS capable of switching between the two downlink operating modes comprises an RF transceiving and processing unit, a negotiating unit, a control unit and a monitoring unit.

Wherein, the RF transceiving and processing unit comprises:

an RF receiver for inputting the RF signals received by an antenna into a baseband processing module;

a baseband processing module for sending the RF signals to an RF transmitter after having performed digital baseband processing thereto;

an RF transmitter for transmitting via the antenna the signals sent from the baseband processing unit.

The monitoring unit determines by monitoring the status of a cell whether it is necessary to trigger the RS to switch its downlink operating mode, and when a judgment is made that it is necessary to trigger the RS to switch the downlink operating mode, it reports via a BS to the network its monitoring results, and instructs the negotiating unit to negotiate with the BS; for example, it monitors the communication status of the connection between the SS/MSs and the radio access points (RAPs) of other cells during idle time slots, wherein the RAPs comprise BSs and RSs, if it is found that some SS/MSs are trying to connect to an RAP of another cell and the quality of the received signals is relatively high, it indicates that these SS/MSs are close to the RS, then the downlink operating mode can be switched.

The negotiating unit, under the instruction of the monitoring unit, negotiates with the BS about the switching of downlink operating mode, and after having received the instruction to switch the operating mode, it informs the control unit that the downlink operating mode needs to be switched. Preferably, the negotiating unit is also used to have the initial negotiation with the BS when it is initiated, to report the operating modes it supports for transmitting downlink signaling, and after having received the instruction on the initial operating mode returned from the BS, to instruct the control unit to perform a corresponding operation.

The control unit comprises a downlink mode controller, which, after having received the instruction to switch the operating mode from the negotiating unit, sends a control signal to the RF transceiving and processing unit; after the negotiating unit having sent it the instruction to switch the

operating mode to the downlink operating mode I, it instructs the RF transceiving and processing unit to stop transmitting downlink signaling; and after the negotiating unit having sent it the instruction to switch the operating mode to the downlink operating mode II, it instructs the RF transceiving and processing unit to receive the downlink signaling pre-transferred from the BS before the transmission time, and to transmit the downlink signaling simultaneously with the BS during the transmission time.

Fig. 5b is a schematic structure view of a BS for controlling an RS to switch between two operating modes according to the first embodiment. As shown in Fig. 5b, in this embodiment, the BS for controlling the RS to switch between two downlink operating modes comprises an RF transceiving and processing unit, a negotiating unit, a control unit and a monitoring unit.

Wherein, the RF transceiving and processing unit comprises an RF receiver, a baseband processing module and an RF transmitter; wherein:

the RF receiver is for inputting the RF signals received by an antenna into the baseband processing module;

the baseband processing module is for sending the RF signals to an RF transmitter after having performed digital baseband processing thereto; and

the RF transmitter is for transmitting via the antenna the signals sent from the baseband processing unit.

When receiving the monitoring results from the RS for reporting to the network, the monitoring unit sends the monitoring results reported from the RS to the network through the wired connection between it and the network; when discovering that the parameters initial ranging by the SS/MS are significantly different from the measurement results reported from the RS, it sends the measurement results to the network via the wired connection, and instructs the negotiating unit to negotiate with a corresponding RS about the switching of its downlink operating mode.

The negotiating unit negotiates with the corresponding RS about the switching of its downlink operating mode through the RS transceiving and processing unit, and after the completion of the negotiation or having received the instruction to switch from the network, it sends the instruction to switch the operating mode to the RS, and sends the instruction to switch the operating mode to the control unit so as to instruct the control unit to execute a corresponding operation. Preferably, the negotiating unit is also used to select an initial operating mode after having received from the RS the operating modes it supports for transmitting downlink signaling reported when it is initiated, and to inform the RS.

According to the instruction to switch the operating mode sent from the negotiating unit, the control unit controls via the RF transceiving and processing unit the switching of the RS between the downlink operating modes.

The control unit can comprise a pre-transferring module, for pre-sending downlink signaling to the RS in the downlink operating mode II. For example, if it is prescribed to send downlink signaling to the SS/MS within the *n*th time slot (i.e. the transmission time), then the downlink signaling is pre-sent to the RS in the downlink operating mode II within the (*n-1*)th time slot, so that the RS in the downlink operating mode II can transmit the downlink signaling simultaneously with the BS to the SS/MS within the *n*th time slot (i.e. the transmission time).

Based on the RS and BS described above, at the stage of network planning, the downlink operating modes of the RSs in a cell can be configured one by one according to the coverage conditions. As described above, an RS can switch between two downlink operating modes, obviously, in order to improve spectrum efficiency, if there is no explicit coverage blind-spot within the cell, all RSs may as well be in the downlink operating mode I because the RS in the downlink operating mode I occupies nearly no wireless resources. If there exists an explicit coverage blind-spot in the cell, one RS is needed to be in the downlink operating mode II and this RS may as well be

the one closest to the coverage blind-spot. The coverage blind-spot can be located through various approaches. Thus, different RSs within one cell may be in different operating modes.

When the network is established, whether to trigger a corresponding RS to switch its operating mode is determined according to practical network monitoring results or requirements, and when it is necessary to trigger, the operating mode of the RS is switched.

As described above, if an RS detects that a SS/MS of relatively high signal quality is attempting to connect with the radio access point (RAP) of another cell, or the BS detects that the parameters of initial ranging by the SS/MS are different significantly from those sent from the RS, for example above a preset difference threshold, or the network wishes to change the coverage area of the cell so as to achieve load equilibrium, a corresponding RS can be triggered to switch its operating mode. A specific switching procedure will be explained below in combination with Fig. 5a and Fig. 5b. Wherein Fig. 5a is a schematic structure view of the RS according to this embodiment for switching between two downlink operating modes, Fig. 5b is a schematic structure view of the BS according to this embodiment for controlling the RS to switch between two downlink operating modes.

If the monitoring unit of an RS in the downlink operating mode I detects that a SS/MS with signals of relatively high quality is trying to connect with the RAP of another cell, it informs the negotiating unit of the RS and the negotiating unit sends a signal to the BS through the RF transceiving and processing unit of the RS; the monitoring unit of the BS forwards the signals to the network and instructs the negotiating units of the RS and the BS to send and receive the negotiation data through their respective RF transceiving and processing units; when the negotiation is completed, if it is determined to switch the RS from the downlink operating mode I into the downlink operating mode II, the negotiating unit of the BS sends the instruction to switch the operating mode to the downlink operating mode II to a pre-transferring module,

and the pre-transferring module instructs the RF transceiving and processing unit of the BS to send the downlink signaling to be transmitted to the RS before the transmission time; the negotiating unit of the RS send the instruction to switch the operating mode to the downlink operating mode II to the downlink mode controller, the downlink mode controller of the RS instructs the RF transceiving and processing unit of the RS to receive the downlink signaling sent from the BS before the transmission time and to transmit the downlink signaling jointly with the BS simultaneously during the transmission time.

If the monitoring unit of the BS detects that the parameters of initial ranging by a SS/MS are different significantly from those sent from an RS in the downlink operating mode I, it informs the network and instructs the negotiating unit of the BS to negotiate with that of the RS; when the negotiation is completed, if it is determined to switch the RS from the downlink operating mode I to the downlink operating mode II, the negotiating unit of the BS sends the instruction to switch the operating mode to the downlink operating mode II to the pre-transferring module, and the pre-transferring module instructs the RF transceiving and processing unit of the BS to send the downlink signaling to be transmitted to the RS before the transmission time; the negotiating unit of the RS sends the instruction to switch the operating mode to the downlink operating mode II to the downlink mode controller, the downlink mode controller of the RS instructs the RF transceiving and processing unit of the RS to receive the downlink signaling sent from the BS before the transmission time and to transmit the downlink signaling jointly with the BS simultaneously during the transmission time.

If it is the network that wishes to change the coverage area of the cell so as to achieve a load equilibrium, it informs the monitoring unit of the BS about this, the monitoring unit of the BS instructs the negotiating unit of the BS to negotiate with the negotiating unit of the RS; when the

negotiation is completed, if it is determined to switch the RS from the downlink operating mode I to the downlink operating mode II, the negotiating unit of the BS sends the instruction to switch the operating mode to the downlink operating mode II to the pre-transferring module, and the pre-transferring module instructs the RF transceiving and processing unit of the BS to send the downlink signaling to be transmitted to the RS before the transmission time; the negotiating unit of the RS sends the instruction to switch the operating mode into the downlink operating mode II to the downlink mode controller, and the downlink mode controller of the RS instructs the RF transceiving and processing unit of the RS to receive the downlink signaling sent from the BS before the transmission time and to transmit the downlink signaling jointly with the BS simultaneously during the transmission time.

The process of switching from the downlink operating mode II to the downlink operating mode I is relatively simple: if the BS by long-term learning makes a conclusion that the downlink operating mode I is safe enough or it receives an instruction from the network, the operating mode can be switched from the downlink operating mode II to the downlink operating mode I, then the monitoring unit of the BS instructs the negotiating unit of the BS to negotiate with the negotiating unit of the RS; when the negotiation is completed, if it is determined to switch the RS from the downlink operating mode II to the downlink operating mode I, the negotiating unit of the BS sends the instruction to switch the operating mode to the downlink operating mode I to the pre-transferring module, the pre-transferring module instructs the RF transceiving and processing unit of the BS to stop sending the downlink signaling to the RS; the negotiating unit of the RS sends the instruction to switch the operating mode to the downlink operating mode I to the downlink mode controller, the downlink mode controller of the RS instructs the RF transceiving and processing unit of the RS to stop transmitting the downlink signaling, thus the RS no longer participates in the transmission of the downlink signaling.

If an RS is in the downlink operating mode II, the BS needs to pre-transfer the downlink signaling to be transmitted to the RS, and this pre-transferring of the downlink signaling will occupy wireless resources. The occupation status of the wireless resources within a cell depends on the quantity of the RS in the downlink operating mode II, this is because the adopted modulation/encoding scheme has to be determined according to the conditions of the operation link, typically according to the link conditions between the BS and the RS located at a position of most disadvantageous. Obviously, any increase in the number of the RSs in the downlink operating mode II will cause the deterioration of the conditions of operation link, and therefore more wireless resources are needed. To be brief, the more the RSs are in the downlink operating mode II, the more wireless resources have to be reserved for the transmission of the downlink signaling.

The ability of the RS to switch between different operating modes for transmitting the downlink signaling can provide a flexible deployment when the network environment changes, for example providing a flexible deployment when a coverage problem appears or when the load equilibrium between cells is broken. Compared with the conventional ways of achieving the load equilibrium by changing the power of the downlink signaling or by tilting an antenna, the switching of the RS's operating mode is able to obtain irregular variation of the covering area, thus the real covering area can be flexibly changed according to practical demands, and it is more suitable for performing a more precise regulation of load equilibrium.

Second embodiment

According to the second embodiment of the present invention, a BS and more than one RS are deployed in a cell, according to the environments and the conditions of the network and under the control of the BS said RS is able to switch between different operating modes for transmitting downlink signaling. The second embodiment differs from the first embodiment in that: in the second embodiment, the RS can switch

among three downlink operating modes, that is switch among a downlink operating mode I, a downlink operating mode II and a downlink operating mode III. When in the downlink operating mode I, the RS does not participate in the transmission of downlink signaling; in the downlink operating mode II, the RS transmits the downlink signaling jointly with the BS; in the downlink operating mode III, the RS transmits a preamble code jointly with the BS, since the preamble code is generally constant, the BS only needs to pre-transfer the preamble code to the RS once, after this no more pre-transferring cooperation needs to be executed, and the RS transmits the preamble code jointly with the BS during the transmission time. An RS in the downlink operating mode III cannot eliminate a coverage blind-spot, but to some extent it can attract more SS/MSs to the current cell. Therefore, if the network needs to attract more SS/MSs to the current cell while the wireless resources of the current cell are insufficient or there is no coverage blind-spot in the current cell, it can instruct a corresponding RS of the current cell to operate in the downlink operating mode III.

Figure 6 illustrates the status machine of the RS switching between three downlink operating modes for transmitting downlink signaling. It can be seen in Fig. 6 that, in this embodiment, the switching details of the RS are as follows:

when the RS operates in the downlink operating mode I, if it is detected that a coverage blind-spot appears in the current cell or the wireless resources of an adjacent cell are insufficient, the BS instructs the RS to switch into the downlink operating mode II; if the wireless resources of an adjacent cell are detected to be insufficient, it can also switch to the downlink operating mode III; and

when the RS operates in the downlink operating mode II, if it is detected that the coverage blind spot in the current cell is eliminated or the wireless resources of the current cell are insufficient, the BS instructs the RS to switch to the downlink operating mode I; if the coverage blind-spot in the current cell is detected to have disappeared, it can also switch to the downlink operating mode III;

when the RS operates in the downlink operating mode III, if it is detected that the wireless resources of the adjacent cell are no longer insufficient, the BS instructs the RS to switch to the downlink operating mode I; if a coverage blind-spot is detected in the current cell, the BS instructs the RS to switch to the downlink operating mode II.

The RS capable of switching among three downlink operating modes is virtually the same as the RS shown in Fig. 5a, and the differences between them lie in that, after having received an instruction to switch to the operating mode III from the negotiating unit, the downlink mode controller of the control unit sends a control signal to the RF transceiving and processing unit, instructing the RF transceiving and processing unit to receive the preamble code pre-transferred from the BS before the transmission time, and to transmit the preamble code during transmission time jointly with the BS simultaneously to the SS/MS, and said operation of receiving the pre-transferred preamble code is executed only once.

The BS which instructs the RS to switch among three downlink operating modes is virtually the same as the BS shown in Fig. 5b, and the differences between them lie in that, the negotiating unit also sends out an instruction to switch into the downlink operating mode III; after the control unit has switched to the downlink operating mode III according to the instruction to switch from the negotiating unit, the pre-transferring module pre-transmits the preamble code to the RS operating in the downlink operating mode III, for the RS operating in the downlink operating mode III to transmit the preamble code jointly with the BS simultaneously to the SS/MS during the transmission time, and said operation of pre-transferring the preamble code is executed only once.

Third embodiment

According to the third embodiment of the present invention, one BS and more than one RS are provided in a cell, and under the control of the BS, the RS switches between different operating modes for transmitting uplink signaling, for example

between an uplink operating mode I and an uplink operating mode II. The transmission of the uplink signaling within the cell is explained in detail below.

Since the RS is a digital relay device, during the transmission of the uplink signaling, after having received the uplink signaling transmitted from the SS/MS, the RF transceiving and processing unit transmits the signaling after having performed a digital baseband processing on it, and the quality of the signaling transmission is ensured because the digital baseband processing has been performed on the signaling. However, also because of the existence of the digital baseband processing, the time required for transmitting the uplink signaling will generally be increased. This has virtually no impact on normal signaling, but on some signaling having relatively high demands about delay, called delay-sensitive signaling hereafter, this delay of transmission time will probably cause some serious consequences. Generally, the PHY layer signaling for perception and scheduling of information channels, hybrid automatic requesting for re-transmission (HARQ), fast power control and/or fast adaptability modulation/encoding and so on are delay-sensitive signaling.

It will be explained by Fig. 7 below how a PHY frame in the system is configured. As shown in Fig. 7, the configuration of each PHY frame is represented by information units in the downlink mapping (DL-MAP) signaling associated with a downlink sub-frame and information units in the uplink mapping (UL-MAP) signaling associated with an uplink sub-frame. Particularly, in the case in which the BS centrally controls all activities within a cell, the BS controls the SS/MS activities of the uplink route through the information unit in the UL-MAP. In a system based on IEEE802.16, the uplink signaling transferred in channel quality indicator channels (CQICH), an acknowledgement channel (ACKCH) and CDMA ranging fields are typically used as the PHY layer signaling most relevant to some of the delay-sensitive control/management topics. Particularly, in a WiBro system compatible with IEEE 802.16e, the first three orthogonal

frequency division multiple (CDMA) symbols in the uplink sub-frame are reserved as CQICH, ACKCH and CDMA ranging fields. In the present embodiment, the delay-sensitive uplink signaling occupies one or more than one successive orthogonal frequency division multiple (OFDM) symbols in the uplink sub-frame.

In the present embodiment, the RS can switch between two uplink operating modes for transmitting the uplink signaling. In an uplink operating mode I, the RS transmits the whole received uplink signaling after having performed digital baseband processing on it and the RS is used here as a routine digital relay device. In an uplink operating mode II, the RS transmits delay-sensitive signaling after having stored it and here the RS is used as an analog relay device; while delay-insensitive signaling is transmitted after having performed digital baseband processing on it and the RS is used here as a routine digital relay device. Thus it can be seen that, in the uplink operating mode II, the RS makes a difference between the delay-sensitive signaling and the delay-insensitive signaling, so as to reduce the transmission delay of the delay-sensitive signaling as much as possible.

When initiated, the RS can negotiate with the BS, and report the two operating modes it supports for transmitting uplink signaling; the BS determines an initial operating mode for the RS and controls the RS to operate in the determined operating mode.

Figure 8 illustrates the status machine of two uplink operating modes for transmitting uplink signaling. It can be seen from Fig. 8 that, in the uplink operating mode I, the RS performs digital baseband processing on the whole uplink signaling, where the time delay of the signaling is relatively large while the transmission quality is relatively good; and in the uplink operating mode II, the RS does not perform digital baseband processing on uplink signaling, so as to reduce the delay of the delay-sensitive signaling, while the transmission quality is relatively poor. Therefore, which uplink operating mode is to be adopted in a particular case is decided according to practical requirements, that is, the uplink operating mode

II is adopted when the requirement about delay is strict; the uplink operating mode I is adopted when the delay requirement is not high, especially when the quality requirement is strict. If the BS determines that current requirement about delay is relatively high, it instructs the RS to switch from the uplink operation I to the uplink operating mode II; if the BS determines that the current requirement about delay is relatively low, or the requirements about transmission quality is relatively high, it instructs the RS to switch from the uplink operation II to the uplink operating mode I.

Figure 9a is a schematic structure view of an RS switching between two uplink operating modes according to the third embodiment. As shown in Fig. 9a, the RS of the embodiment comprises an RF transceiving and processing unit, a negotiating unit, a control unit and a monitoring unit.

The negotiating unit sends out to the control unit an instruction to switch operating mode after having negotiated with the BS.

According to the instruction to switch operating mode sent from the negotiating unit, the control unit controls the RF transceiving and processing unit to switch between two operating modes for transmitting uplink signaling.

The control unit comprises an uplink mode controller, for instructing the RF transceiving and processing unit to transmit the whole uplink signaling after having performed the digital baseband processing on it after the negotiating unit has sent it an instruction to switch to the uplink operating mode I; and for instructing the RF transceiving and processing unit, after the negotiating unit has sent it an instruction to switch to the uplink operating mode II, to receive the delay-sensitive uplink signaling at an uplink signaling gap set by the base station, to transmit the delay-sensitive uplink signaling at an amplified gap reserved by the base station for the relay station after having stored it, and to receive the delay-insensitive uplink signaling, and to transmit the delay-insensitive uplink signaling after having performed the digital baseband processing on it.

Wherein, the RF transceiving and processing unit comprises an RF receiver, a baseband processing module and an RF transmitter.

In the uplink operating mode I, said baseband processing module performs digital baseband processing on the whole uplink signaling received by the RF receiver, and said RF transmitter transmits the whole uplink signaling; and

in the uplink operating mode II, after the storage module has stored the delay-sensitive uplink signaling received by the RF receiver during the uplink signaling gap set by the base station, the RF transmitter transmits the delay-sensitive uplink signaling during the amplified gap reserved by the base station; and after the baseband processing module has performed the digital baseband processing to the delay-insensitive uplink signaling received by the RF receiver, the RF transmitter transmits the delay-insensitive uplink signaling.

Further, the RF transceiving and processing unit comprises a first switch and a second switch. Wherein the first switch has a port A and a port B, for respectively outputting the signals from the storage module and the baseband processing module into the RF transmitter. The second switch also has a port A and a port B, and when only the port A is opened, only the RF emitter is connected to an antenna, the antenna can only transfer RF signals to the RF receiver; when only the port B is opened, only the RF emitter is connected to the antenna, the antenna can only transmit out the signals sent from the RF transmitter, so as to avoid the self-oscillation caused by the superposition of the receiving and transmitting; when the ports A and B are opened simultaneously, both the RF receiver and the RF transmitter can be connected to the antenna, and then it can receive as well as the transmit.

When the RS is in the uplink operating mode I, the uplink mode controller instructs the first switch only to open the port B, and in this mode the storage module does not work, the whole uplink signaling is transmitted by the RF transmitter after having performed the digital baseband processing by the baseband processing module;

when the RS operates in the uplink operating mode II, the uplink mode controller receives information extracted by the baseband control module from the UL-MAP, and determines the gap of the delay-sensitive signaling in the uplink signaling (called uplink signaling gap) and the gap for transmitting the delay-sensitive signaling (amplified gap); as described above, since the delay-sensitive uplink signaling of PHY layer are transmitted in several adjacent OFDM symbols, it is convenient to determine the uplink signaling gap and the amplified gap.

Within the uplink signaling gap, the uplink mode controller can execute the following operations:

instructing the second switch to open only its port A, so that the RF receiver receives the delay-sensitive uplink signaling;

instructing the storage module to prepare for storing the delay-sensitive uplink signaling received by the RF receiver; and

within the amplified gap, the uplink mode controller can execute the following operations:

instructing the first switch to open only its port A, so as to transfer the delay-sensitive uplink signaling in the storage module to the RF transmitter; and

instructing the second switch to open only its port B, so that the RF transmitter transmits the delay-sensitive uplink signaling at an amplified power.

Within other gaps in the uplink sub-frame, the uplink mode controller can execute the following operations:

instructing the second switch to open its port A, so that the RF receiver receives other uplink signaling;

instructing the baseband processing module to process the uplink signaling sent from the RF receiver, that is, to perform the digital baseband processing;

instructing the first switch to open its port B, so as to output the uplink signaling sent from the baseband processing module to the RF transmitter; and

instructing the second switch to open its port B, so as to transmit via the antenna the uplink signaling supplied by the RF transmitter.

Preferably, the negotiating unit is also used to negotiate with the BS when the RS is initiated, to report the operating modes it supports for transmitting uplink signaling, and after having received the initial operating mode instruction returned from the BS, to instruct the uplink mode controller of the control unit to execute a corresponding operation.

As described above, for the delay-sensitive signaling, the RS is essentially used as an analog relay device, in which the digital baseband processing is not performed on the signaling and only a certain delay is imposed on the signaling, which is outputted at an amplified power. Since this delay is small, it can ensure that the transmission delay of delay-sensitive signaling is small. As for other uplink signaling, especially for some quality-sensitive signaling, the RS is still used as a digital relay device, and the signaling is transmitted after having performed the digital baseband processing, thus although there exists a relatively large delay, the quality of the signal can be ensured.

Figure 9b is a schematic structure view of a BS for controlling the RS so as to switch between two uplink operating modes according to the second embodiment. It can be seen in Fig. 9b that the BS of this embodiment comprises: an RF transceiving and processing unit, a negotiating unit and a control unit.

The negotiating unit negotiates with an RS to determine the operating mode of the RS for transmitting uplink signaling, informs the RS, and sends to the control unit an instruction to switch operating mode.

Preferably, the negotiating unit is also used to decide, after having received from the RS the operating modes it supports for transmitting downlink signaling reported when it is initiated, on an initial operating mode, and to inform the RS.

The control unit controls said RS so as to switch between two uplink operating modes through the RF transceiving and processing unit according to the instruction to switch operating mode sent from the negotiating unit.

The control unit comprises an uplink allocation module for determining the delay-sensitive signaling, the signaling gap where the delay-sensitive uplink signaling is located in an uplink sub-frame, an amplified gap reserved for the RS to transmit the delay-sensitive uplink signaling, and then for informing the RS through the RF transceiving and processing unit; the control unit can also control the BS so as to perform corresponding processing to the uplink signaling after having received it from the RS, and when the BS receives the uplink signaling from the RS, a plurality of combination schemes can be adopted to process the unlink signaling of original PHY layer and delay-sensitive signaling.

In the uplink operating mode II, the process for the BS to instruct the RS to transmit uplink signaling can comprise the following steps:

Step 1: the BS determines the transmitting gaps, i.e. uplink signaling gaps, of the delay-sensitive signaling aiming at various RSs within the cell, determines the amplified gaps in uplink sub-frames which have equal length to the uplink signaling gaps, and informs the respective RSs of the uplink signaling gap and amplified gap, for example, the RSs can be informed using the information units in the UL-MAP. The amplified gap and the uplink signaling gap in the uplink sub-frame can also be unequal.

Step 2: within the unlink signaling gap determined by the BS, the RS, as an analog relay device, receives and stores the delay-sensitive signaling, and transmits it within the amplified gap in the uplink sub-frame; at other times, the RS acts as a routine digital relay device to transmit other received uplink signaling after having performed digital baseband processing on it.

Step 3: the BS receives the delay-sensitive uplink signaling sent from the RS according to the determined

amplified gap in the uplink sub-frame, and receives other uplink signaling within other gaps.

During a practical implementing process, it is necessary to set appropriate amplified gap and corresponding amplifying gain to achieve the reliable transfer of the delay-sensitive PHY layer uplink signaling, so as to facilitate the implementation of channel-aware technology in a cell comprising the RSs under the control of the BS. The number of the RSs having the functions of the two modes described above for transmitting uplink signaling and the amplifying gain adopted by the respective RSs can be configured adaptively by the BS (and/or network) according to various factors, and these factors comprise, but are not limited to, the load levels of the respective RSs and that of the respective RSs of adjacent cells.

The type of the PHY layer uplink signaling processed by the RS can be modified adaptively by the BS (and/or network), and this modification will result in the modification of the lengths of the signaling gaps and that of the corresponding amplified gaps. Such adaptive modification can be simplified by defining the associated information units of the UL-MAP and the amplified gaps. The BS (and/or network) can adaptively coordinate the amplified gaps for the respective RSs so as to perform the interference management. For example, it can define groups among the RSs of two functions, and make the RSs of the same group transmit in the same gap.

The BS can assign N different amplified gaps for M RSs in the cell, and reserve one or more than one of the N amplified gaps for each RS, wherein M is a positive integer, and N is an integer; the RS transmits the received delay-sensitive signaling within the one or several of the N amplified gaps reserved for it by the BS. Thus, the RSs can transmit the delay-sensitive signaling in several different amplified gaps, so as to make the transmission quality of the delay-sensitive signaling better.

Referring to Fig. 1 again, a cell comprises a BS, RS1, RS2, MS1 and MS2. Since RS1 is close to MS1 and RS2 is close to MS2,

usually the signals received by RS1 from MS1 are stronger than the signals of MS2, the signals received by RS2 from MS2 are stronger than that of MS1. Therefore, the amplified signal transmitted by RS1 can carry more useful information from MS1, while the amplified signal transmitted by RS2 can carry more useful information from MS2. The BS can make use of this feature to assign non-superposition amplified gaps for RS1 and RS2, and then decode the information from RS1 and RS2 respectively, for example, decode the signaling from MS1 by using the amplified signal from RS1, and decode the signaling from MS2 by using the amplified signal from RS2.

The function of "storing-delaying-amplifying" delay-sensitive signaling can be implemented in a frequency selectable manner, so as to make the configuring of the uplink sub-frame more flexible, and to improve the spectrum efficiency.

Figure 10 illustrates the configuration of three possible uplink sub-frames, in Fig. 10 the vertical axis is time and the horizontal axis is frequency. It can be seen in Fig. 10 that, in the case A, RS1 and RS2 are assigned with amplified gaps of non-superposition, that is, RS1 and RS2 transmit respectively the delay-sensitive signaling within different amplified gaps at the same frequency; in the case B, RS1 and RS2 are assigned with the same amplified gap, that is, RS1 and RS2 transmit the delay-sensitive signaling within the same amplified gaps at the same frequency, and in this way the gaps can be saved; in the case C, RS1 and RS2 are assigned with amplified gaps of non-superposition, and the analog relay function has the ability to select frequency, that is, RS1 and RS2 transmit delay-sensitive signaling within different amplified gaps at the same frequency, and business data are transmitted within these two amplified gaps at different frequencies.

This embodiment can select appropriate transmission modes for uplink signaling according to different delay requirements, and this is advantageous for the network to select different transmission schemes for uplink signaling according to different situations and conditions.

Fourth embodiment:

According to the fourth embodiment of the present invention, a BS and more than one RS are provided in a cell, and under the control of the BS, the RS switches between different operating modes for transmitting uplink signaling, this embodiment differs from the third embodiment in that the RS of this embodiment switches between three uplink operating modes, for example, it switches between an uplink operating mode I, an uplink operating mode II and an uplink operating mode III. In the uplink operating mode I, the RS transmits the whole received uplink signaling after having performed digital baseband processing on it, and in this case the RS is used as a routine digital relay device. In the uplink operating mode II, the RS transmits delay-sensitive signaling after having stored it, and the RS acts as an analog relay device; while it transmits delay-insensitive signaling after having performed digital baseband processing on it, and the RS acts in a routine digital relay state. In the uplink operating mode III, the RS transmits the whole uplink signaling after having stored it.

Figure 11 illustrates the status machine for the transmission of signaling in three operating modes. It can be seen in Fig. 11 that, in the present embodiment, the status switching process of the uplink operating mode is as follows:

when the RS operates in the uplink operating mode I, if the BS makes a judgment that a current time-delay requirement is increased to a first time-delay threshold, it instructs the RS to switch from the uplink operating mode I to the uplink operating mode III; if the BS makes a judgment that the current time-delay requirement is increased to a second time-delay threshold, it instructs the RS to switch from the uplink operating mode I into the uplink operating mode II, and said first threshold is higher that the second threshold.

When the RS operates in the uplink operating mode II, if the BS makes a judgment that the current time-delay requirement is increased to the first time-delay threshold, it instructs the RS to switch from the uplink operating mode II into the

uplink operating mode III; if the BS makes a judgment that the current time-delay requirement is dropped to below the second time-delay threshold or a quality requirement is increased to a first quality threshold, it instructs the RS to switch from the uplink operating mode II into the uplink operating mode I.

When the RS operates in the uplink operating mode III, if the BS makes a judgment that the current time-delay requirement is dropped to below the first time-delay threshold, it instructs the RS to switch from the uplink operating mode III into the uplink operating mode II; if the BS determines that the current time-delay requirement is dropped to below the second time-delay threshold or the quality requirement is increased to the first quality threshold, it instructs the RS to switch from the uplink operating mode III to the uplink operating mode I.

The RS capable of switching among three uplink operating modes is virtually the same as the RS shown in Fig. 9a, and the differences between them are that after the negotiating unit sends an instruction to switch into the uplink operating mode I, the uplink mode controller of the control unit instructs the RF transceiving and processing unit to transmit the whole uplink signaling after having stored it. In the downlink operating mode III, the RS acts as an analog relay device.

The BS capable of instructing the RS to switch among three uplink operating modes is virtually the same as the BS shown in Fig. 9b, and the differences between them are that the negotiating unit also sends out the instruction to switch into the uplink operation III.

Fifth embodiment

In the fifth embodiment of the present invention, there exist wired connections between some of the RSs in a cell and a backbone network, as shown in Fig. 12, there exist between a BS and the backbone network a high quality wired connection, but RS1 and RS3 have no connection with the backbone network, while RS2 has a wired connection with the backbone network, too. Although the performance of the wired connection between RS2

and the backbone network is lower than that between the BS and the backbone network, it can also be used in the same way to transmit data.

Fig. 13a illustrates a schematic structure view of the RS of the present invention, which switches between at least two operating modes for transmitting signaling and has a wired connection to a backbone network.

It can be seen in Fig. 13a that, the RS according to the present invention comprises an RF transceiving and processing unit, a negotiating unit, a control unit and an interface unit.

Wherein the RF transceiving and processing unit performs the basic functions of RF receiving, digital baseband processing, RF transmitting and so on; the negotiating unit sends an instruction to switch operating mode to the control unit after having negotiated with the BS of the cell; and the control unit controls the RF transceiving and processing unit to switch between at least two operating modes for transmitting signaling according to the instruction to switch operating mode sent from the negotiating unit.

The negotiating unit is also used to report the wired connection between it and the backbone network, and after having received the instruction of whether to use the wired connection returned from the BS, to inform the control unit.

Preferably, the negotiating unit can also negotiate with the BS when it is initiated, report the wired connection between it and the backbone network, and inform the control unit after having received the instruction of whether to use the wired connection returned from the BS.

The control unit also comprises a wired connection controller, for instructing, after having received the instruction of using the wired connection sent from the negotiating unit, the interface unit to use the wired connection to forward data.

Under the instructions of the wired connection controller, the interface unit uses the connection between the RS and the backbone network to forward data.

Fig. 13b illustrates the structure of the BS according to

the present invention for controlling the RS to switch between at least two operating modes for transmitting signaling and for controlling the RS to use the connection between it and a backbone network. It can be seen in Fig. 13b that the BS according to the present invention comprises an RF transceiving and processing unit, a negotiating unit and a control unit.

Wherein, the RF transceiving and processing unit performs the basic functions of RF receiving, digital baseband processing, RF transmitting and so on; the negotiating unit sends an instruction to switch operating mode to the control unit after having negotiated with the RS; and the control unit controls the RS to switch between at least two operating modes for transmitting signaling through the RF transceiving and processing unit according to the instruction to switch operating mode sent from the negotiating unit.

The negotiating unit can also make a judgment, after having received a report from the RS about its wired connection with the backbone network, whether it is needed to make use of the wired connection according to load: if the load of the current cell is not heavy, and/or the quality of the wired connection is poor, it decides not to use the wired connection, and instructs the RS not to use its wired connection with the backbone network, all business data and signaling sent to and from the backbone network are transmitted through the BS. If the load of the current cell is relatively heavy, and/or the quality of the wired connection is quite good, the wired connection can be used, and the RS is instructed to use the wired connection for forwarding at least part of the business data and part of the signaling. In this case, the BS still controls the cell's air ports, i.e. the wireless connections of the cell, specifically it comprises the wireless connections for all SS/MSs to communicate with RAPs (including BS and provided RS), the connections for all RSs without wired connection with the backbone network to communicate with the BS, and the wireless connections for all RSs having wired connection with the backbone network to communicate with the BS when required.

According to QoS requirement and under the control of the BS, the RS transmits/receives data as much as possible through its own wired connection with the backbone network, where the data can comprise business data and signaling. That is to say, the RS can either send the data of the SS/MSs to the backbone network, or send directly the data sent from the backbone network to the SS/MSs, but this activity must be under the centralized control of the BS.

It needs to be explained that, to achieve the direct transmission of data to the backbone network or transmission of the data from the backbone network to the SS/MSs, the RS has to have a functional entity of above layer 2.

When an RS uses a wired connection, the RS can be used by the BS to determine the route of a multi-hop SS/MS, for example, in Fig. 12, those SS/MSs communicating directly with RS3 can be assigned with a route, and their business data can be sent to the backbone network directly via the RS, without having to go through the BS; and the business data from the backbone network can also be sent directly to these SS/MSs, also without having to go through the BS.

Because of the use of the wired connection between the RS and the backbone network, more SS/MSs can be accommodated in one cell without requiring extra wireless resources. Moreover, when the quality of the wired connection between the RS and the backbone network is good enough, higher QoS services can be provided to multi-hop SS/MSs.

The present invention can also comprise the RS and BS with the combined functions of all the embodiments described above. When the RS is connected to the network to start its initial negotiation with the BS, it requests the BS to determine its operating mode in three cases, the BS determines respectively the operating modes of the RS for transmitting downlink signaling, for transmitting uplink signaling, and when the RS reports its wired connection with the backbone network, determines whether to use the wired connection. Then, the BS will instruct the RS to operate respectively in which operating modes in these three cases. During the operating process, the

operating modes of the RS can be regulated according to practical situations.

What is described above are merely the preferred embodiments of the present invention, which are not to limit the present invention, and any modification, equivalent substitution and refinement etc. within the spirits and principles of the present invention should be included with the scope of protection of the present invention.

Claims

1. A method for transmitting data in mobile communication and for application in a cell having a base station and more than one relay station, wherein under the control of said base station, said relay stations switch between at least two operating modes when transmitting an uplink signaling or a downlink signaling.

2. The method as claimed in claim 1, wherein during the transmission of the downlink signaling, said relay stations switch between an operating mode of not participating in the transmission of the downlink signaling and an operating mode of jointly transmitting the downlink signaling with the base station.

3. The method as claimed in claim 2, wherein when the base station detects a coverage blind-spot in the cell, after having negotiated with the relay station close to the coverage blind-spot in the cell, it instructs the relay station to switch from the operating mode of not participating in the transmission of the downlink signaling into the operating mode of jointly transmitting the downlink signaling with the base station.

4. The method as claimed in claim 3, wherein the situation that the base station detects the occurrence of the coverage blind-spot in the cell is confirmed according to the following process:
the base station detects that a difference between an initial ranging parameter of more than one user station/mobile station and a measurement parameter reported by the relay stations is larger than a preset difference threshold.

5. The method as claimed in claim 2, wherein when the relay station detects a coverage blind-spot in the cell, after having negotiated with the base station, it switches from the operating mode of not participating in the transmission of the

downlink signaling into the operating mode of jointly transmitting the downlink signaling with the base station.

6. The method as claimed in claim 5, wherein the situation that said relay station detects the occurrence of the coverage blind-spot in the cell is confirmed according to the following process:
said relay station detects during its idle time slot that more than one user station/mobile station is attempting to connect to a radio access point of another cell, but the signal quality from the user stations/mobile stations received by said relay station is above a preset signal quality threshold.

7. The method as claimed in claim 3 or 5, wherein when the base station confirms that the coverage blind-spot in the cell has been eliminated, after having negotiated with the relay station that transmits the downlink signaling jointly with the base station in the cell, the base station instructs the relay station to switch back to the operating mode of not participating in the transmission of the downlink signaling.

8. The method as claimed in claim 7, wherein the steps for the base station to confirm the elimination of the coverage blind-spot in the cell comprise:
the base station reduces step by step the signaling transmitting power of the relay station that transmits the downlink signaling jointly with the base station in the cell and observes the responses from the user stations/mobile stations, and if after the transmitting power has been reduced to a normal transmission power, the user stations/mobile stations are still capable of receiving normally, then the base station determines that the coverage blind-spot in the cell has been eliminated.

9. The method as claimed in claim 2, wherein when a network confirms that the wireless resource of a cell is currently sufficient and that of an adjacent cell is insufficient, by

instructing the base station in the cell to negotiate with the relay station in the cell close to the adjacent cell, it makes the relay station switch from the operating mode of not participating in the transmission of the downlink signaling into the operating mode of jointly transmitting the downlink signaling with the base station; or
when the network confirms that the wireless resource of a cell is currently insufficient and that of an adjacent cell is sufficient, by instructing the base station in the cell to negotiate with the relay station in the cell close to the adjacent cell, it makes the relay station switch from the operating mode of jointly transmitting the downlink signaling with the base station into the operating mode of not participating in the transmission of the downlink signaling.

10. The method as claimed in claim 2, wherein when said relay station is in the operating mode of jointly transmitting the downlink signaling with the base station,
said relay station receives a downlink signaling pre-transmitted by the base station before a transmission time; and at the transmission time, the relay station and the base station transmit said downlink signaling to the user stations/mobile stations simultaneously.

11. The method as claimed in claim 1, wherein during the transmission of the downlink signaling, said relay station switches among three operating modes of not participating in the transmission of the downlink signaling, jointly transmitting the downlink signaling with the base station, and jointly transmitting a preamble code with the base station.

12. The method as claimed in claim 11, wherein when the network confirms that the wireless resource of an adjacent cell of one cell is insufficient, by instructing the base station in the cell to negotiate with the relay station in the cell close to the adjacent cell, it makes the relay station switch from the operating mode of not participating in the transmission of

the downlink signaling into the operating mode of jointly transmitting the preamble code with the base station; or
when the network confirms that the wireless resource of an adjacent cell of one cell is sufficient, by instructing the base station in the cell to negotiate with the relay station in the cell close to the adjacent cell, it makes the relay station switch from the operating mode of jointly transmitting the preamble code with the base station into the operating mode of not participating in the transmission of the downlink signaling.

13. The method as claimed in claim 11, wherein when the base station detects that a coverage blind-spot appears in the cell, after having negotiated with the relay station close to the coverage blind-spot, it instructs the relay station to switch from the operating mode of jointly transmitting the preamble code with the base station into the operating mode of jointly transmitting the downlink signaling with the base station; or
when the base station confirms that the coverage blind-spot in the cell has been eliminated, after having negotiated with the relay station in the cell that jointly transmits the downlink signaling with the base station, it instructs said relay station to switch from the operating mode of jointly transmitting the downlink signaling with the base station into the operating mode of jointly transmitting the preamble code with the base station.

14. The method as claimed in claim 1, wherein when transmitting the uplink signaling, said relay station switches between an operating mode of transmitting the whole uplink signaling after having performed digital baseband processing on it, and an operating mode of transmitting delay-sensitive uplink signaling after having stored it and transmitting delay-insensitive uplink signaling after having performed digital baseband processing on it.

15. The method as claimed in claim 14, wherein when said base station makes a judgment that the current time-delay requirement is relatively high, after having negotiated with said relay station, it instructs the relay station to switch from the operating mode of transmitting the whole uplink signaling after having performed digital baseband processing on it into the operating mode of transmitting delay-sensitive uplink signaling after having stored it and transmitting delay-insensitive uplink signaling after having performed digital baseband processing on it; or
when the base station makes a judgment that the current time-delay requirement is relatively low or a requirement for transmission quality is relatively high, after having negotiated with said relay station, it instructs the relay station to switch from the operating mode of transmitting delay-sensitive uplink signaling after having stored it and transmitting delay-insensitive uplink signaling after having performed digital baseband processing on it into the operating mode of transmitting the whole uplink signaling after having performed digital baseband processing on it.

16. The method as claimed in claim 14, wherein when said relay station is in the operating mode of transmitting delay-sensitive uplink signaling after having stored it,
said relay station receives information of an uplink signaling gap and an amplified gap preset by the base station for transmitting a delay-sensitive signaling on an uplink subframe; and
said relay station receives the delay-sensitive uplink signaling within said uplink signaling gap, and transmits said delay-sensitive uplink signaling within said amplified gap.

17. The method as claimed in claim 16, wherein the process for said base station to preset the amplified gap comprises:
said base station dividing the more than one relay station in the cell into groups, and reserving a different amplified gap

in the uplink subframe for the relay stations in each group; and
said relay stations transmitting the received delay-sensitive signaling within their respective amplified gaps.

18. The method as claimed in claim 16, wherein the process for said base station to preset the amplified gap comprises:
said base station assigning N different amplified gaps for M relay stations in the cell, reserving one or several of the N amplified gaps for each of the relay stations, wherein M is a positive integer, and N is an integer; and
said relay station transmitting the received delay-sensitive signaling within the one or several of the N amplified gaps reserved for it by the base station.

19. The method as claimed in claim 16, wherein said relay station extracts said uplink signaling gap and said amplified gap from an information unit in a received downlink mapping signaling DL-MAP of the base station.

20. The method as claimed in claim 16, wherein said delay-sensitive uplink signaling comprises a channel quality indicator channel (CQICH) of a physical layer (PHY), an acknowledgement channel (ACKCH), and an uplink signaling transmitted in a CDMA ranging field, or any combination thereof.

21. The method as claimed in claim 16, wherein said delay-sensitive uplink signaling occupies one or several continuous time slots in the uplink subframe.

22. The method as claimed in claim 1, wherein during the transmission of the uplink signaling, said relay station switches between an operating mode of transmitting the whole uplink signaling after having performed digital baseband processing to it, an operating mode of transmitting delay-sensitive uplink signaling after having stored it and

transmitting delay-insensitive uplink signaling after having performed digital baseband processing on it, and an operating mode of transmitting the whole uplink signaling after having stored it.

23. The method as claimed in claim 22, wherein when said relay station is in the operating mode of transmitting the whole uplink signaling after having performed digital baseband processing on it, if the base station makes a judgment that a current time-delay requirement is increased to a first time-delay threshold, by negotiating with said relay station, the base station instructs the relay station to switch to the operating mode of transmitting the whole uplink signaling after having stored it; if the base station makes a judgment that the current time-delay requirement is increased to a second time-delay threshold, by negotiating with said relay station, the base station instructs the relay station to switch to the operating mode of transmitting delay-sensitive uplink signaling after having stored it and transmitting delay-insensitive uplink signaling after having performed digital baseband processing on it ;
when the relay station is in the operating mode of transmitting delay-sensitive uplink signaling after having stored it and transmitting delay-insensitive uplink signaling after having performed digital baseband processing on it, if the base station makes a judgment that the current time-delay requirement is increased to the first time-delay threshold, by negotiating with the relay station, the base station instructs the relay station to switch to the operating mode of transmitting the whole uplink signaling after having stored it; if the base station makes a judgment that the current time-delay requirement is reduced to below the second time-delay threshold or a quality requirement is increased to a first quality threshold, by negotiating with the relay station, the base station instructs the relay station to switch into the operating mode of transmitting the whole uplink signaling after having performed digital baseband processing on it;

when the relay station is in the operating mode of transmitting the whole uplink signaling after having stored it, if the base station makes a judgment that the current time-delay requirement is reduced to below the first time-delay threshold, by negotiating with the relay station, the base station instructs the relay station to switch into the operating mode of transmitting delay-sensitive uplink signaling after having stored it and transmitting delay-insensitive uplink signaling after having performed digital baseband processing on it; if the base station makes a judgment that the current time-delay requirement is reduced to below the second time-delay threshold or the quality requirement is raised to the first quality threshold, by negotiating with the relay station, the base station instructs the relay station to switch to the operating mode of transmitting the whole uplink signaling after having performed digital baseband processing on it; and
said time-delay requirement corresponding to said first time-delay threshold is higher than the time-delay requirement corresponding to said second time-delay threshold.

24. The method as claimed in claim 1, wherein it also comprises:
said relay station performing an initial negotiation with said base station when it is initiated and reporting all operating modes it supports for signaling transmission; and
said base station designating an initial operating mode for said relay station, and controling said relay station to operate in the designated initial operating mode.

25. The method as claimed in claim 1, wherein it further comprises:
said relay station reporting to the base station when it detects that a wired connection is established between itself and a backbone network; and
after said base station has decided to make use of the wired connection between the relay station and the backbone network,

it instructs said relay station to forward data via the wired connection between the relay station and the backbone network.

26. The method as claimed in claim 25, wherein when the relay station detects the existence of the wired connection between itself and the backbone network, it initially negotiates with the base station, and reports the existence of the wired connection between itself and the backbone network.

27. The method as claimed in claim 25, wherein said base station decides whether or not to use the wired connection according to the load in the cell and/or the quality of the wired connection;
if the load in the cell is relatively small and/or the quality of the wired connection is relatively poor, it decides not to use the wired connection; and if the load in the cell is relatively large and/or the quality of the wired connection is relatively good, it decides to use the wired connection.

28. The method as claimed in claim 25, wherein said relay station forwards business data and signaling via the wired connection between itself and the backbone network according to QoS requirements.

29. The method as claimed in claim 25, wherein when said relay station forwards data through the wired connection between itself and the backbone network, wireless connections for said relay station to communicate with user stations/mobile stations in the cell and wireless connections for said relay station to communicate with the base station when necessary are both controlled by the base station.

30. A system for transmitting data in mobile communication, comprising one base station and more than one relay station in a cell, wherein under the control of said base station, said relay stations switch between at least two operating modes when transmitting an uplink signaling or a downlink signaling.

31. The system as claimed in claim 30, wherein when transmitting downlink signaling, said relay stations switch between an operating mode of not participating in the transmission of the downlink signaling and an operating mode of jointly transmitting the downlink signaling with the base station.

32. The system as claimed in claim 30, wherein said relay stations switch among three operating modes of not participating in the transmission of the downlink signaling, jointly transmitting the downlink signaling with the base station, and jointly transmitting a preamble code with the base station.

33. The system as claimed in claim 30, wherein when transmitting uplink signaling, said relay stations switch between an operating mode of transmitting the whole uplink signaling after having performed digital baseband processing on it, and an operating mode of transmitting delay-sensitive uplink signaling after having stored it and transmitting delay-insensitive uplink signaling after having performed digital baseband processing on it.

34. The system as claimed in claim 30, wherein said relay stations switch between three operating modes of transmitting the whole uplink signaling after having performed digital baseband processing on it, of transmitting delay-sensitive uplink signaling after having stored it and transmitting delay-insensitive uplink signaling after having performed digital baseband processing on it, and of transmitting the whole uplink signaling after having stored it.

35. A relay station positioned in a cell of a wireless cellular network for transmitting data in mobile communication, comprising an RF transceiving and processing unit, and also comprising a negotiating unit and a control unit;

said negotiating unit sends an operating mode switching instruction to the control unit after having negotiated with a base station in said cell; and
said control unit controls the RF transceiving and processing unit so as to switch between at least two operating modes for transmitting signaling according to the mode switching instruction sent from the negotiating unit.

36. The relay station as claimed in claim 35, wherein the operating modes of said signaling transmission comprise a downlink operating mode I of not participating in the transmission of a downlink signaling and a downlink operating mode II of transmitting jointly with the base station; and
said control unit comprises:
a downlink mode controller for instructing the RF transceiving and processing unit to stop transmitting the downlink signaling, after the negotiating unit has sent it an instruction to switch the operating mode into the downlink operating mode I; and for instructing the RF transceiving and processing unit to receive a downlink signaling pre-transmitted from the base station before a transmission time and to transmit said downlink signaling to a user station/mobile station jointly with the base station at the transmission time after the negotiating unit has sent it an instruction to switch the operating mode into the downlink operating mode II.

37. The relay station as claimed in claim 36, wherein said RF transceiving and processing unit comprises an RF receiver, an RF transmitter, and a baseband processing module; and
in the operating mode II for transmitting the downlink signaling, said RF receiver receives a pre-transmission of the downlink signaling transmitted from the base station before the transmission time, said baseband processing module performs digital baseband processing on said downlink signaling, and said RF transmitter transmits the downlink signaling jointly with the base station at the transmission time.

38. The relay station as claimed in claim 35, wherein the operating modes of said signaling transmission comprise a downlink operating mode I of not participating in the transmission of a downlink signaling, a downlink operating mode II of jointly transmitting with the base station, and a downlink operating mode III of transmitting a preamble code jointly with the base station; and
said control unit comprises:
a downlink mode controller, for instructing the RF transceiving and processing unit to stop transmitting the downlink signaling after the negotiating unit has sent it an instruction to switch the operating mode into the downlink operating mode I; for instructing the RF transceiving and processing unit to receive a downlink signaling pre-transmitted from the base station before a transmission time and to transmit the downlink signaling to a user station/mobile station jointly with the base station at the transmission time after the negotiating unit has sent it an instruction to switch the operating mode into the downlink operating mode II; and for instructing the RF transceiving and processing unit to transmit the preamble code to the user station/mobile station jointly with the base station at the transmission time after the negotiating unit has sent it an instruction to switch the operating mode into the downlink operating mode III.

39. The relay station as claimed in claim 35, wherein it further comprises:
a monitoring unit, for reporting to the base station and instructing the negotiating unit to negotiate with the base station when it detects a coverage blind-spot in the cell.

40. The relay station as claimed in claim 35, wherein the operating modes of said signaling transmission comprise an uplink operating mode I of transmitting the whole uplink signaling after having performed digital baseband processing on it, and an uplink operating mode II for the relay station to transmit delay-sensitive uplink signaling after having stored

it and to transmit delay-insensitive uplink signaling after having performed the digital baseband processing on it; and
said control unit comprises:
an uplink mode controller, for instructing the RF transceiving and processing unit to transmit the whole uplink signaling after having performed the digital baseband processing on it after the negotiating unit has sent it an instruction to switch to the uplink operating mode I; and for instructing the RF transceiving and processing unit, after the negotiating unit has sent it an instruction to switch to the uplink operating mode II, to receive the delay-sensitive uplink signaling at an uplink signaling gap set by the base station, to transmit the delay-sensitive uplink signaling at an amplified gap reserved by the base station for the relay station after having stored it, and to receive the delay-insensitive uplink signaling, and transmit the delay-insensitive uplink signaling after having performed the digital baseband processing on it.

41. The relay station as claimed in claim 40, wherein said RF transceiving and processing unit comprises an RF receiver, an RF transmitter, a storage module, and a baseband processing module;
in the uplink operating mode I, said RF receiver receives the uplink signaling, said baseband processing module performs digital baseband processing on the whole uplink signaling, and said RF transmitter transmits the whole uplink signaling;
in the uplink operating mode II, said RF receiver receives the delay-sensitive uplink signaling within the uplink signaling gap set by the base station, said storage module stores the delay-sensitive uplink signaling, said RF transmitter transmits the delay-sensitive uplink signaling within the amplified gap reserved by the base station; said RF receiver receives the delay-insensitive uplink signaling, said baseband processing module performs the digital baseband processing on the delay-insensitive uplink signaling, and said RF transmitter transmits the delay-insensitive uplink signaling.

42. The relay station as claimed in claim 41, wherein said RF transceiving and processing unit further comprises:
a first switch having a first port and a second port, wherein when the first port is opened, an output terminal of said storage module is connected to an input terminal of the RF emitter, and when the second port is opened, an output terminal of said baseband processing module is connected to the input terminal of the RF emitter;
a second switch having a first port and a second port, wherein when the first port is opened, the RF receiver is connected to an antenna, and when the second port is opened, the RF emitter is connected to the antenna;
in the uplink operating mode I, the first switch only opens the second port, and the whole uplink signaling is transmitted by the RF transmitter after having performed the digital baseband processing by the baseband processing module;
in the uplink operating mode II, within said uplink signaling gap, the second switch only opens the first port, and after the storage module has stored the delay-sensitive uplink signaling received by the RF transceiver, the storage module stores the delay-sensitive uplink signaling; within the amplified gap, the first switch only opens the first port and the second switch only opens the second port, the RF emitter fetches the delay-sensitive uplink signaling from the storage module and transmits it; within other uplink subframe gaps, the second switch opens the first port and the first switch opens the second port, the RF receiver receives the delay-insensitive uplink signaling, the baseband processing module outputs the delay-insensitive uplink signaling to the RF transmitter after having performed the digital baseband processing on it, the second switch opens the second port, and the RF transmitter transmits the delay-insensitive uplink signaling.

43. The relay station as claimed in claim 35, wherein the operating modes of said signaling transmission comprise an uplink operating mode I of transmitting the whole uplink signaling after having performed digital baseband processing on

it, an uplink operating mode II of transmitting the delay-sensitive uplink signaling after having stored it and transmitting the delay-insensitive uplink signaling after having performed the digital baseband processing on it, and an uplink operating mode III of transmitting the whole uplink signaling after having stored it;
said control unit comprises:
an uplink mode controller, for instructing the RF transceiving and processing unit, after the negotiating unit has sent it an instruction to switch to the uplink operating mode I, to transmit the whole uplink signaling after having performed the digital baseband processing on it; for instructing the RF transceiving and processing unit, after the negotiating unit has sent it an instruction to switch to the uplink operating mode II, to receive the delay-sensitive uplink signaling within an uplink signaling gap set by the base station, after having stored the delay-sensitive uplink signaling, and to transmit the same within an amplified gap reserved by the base station for the relay station, to receive the delay-insensitive uplink signaling and to transmit it after having performed the digital baseband processing; and for instructing the RF transceiving and processing unit, after the negotiating unit sends it an instruction to switch to the uplink operating mode III, to store and then transmit the whole uplink signaling.

44. The relay station as claimed in claim 35, wherein said negotiating unit is also used to conduct an initial negotiation with the base station when the relay station is initiated, to report its supported operating modes for signaling transmission, and to inform the control unit after having received an instruction on the initial operating mode returned from the base station.

45. The relay station as claimed in claim 35, further comprising an interface unit, wherein
said negotiating unit is also used to report to the base station that a wired connection exists between the relay

station and a backbone network when the relay station is initiated, and to inform the control unit after having received an instruction returned from the base station about whether or not to use the wired connection; and
said control unit comprises a wired connection controller for controlling said interface unit so as to forward data by using the wired connection, after having received an instruction returned from the base station to use the wired connection.

46. A base station for transmitting data in mobile communication, positioned in a cell of a multi-hop wireless cellular network, comprising an RF transceiving and processing unit, wherein it further comprises a negotiating unit and a control unit;
said negotiating unit sends an instruction to switch operating mode to the relay station and the control unit after having negotiated with a relay station in the cell; and
said control unit controls said relay station to switch between at least two operating modes of signaling transmission via the RF transceiving and processing unit according to the instruction to switch operating mode sent from the negotiating unit.

47. The base station as claimed in claim 46, wherein said control unit comprises:
a pre-transferring module, for instructing the RF transceiving and processing unit to send a downlink signaling to be transmitted to the relay station in the operating mode of jointly transmitting downlink signaling with the base station before a transmission time.

48. The base station as claimed in claim 46, further comprising:
a monitoring unit, for reporting to the network when it detects a coverage blind-spot in the cell, or when it receives a report from the relay station that a coverage blind-spot appears in

the cell, and at the same time instructing the negotiating unit to negotiate with the relay station.

49. The base station as claimed in claim 46, wherein said control unit comprises:
an uplink allocation module, for determining an uplink signaling gap in which the delay-sensitive uplink signaling is located in an uplink subframe; for reserving an amplified gap for transmitting the delay-sensitive uplink signaling for the relay station in the operating mode of transmitting delay-sensitive uplink signaling after having stored it and transmitting delay-insensitive uplink signaling after having performed digital baseband processing on it; and then informing said relay station of the determined uplink signaling gap and the amplified gap via the RF transceiving and processing unit.

50. The base station as claimed in claim 46, wherein said negotiating unit is also used to select an operating mode and then inform the relay station of it after having received a report about the operating modes it supports sent from the relay station when it is initiated.

51. The base station as claimed in claim 46, wherein said negotiating unit is also used to decide, after having received a report from the relay station when it is initiated that a wired connection exists between the relay station and a backbone network, whether or not to use the wired connection and then inform the relay station.

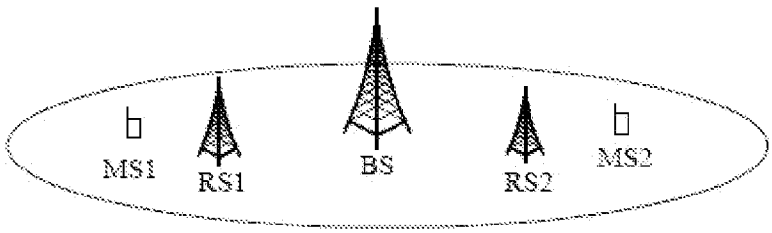

MS1
RS1
BS
RS2
MS2

Fig 1

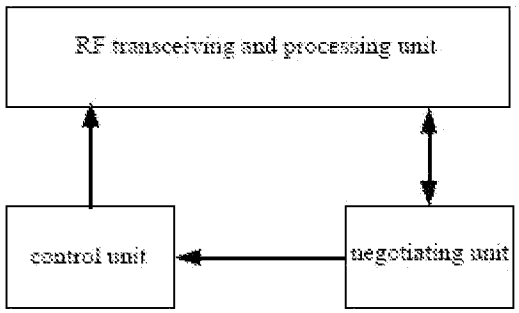

RF transceiving and processing unit
control unit
negotiating unit

Fig 2a

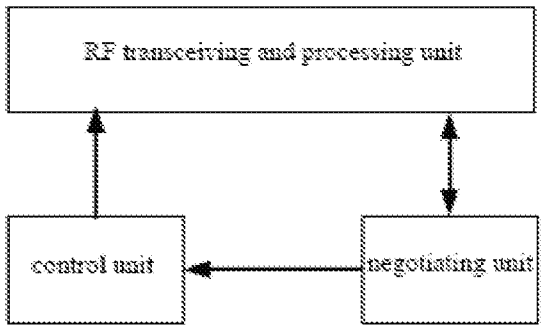

RF transceiving and processing unit
control unit
negotiating unit

Fig 2b

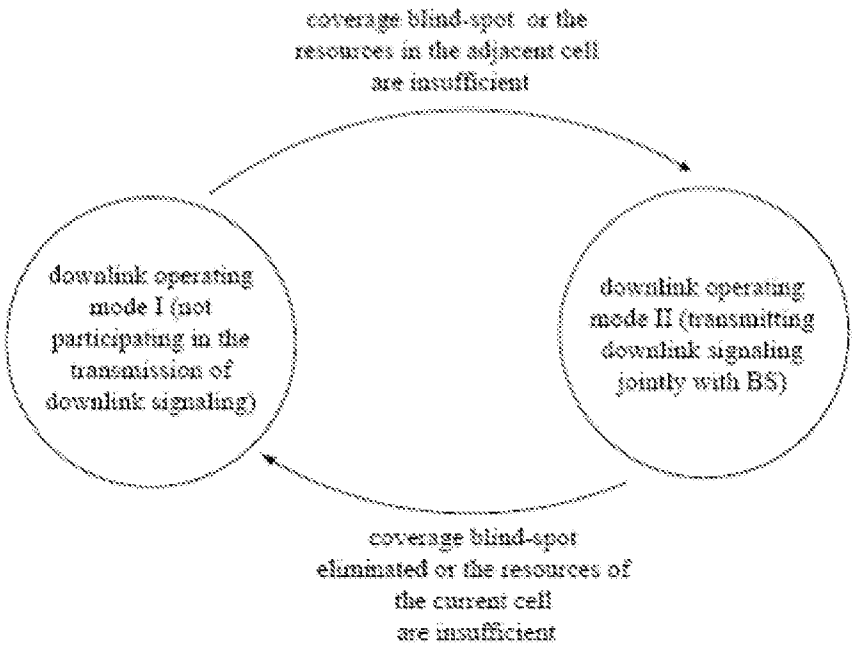

coverage blind-spot or the resources in the adjacent cell are insufficient
downlink operating mode I (not participating in the transmission of downlink signaling)
downlink operating mode II (transmitting downlink signaling jointly with BS)
coverage blind-spot eliminated or the resources of the current cell are insufficient

Fig 3

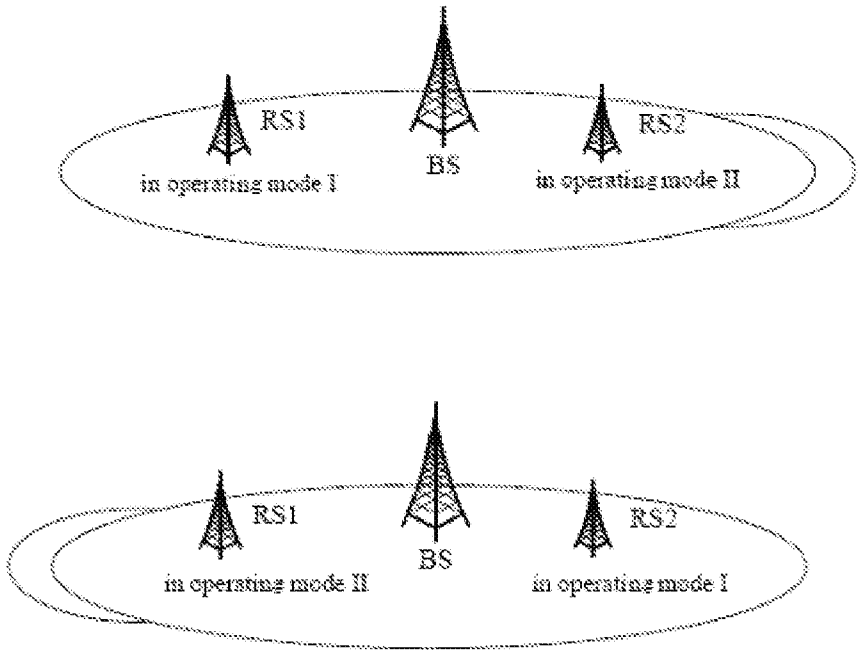

RS1
BS
RS2
in operating mode I
in operating mode II
RS1
BS
RS2
in operating mode II
in operating mode I

Fig 4

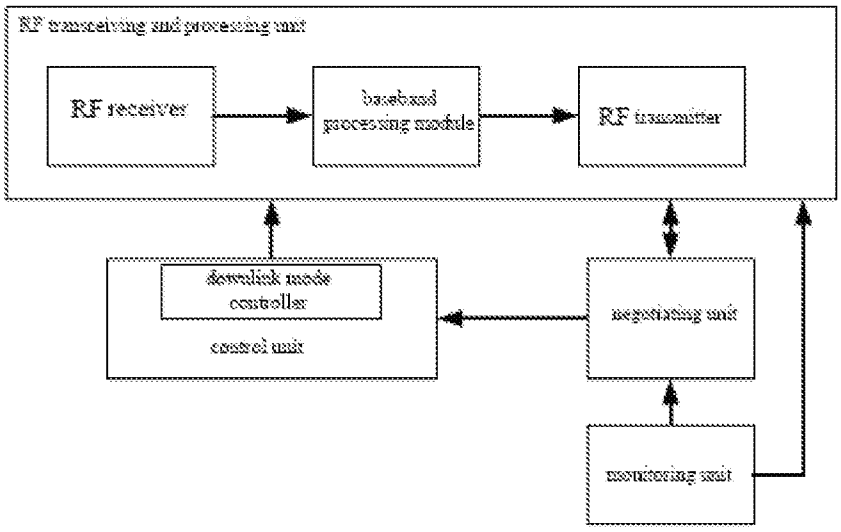

RF transceiving and processing unit
RF receiver
baseband processing module
RF transmitter
downlink mode controller
control unit
negotiating unit
monitoring unit

Fig 5a

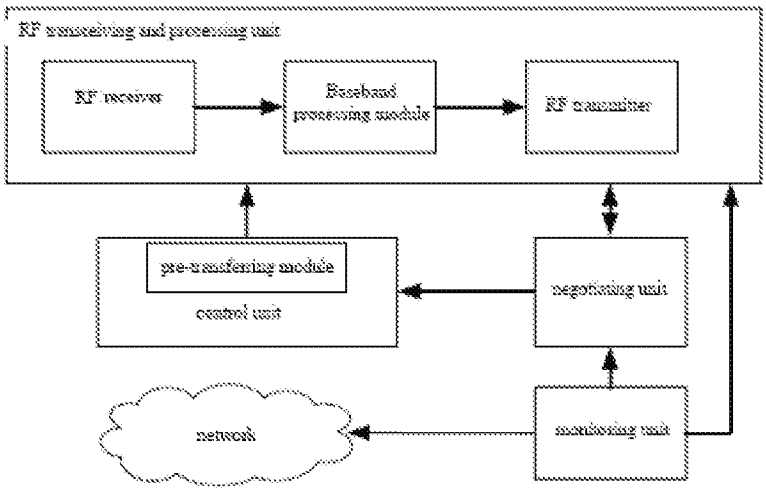

RF transceiving and processing unit
RF receiver
Baseband processing module
RF transmitter
pre-transferring module
control unit
negotiating unit
network
monitoring unit

Fig 5b

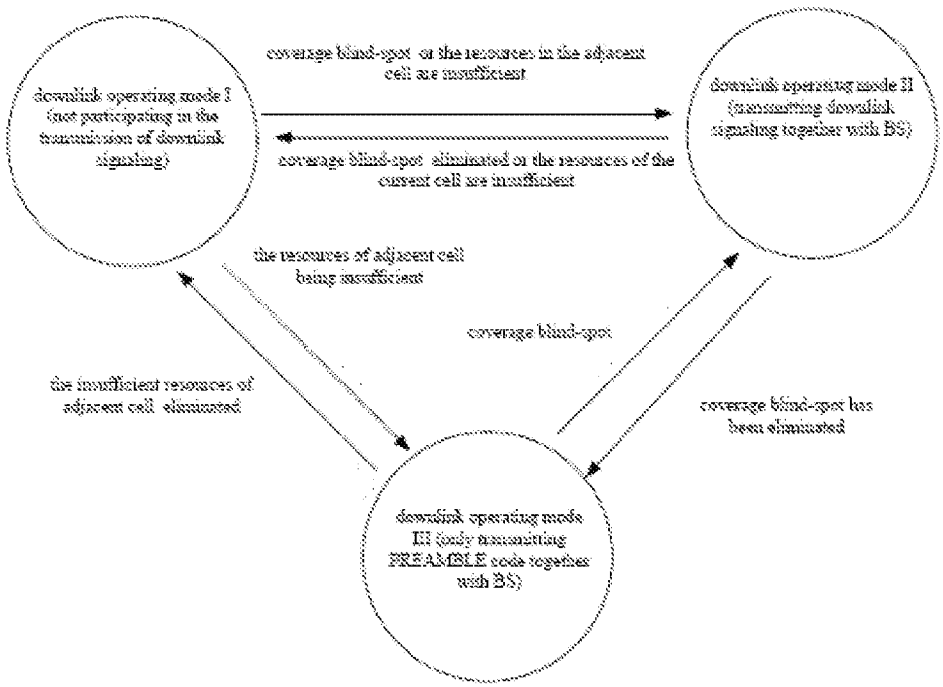

downlink operating mode I (not participating in the transmission of downlink signaling)
coverage blind-spot or the resources in the adjacent cell are insufficient
coverage blind-spot eliminated or the resources of the current cell are insufficient
downlink operating mode II (transmitting downlink signaling together with BS)
the resources of adjacent cell being insufficient
coverage blind-spot
the insufficient resources of adjacent cell eliminated
coverage blind-spot has been eliminated
downlink operating mode III (only transmitting PREAMBLE code together with BS)

Fig 6

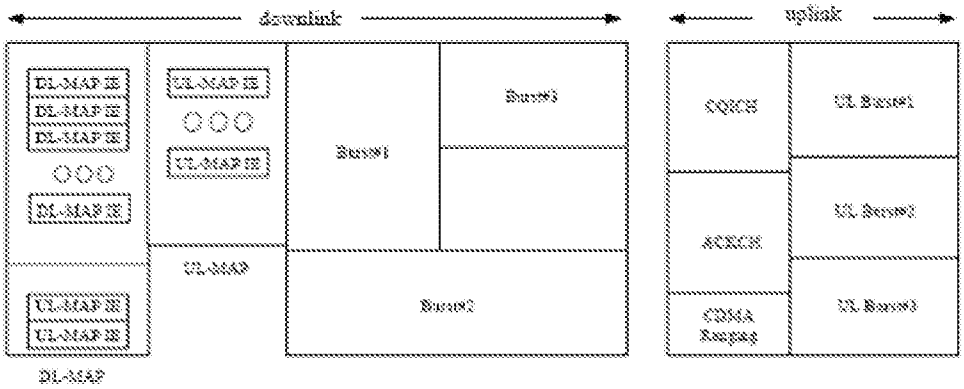

downlink
uplink
DL-MAP IE
DL-MAP IE
DL-MAP IE
DL-MAP IE
UL-MAP IE
UL-MAP IE
Burst3
Burst1
DL-MAP
Burst2
UL-MAP IE
UL-MAP IE
DL-MAP
CQICH
ACKCH
CDMA Ranging
UL Burst1
UL Burst2
UL Burst3

Fig 7

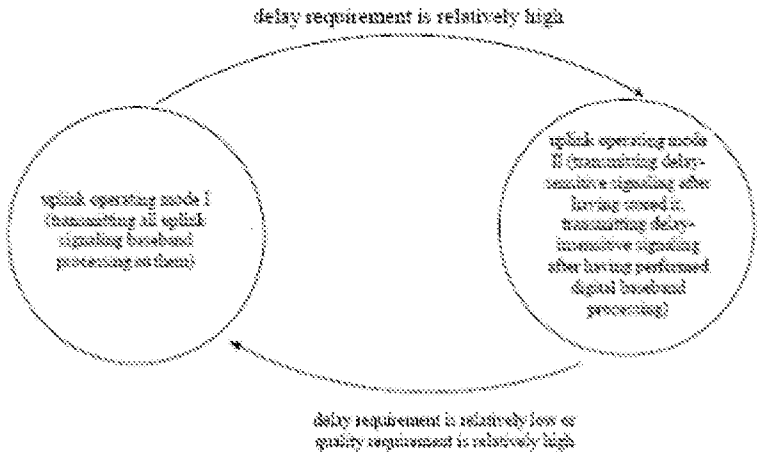

delay requirement is relatively high
uplink operating mode I (transmitting all uplink signaling baseband processing on them)
uplink operating mode II (transmitting delay-sensitive signaling after having stored it, transmitting delay-insensitive signaling after having performed digital baseband processing)
delay requirement is relatively low or quality requirement is relatively high

Fig 8

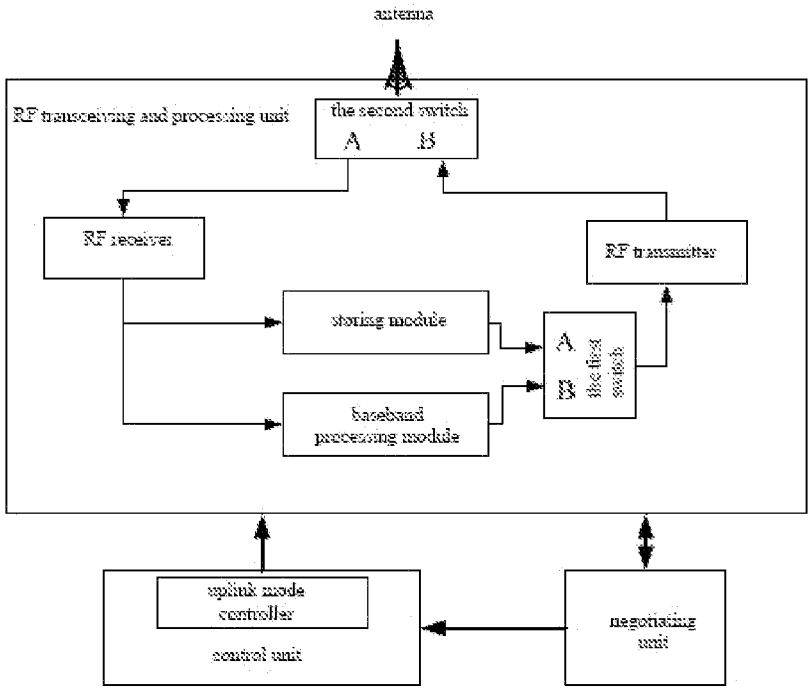

antenna
RF transceiving and processing unit
the second switch
A
B
RF receiver
RF transmitter
storing module
baseband processing module
A
B
the first switch
uplink mode controller
control unit
negotiating unit

Fig 9a

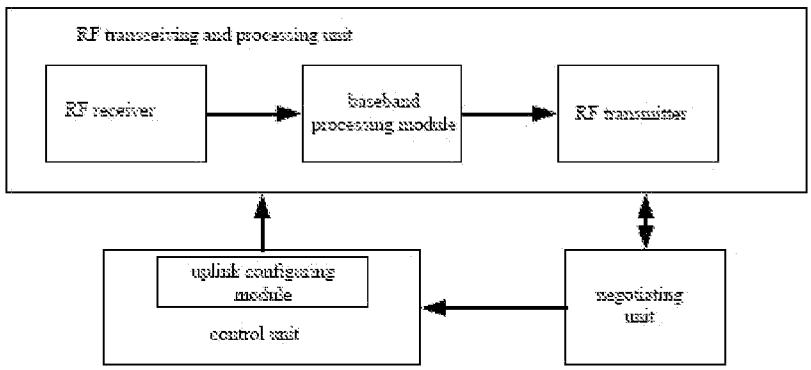

RF transceiving and processing unit
RF receiver
baseband processing module
RF transmitter
uplink configuring module
control unit
negotiating unit

Fig 9b

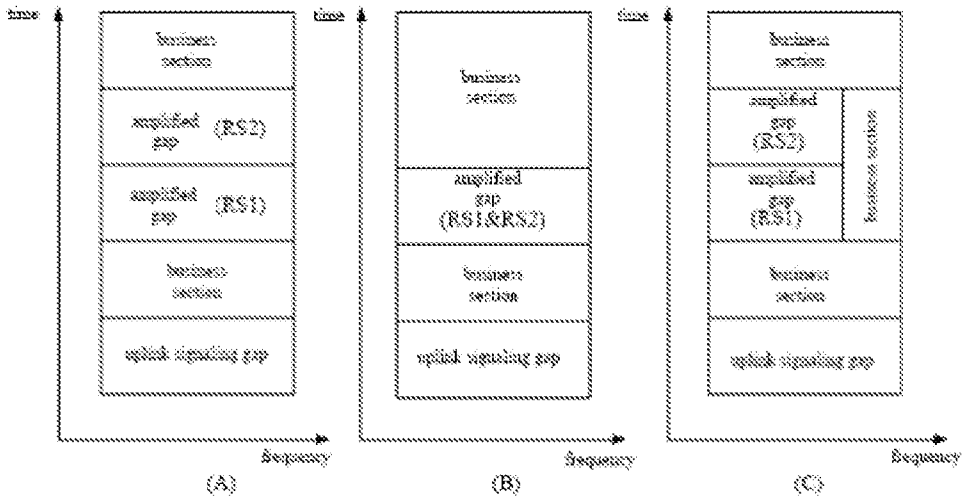

time
business section
amplified gap (RS2)
amplified gap (RS1)
business section
uplink signaling gap
frequency
(A)
time
business section
amplified gap (RS1&RS2)
business section
uplink signaling gap
frequency
(B)
time
business section
amplified gap (RS2)
amplified gap (RS1)
business section
business section
uplink signaling gap
frequency
(C)

Fig 10

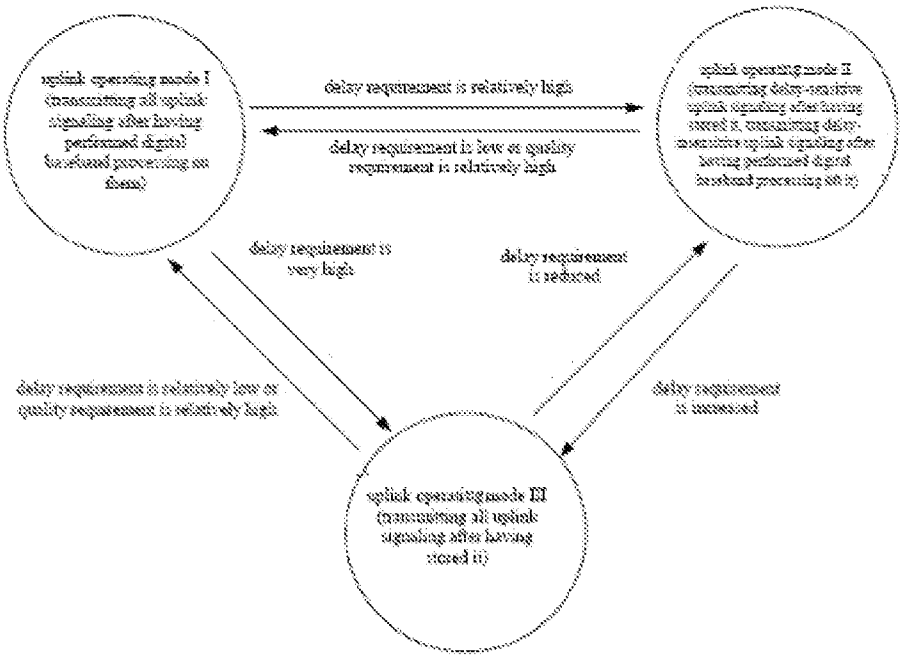

uplink operating mode I (transmitting all uplink signaling after having performed digital baseband processing on them)
delay requirement is relatively high
delay requirement is low or quality requirement is relatively high
uplink operating mode II (transmitting delay-sensitive uplink signaling after having stored it, transmitting delay-insensitive uplink signaling after having performed digital baseband processing on it)
delay requirement is very high
delay requirement is reduced
delay requirement is relatively low or quality requirement is relatively high
delay requirement is increased
uplink operating mode III (transmitting all uplink signaling after having stored it)

Fig 11

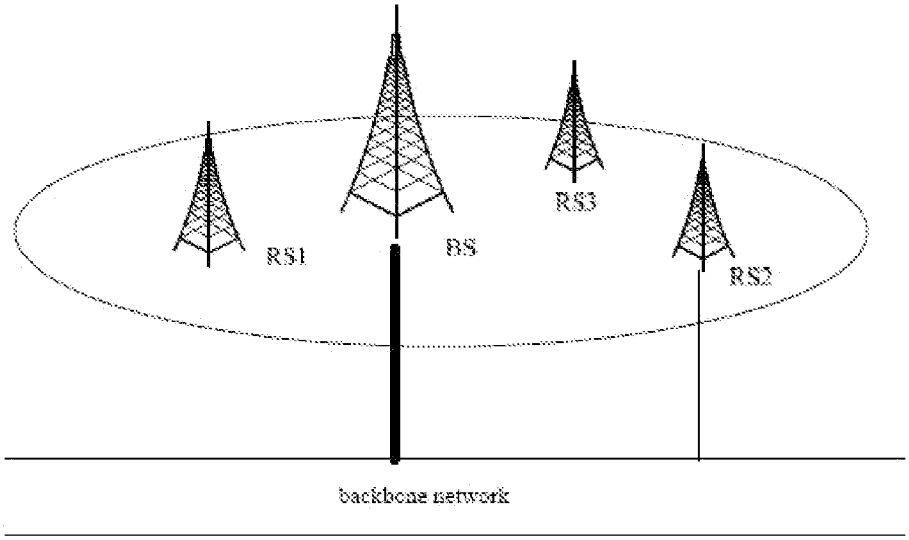


Fig 12

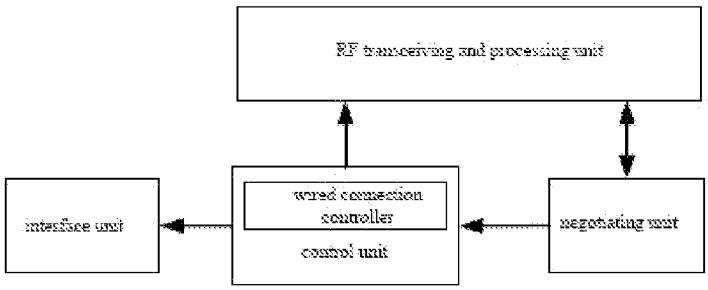


Fig 13a

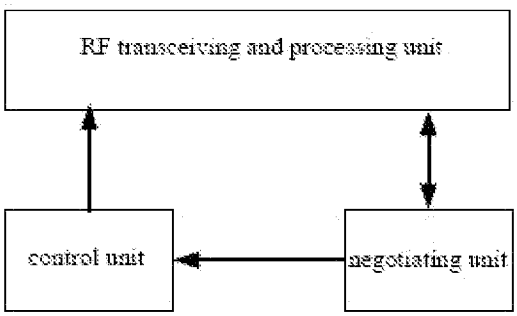

RF transceiving and processing unit
control unit
negotiating unit

Fig 13b