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(54) **SYSTEM AND METHOD FOR CHANNEL STATE INFORMATION TRANSMISSION ON LTE DUAL CONNECTIVITY**

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(57) **ABSTRACT**

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The present invention relates to a way of reporting a wireless channel state of a base station and a terminal. That is, the present invention relates to a system and a method for channel state information transmission on LTE dual connectivity which transmits reliable wireless data transmission by reporting wireless channel states of base stations and terminals. The system for channel state information transmission on LTE dual connectivity includes a terminal that allocates a radio resource to a terminal and performs data communication with the terminal and a sub-base station that performs data communication with the terminal simultaneously with the main base station.

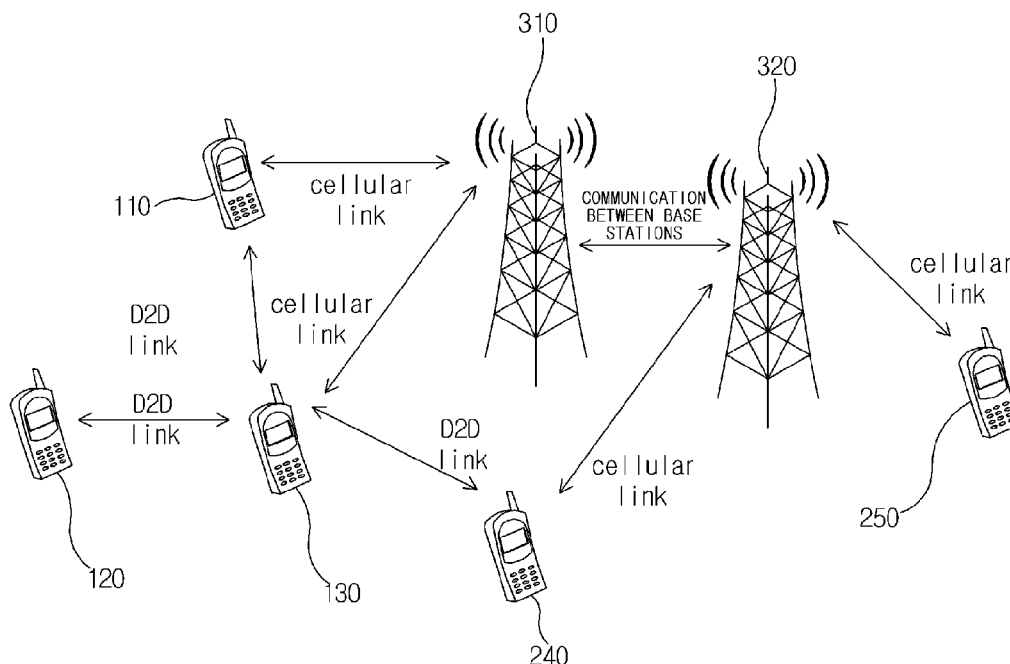


FIG. 1

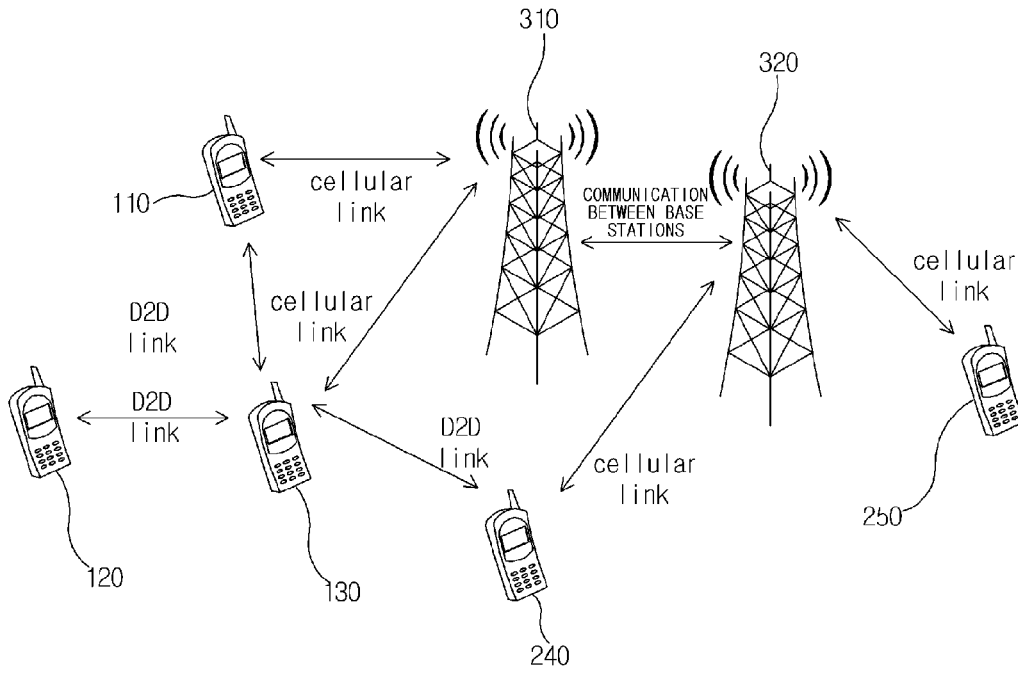


FIG. 2

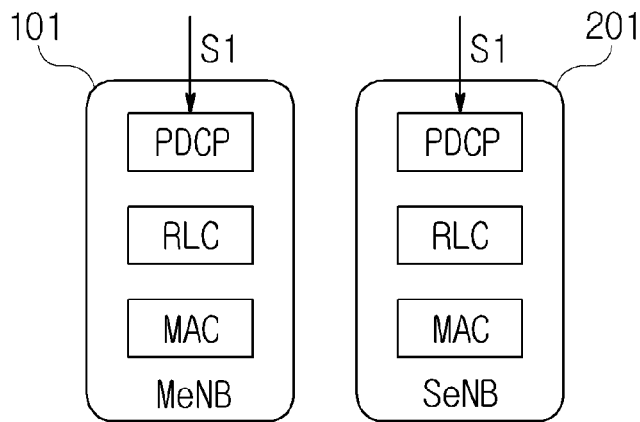


FIG. 3

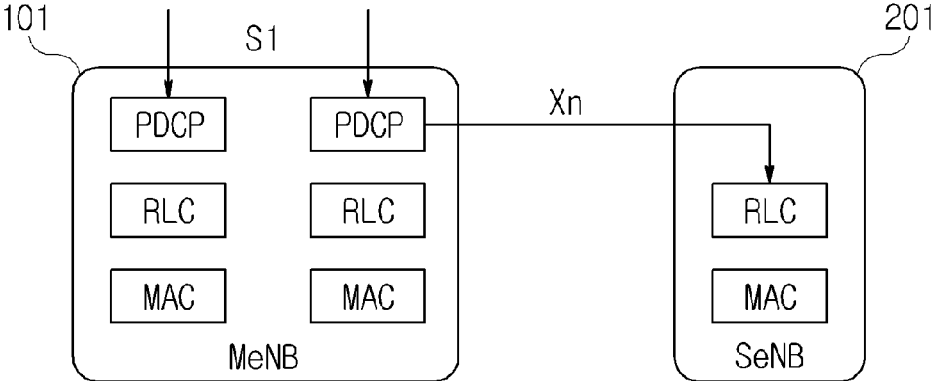


FIG. 4

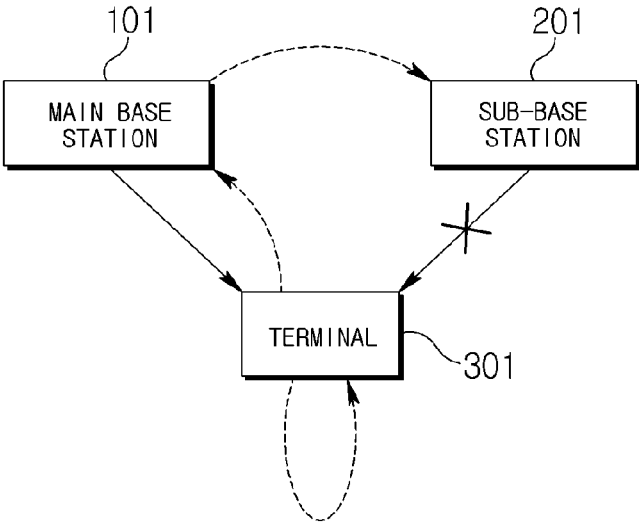


FIG. 5

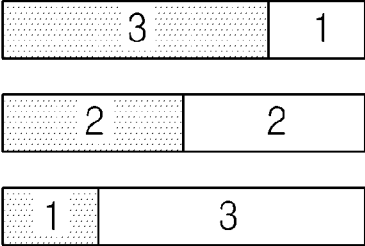
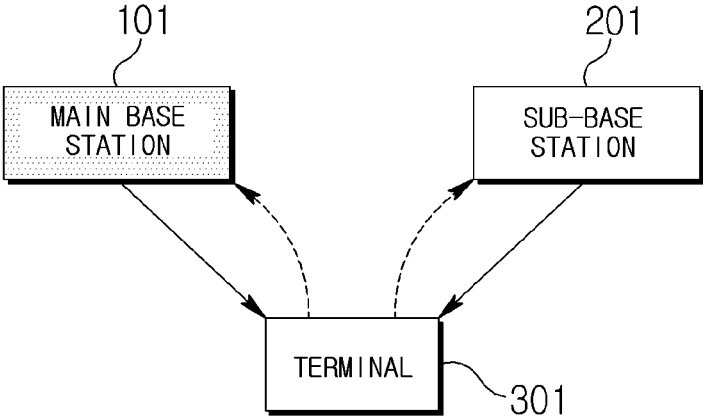


FIG. 6

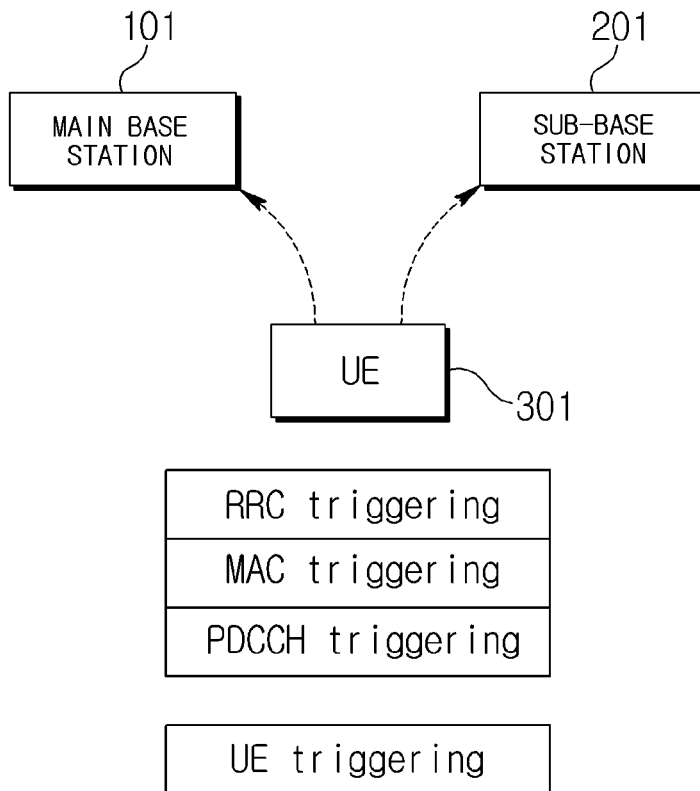


FIG. 7

MIMO: Multiple Input Multiple Output  
QoE: Quality of Experience  
OFDMA: Orthogonal Frequency Division Multiple Access  
TXOP: Transmission Opportunity  
EDCA: Enhanced Distributed Channel Access  
ARQ: Automatic request  
D2D: Device to Device

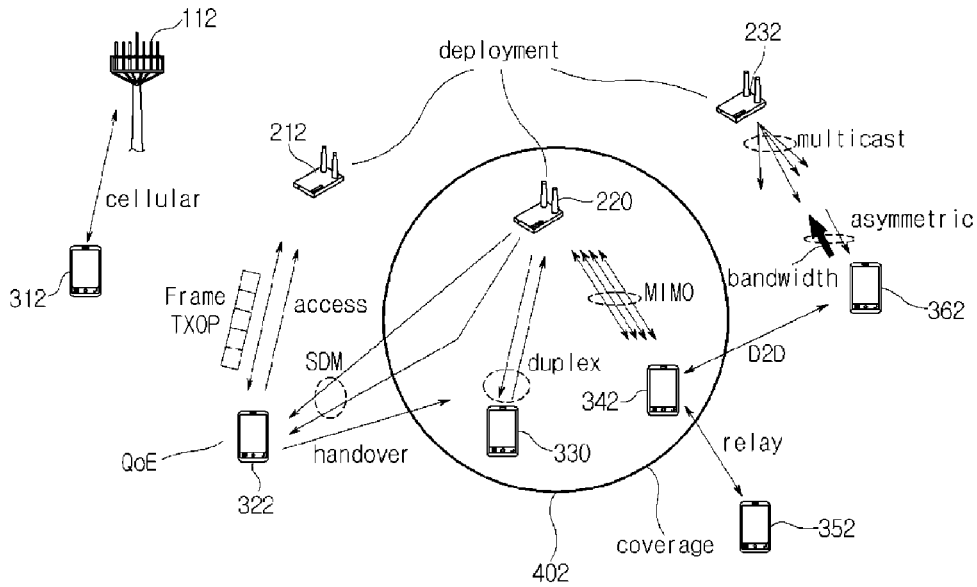


FIG. 8

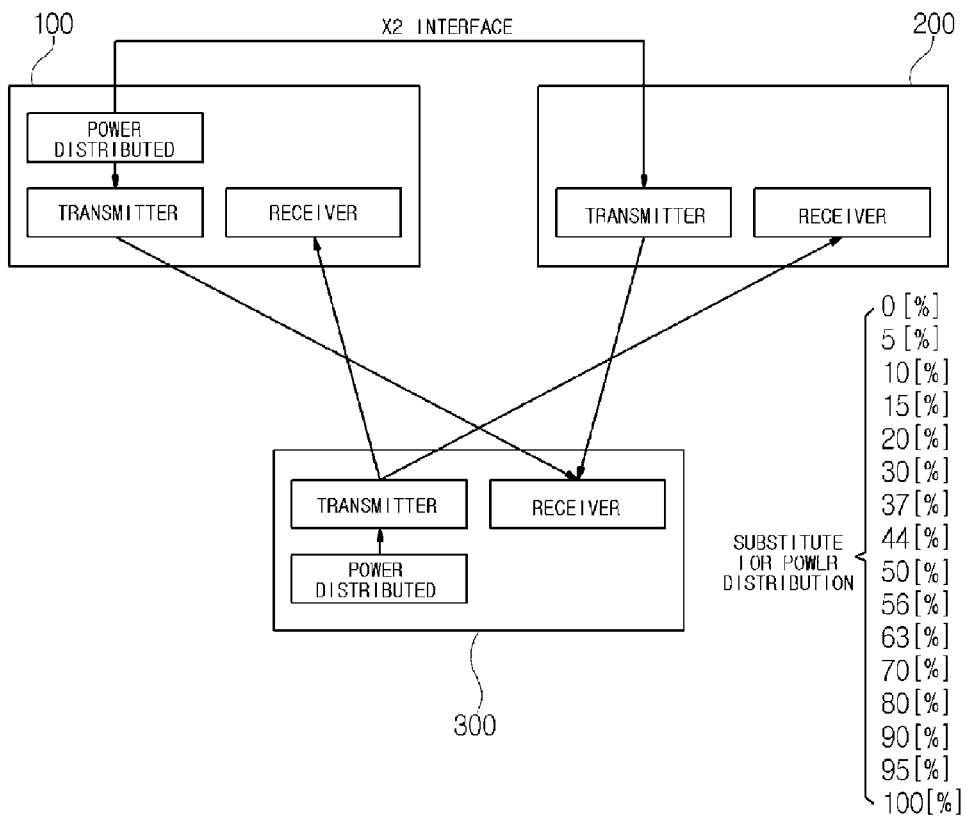


FIG. 9

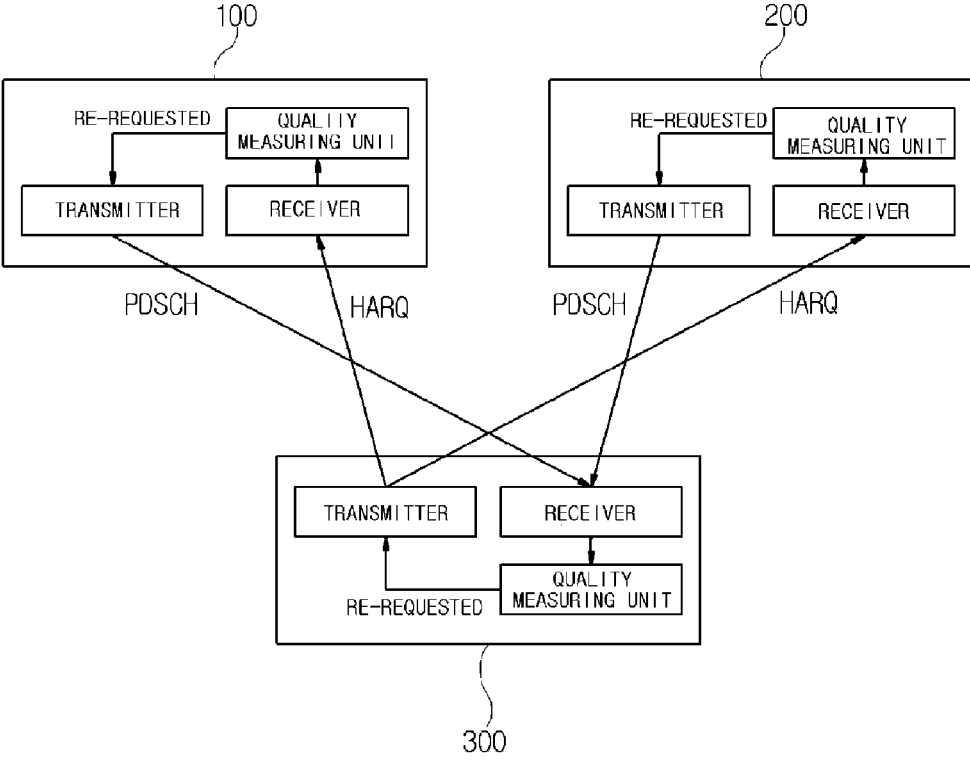




FIG. 10

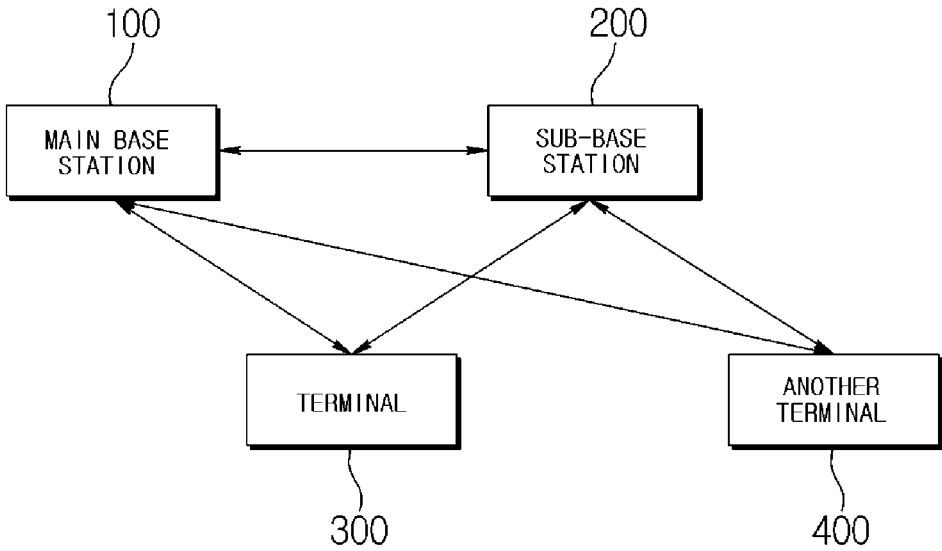


FIG. 11

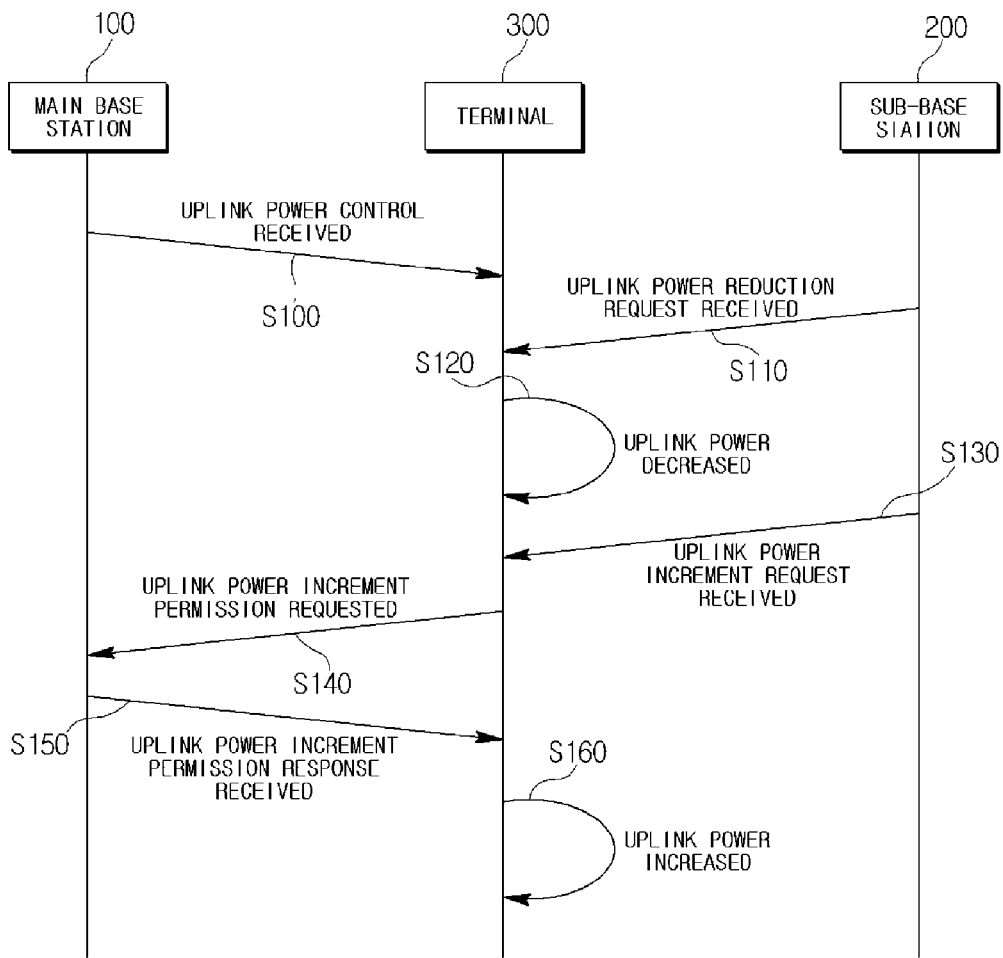


FIG. 12

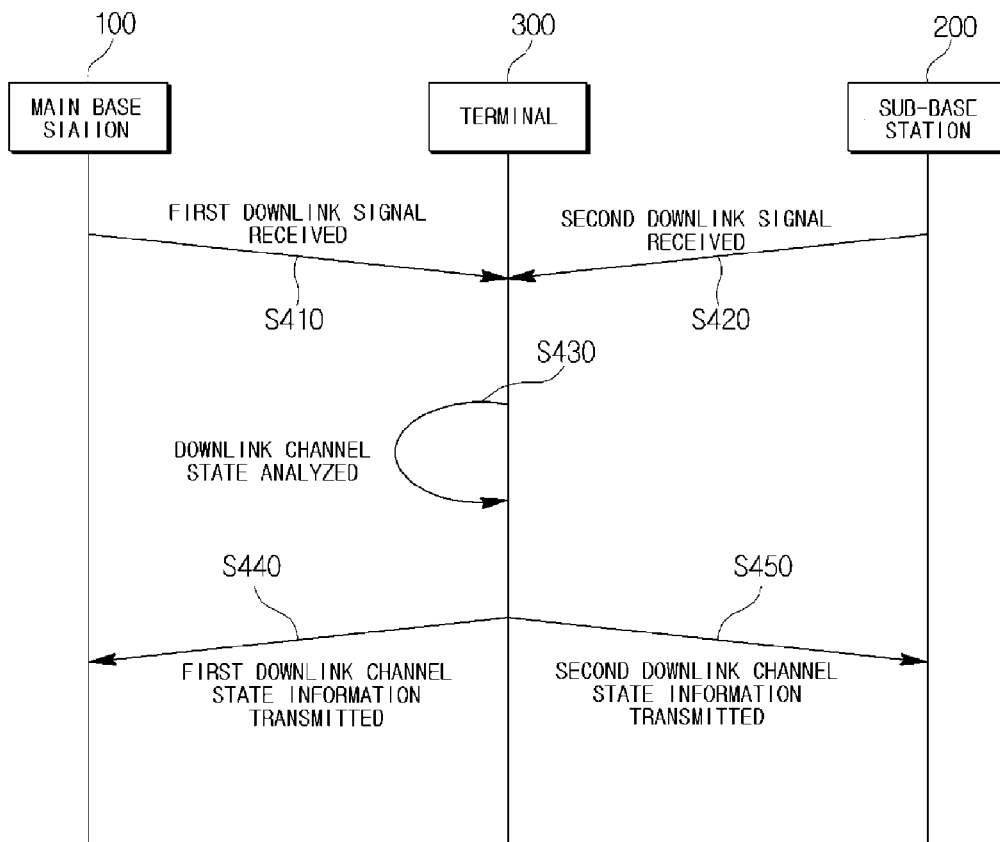


FIG. 13

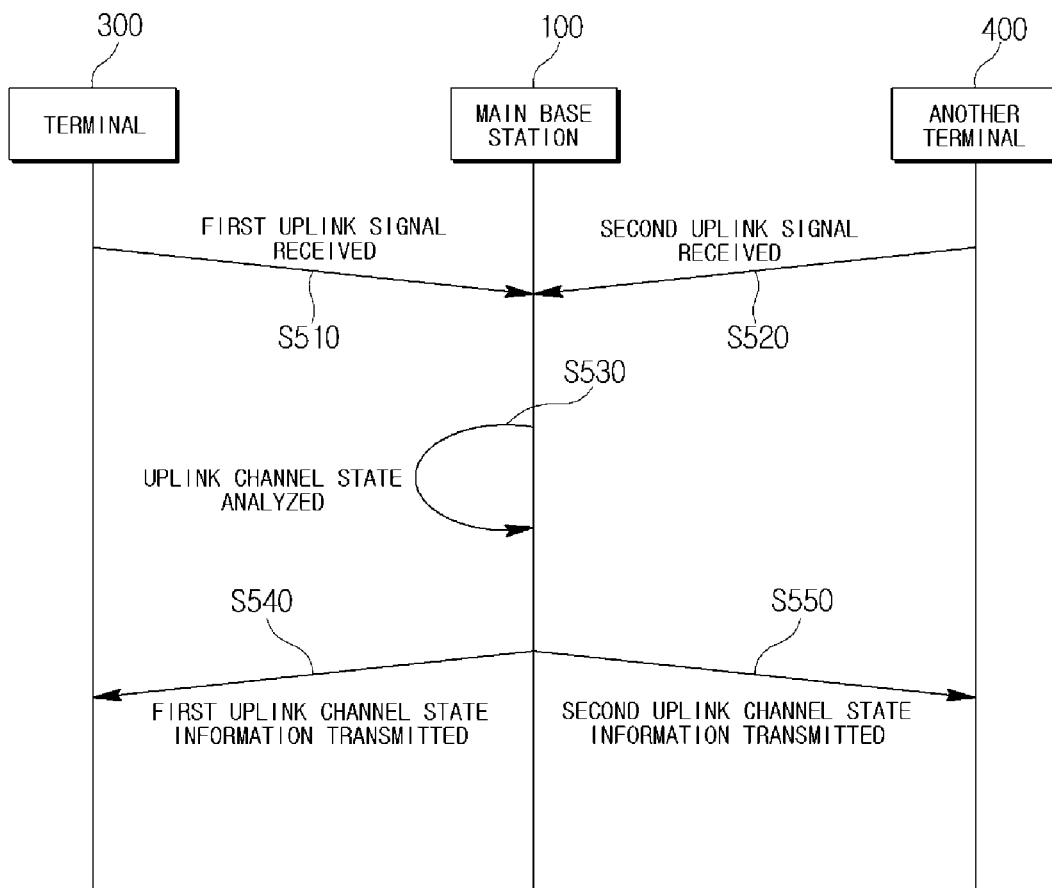


FIG. 14

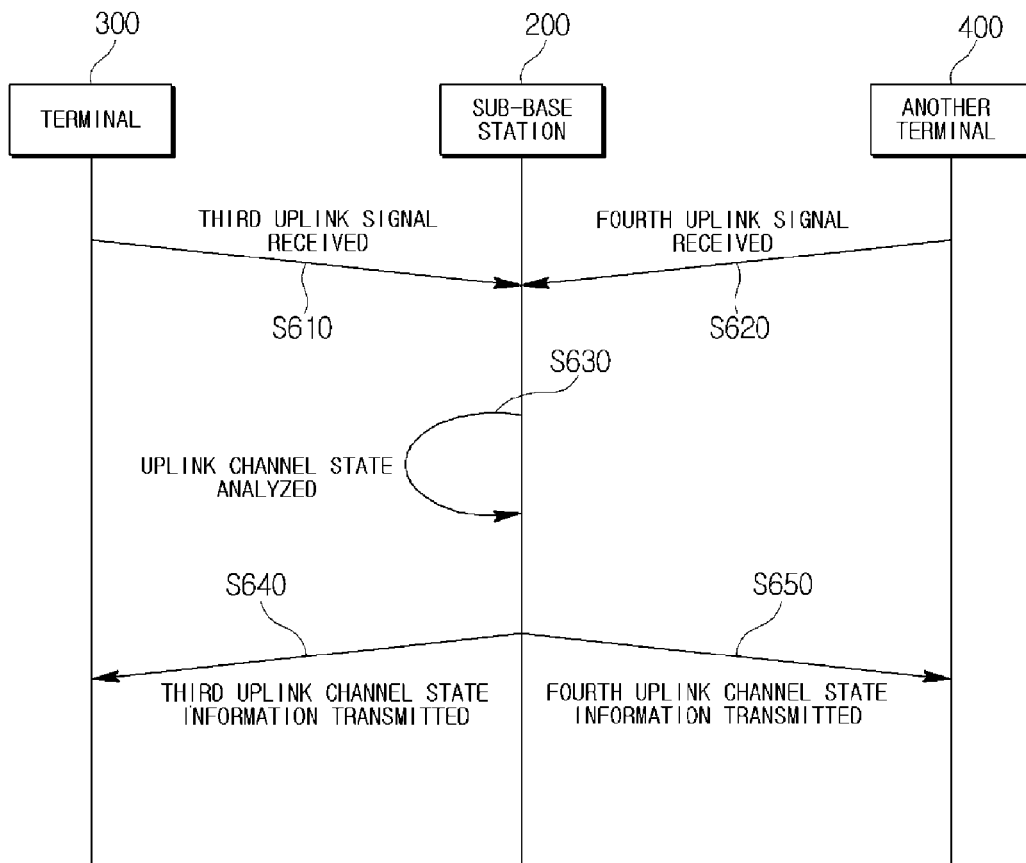
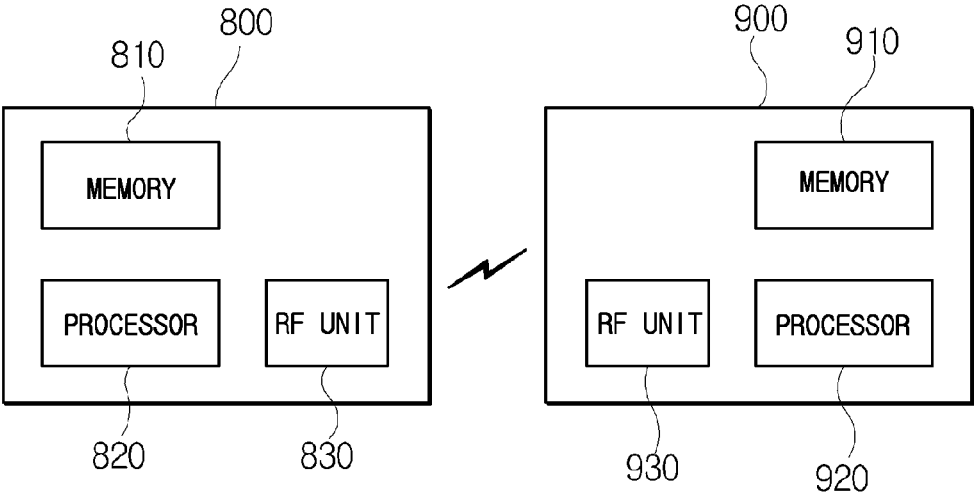


FIG. 15



## SYSTEM AND METHOD FOR CHANNEL STATE INFORMATION TRANSMISSION ON LTE DUAL CONNECTIVITY

### BACKGROUND OF THE INVENTION

#### [0001] 1. Field of the Invention

[0002] Exemplary embodiments of the present invention relate to a system and a method for channel state information transmission on LTE dual connectivity, and more particularly, to reporting a wireless channel state of a base station and a terminal. That is, exemplary embodiments of the present invention relate to a system and a method for channel state information transmission on LTE connectivity which performs reliable wireless data transmission by reporting wireless channel states of base stations and terminals.

#### [0003] 2. Description of the Related Art

[0004] A dual connectivity technique has been introduced as one of cell planning techniques for distributing excessive cellular load or load requiring specific QoS in small cell without a process of handover and efficiently transmitting data in a heterogeneous network environment.

[0005] For terminals, the dual connectivity may be a technique for providing a more efficient way in terms of transmission/reception rates. For example, a terminal can transmit/receive a service to/from two or more serving cells and the serving cells may pertain to different base stations.

[0006] A terminal can simultaneously access or use a macrocell and a small cell in an overlap area within the coverage of both of the macrocell and the small cell.

[0007] That is, on the basis of dual connectivity technique, a terminal may transmit/receive services through wireless communication with two or more different base stations at the different frequency bands. Alternatively, a terminal may transmit/receive services through wireless communication with two or more different base stations at the same frequency bands, so it has been studied.

[0008] For example, in Korean Patent Application Publication No. 10-2014-0123446, there are provided a method and an apparatus for a terminal, which constitutes dual connectivity with a plurality of base stations, to transmit/receive uplink and downlink traffics through a plurality of carriers. The method includes receiving signaling of an upper layer including information for defining dual connectivity with a first base station and a second base station, defining dual connectivity with the first base station and the second base station on the basis of the signaling of an upper layer, and submitting PDCP PDU for each of one or more radio bearers to an RLC object peered in the second base station on the basis of the signaling of an upper layer by a PDCP object.

[0009] For dual connective communication with a plurality of base stations, it is required to set appropriate control for each channel by checking the communication channel state between a terminal and two or more base stations. Accordingly, it has been required to develop a plan for processing channel state information in order to achieve resource-efficient dual connective communication and control.

### DOCUMENTS OF RELATED ART

#### Patent Document

[0010] Korean Patent Application Publication No. 10-2014-0123446 (Oct. 22, 2014)

### SUMMARY OF THE INVENTION

[0011] An object of the present invention is to provide a system and a method for channel state information transmission on LTE dual connectivity, which report a wireless channel state of a base station and a terminal.

[0012] Another object of the present invention is to provide a system and a method for channel state information transmission on LTE dual connectivity, which report a wireless channel state simultaneously to two base stations by reporting a wireless channel state of a base station and a terminal and performing reliable wireless data transmission.

[0013] In accordance with one aspect of the present invention, a device for communication with a plurality of base stations includes: an RF unit that transmits and receives radio signals; and a processor that is connected with the RF unit, in which the processor performs data communication simultaneously with a main base station allocating a radio resource to the device and a sub-base station and determines whether the data communication between the main base station and the sub-base station connected to the main base station is performed in a synchronized mode or a non-synchronized mode.

[0014] The processor may determine at least any one of the case when the difference in transmission delay of data from the main base station and the sub-base station is within a predetermined range, the case when there is no interference between data from the main base station and the sub-base station, and the case when it operates as a TDD, as a synchronized mode.

[0015] The processor may determine it as a non-synchronized mode, when interference is periodically generated in the main base station and the sub-base station.

[0016] In accordance with another aspect of the present invention, a method of controlling power of a terminal communicating with a plurality of base stations includes: an uplink power control reception step of receiving an uplink power control of a terminal from a main base station by means of the terminal; an uplink power increment request reception step of receiving an uplink power increment request of the terminal from a sub-base station by means of the terminal; an uplink power increment permission request step of requesting the main base station to permit uplink power increment of the terminal; an uplink power increment permission response reception step of receiving a response to the uplink power increment permission request step from the main base station by means of the terminal; and an uplink power increment step of increasing uplink power of the terminal on the basis of the uplink power control in the uplink power increment permission response reception step and the uplink power increment request reception step.

[0017] The method may further include: an uplink power reduction request reception step of receiving an uplink power reduction request of the terminal from the sub-base station; and an uplink power reduction step of reducing uplink power of the terminal on the basis of the uplink power control in the uplink power control reception step and the uplink power reduction request reception step.

[0018] In accordance with another aspect of the present invention, a method of channel state information transmission of a plurality of base stations includes: a first downlink signal reception step of receiving a first downlink signal from a main base station by means of a terminal; a second downlink signal reception step of receiving a second downlink signal from a sub-base station by means of the terminal; a downlink channel state analysis step of analyzing downlink channel

states of the first downlink signal received in the first downlink signal reception step and the second downlink signal received in the second downlink signal reception step; a first downlink channel state information transmission step of transmitting first downlink channel state information analyzed on the basis of the first downlink signal reception in the downlink channel state analysis step to the main base station; and a second downlink channel state information transmission step of transmitting second downlink channel state information analyzed on the basis of the second downlink signal reception in the downlink channel state analysis step to the sub-base station.

**[0019]** In the first downlink channel state information transmission step, the first downlink channel state information may be transmitted to the main base station in higher priority than the second downlink channel state information transmission step.

**[0020]** Further, in the second downlink channel state information transmission step, when the second downlink channel state information transmission step has lower priority than the first downlink channel state information transmission step and has insufficient channels for transmitting the second downlink channel state information to the sub-base station, at least one of the terminal and the sub-base station may request the main base station to additionally secure five or more channels to be able to transmit the second downlink channel state information, so the second downlink channel state information may be transmitted to the sub-base station.

**[0021]** In accordance with another aspect of the present invention, a method of channel state information transmission of a plurality of base stations includes: a first uplink signal reception step of receiving a first uplink signal of a first terminal by means of a main base station; a second uplink signal reception step of receiving a second uplink signal of a second terminal after the first uplink signal by means of the main base station; an uplink channel state analysis step of analyzing the uplink channel states of the first uplink signal received in the first uplink signal reception step and the second uplink signal received in the second uplink signal reception step; a first uplink channel state information transmission step of transmitting first uplink channel state information analyzed on the basis of the reception of the first uplink signal in the uplink channel state analysis step to the first terminal; and a second uplink channel state information transmission step of transmitting second uplink channel state information analyzed on the basis of the reception of the second uplink signal in the uplink channel state analysis step to the second terminal.

**[0022]** In the first uplink channel state information transmission step, the first uplink channel state information may be transmitted to the first terminal in higher priority than the second uplink channel state information transmission step.

**[0023]** Further, in the second uplink channel state information transmission step, when the second uplink channel state information transmission step has lower priority than the first uplink channel state information transmission step and channels for transmitting the second uplink channel state information to the second terminal are insufficient, the second uplink channel state information transmission step may transmit the second uplink channel state information to the second terminal by additionally securing five or more channels to be able to transmit the second uplink channel state information.

**[0024]** In accordance with another aspect of the present invention, a method of channel state information transmis-

sion of a plurality of base stations includes: a third uplink signal reception step of receiving a third uplink signal of a first terminal by means of a sub-base station; a fourth uplink signal reception step of receiving a fourth uplink signal of a second terminal after the third uplink signal by means of the main base station; an uplink channel state analysis step of analyzing the uplink channel states of the third uplink signal received in the third uplink signal reception step and the fourth uplink signal received in the fourth uplink signal reception step; a third uplink channel state information transmission step of transmitting third uplink channel state information analyzed on the basis of the reception of the third uplink signal in the uplink channel state analysis step to the first terminal; and a fourth uplink channel state information transmission step of transmitting fourth uplink channel state information analyzed on the basis of the reception of the fourth uplink signal in the uplink channel state analysis step to the second terminal.

**[0025]** In the third uplink channel state information transmission step, the third uplink channel state information may be transmitted to the first terminal in higher priority than the fourth uplink channel state information transmission step.

**[0026]** Further, in the fourth uplink channel state information transmission step, when the fourth uplink channel state information transmission step has lower priority than the third uplink channel state information transmission step and has insufficient channels for transmitting the fourth uplink channel state information to the second terminal, at least one of the second terminal and the sub-base station may request the main base station to additionally secure five or more channels to be able to transmit the fourth downlink channel state information, so the fourth downlink channel state information may be transmitted to the second terminal.

**[0027]** According to a system and a method for channel state information transmission on LTE dual connectivity of the present invention, it is possible to report a wireless channel state of a base station and a terminal.

**[0028]** According to a system and a method for channel state information transmission on LTE dual connectivity of the present invention, it is possible to report a wireless channel state simultaneously to two base stations by performing reliable wireless data transmission by reporting a wireless channels state of a base station and a terminal.

**[0029]** It is to be understood that both the foregoing general description and the following detailed description of the present invention are exemplary and explanatory and are intended to provide further explanation of the invention as claimed.

#### BRIEF DESCRIPTION OF THE DRAWINGS

**[0030]** The above and other objects, features and other advantages of the present invention will be more clearly understood from the following detailed description taken in conjunction with the accompanying drawings, in which:

**[0031]** FIG. 1 is a diagram illustrating the configuration of an LTE network according to an exemplary embodiment of the present invention;

**[0032]** FIG. 2 is a diagram illustrating the configuration of dual connectivity when a first base station of FIG. 1 operates as a main base station and a second base station operates independently as a sub-base station;

**[0033]** FIG. 3 is a diagram illustrating the configuration of dual connectivity when the first base station of FIG. 1 operates as a main base station, the second base station operates as



a sub-base station, and data is separated and combined through the main base station;

**[0034]** FIG. 4 is a diagram illustrating a configuration in detail when the sub-base station of FIGS. 2 and 3 is disconnected from a terminal;

**[0035]** FIG. 5 is a diagram illustrating a configuration in detail when transmission power for a terminal is allocated to the main base station or the sub-base station of FIGS. 2 and 3;

**[0036]** FIG. 6 is a diagram illustrating a configuration in detail when a terminal randomly accesses the main base station or the sub-base station of FIGS. 2 and 3;

**[0037]** FIG. 7 is a diagram illustrating a method of increasing the performance of a terminal in an area concentrated with small cell base stations according to another exemplary embodiment of the present invention;

**[0038]** FIG. 8 is a diagram illustrating the configuration of a system for channel state information transmission on LTE dual connectivity according to another exemplary embodiment of the present invention;

**[0039]** FIG. 9 is a diagram illustrating the configuration of a system for priority data transmission on LTE dual connectivity according to another exemplary embodiment of the present invention;

**[0040]** FIG. 10 is a diagram illustrating the configuration of a system for channel state information transmission on LTE dual connectivity according to another exemplary embodiment of the present invention;

**[0041]** FIG. 11 is a timing diagram illustrating a method of controlling power of a terminal communicating with a plurality of base stations on LTE dual connectivity according to another exemplary embodiment of the present invention;

**[0042]** FIG. 12 is a timing diagram illustrating a method of channel state information transmission on LTE dual connectivity according to another exemplary embodiment of the present invention;

**[0043]** FIG. 13 is a timing diagram illustrating a method of channel state information transmission on LTE dual connectivity according to another exemplary embodiment of the present invention;

**[0044]** FIG. 14 is a timing diagram illustrating a method of channel state information transmission on LTE dual connectivity according to another exemplary embodiment of the present invention; and

**[0045]** FIG. 15 is a block diagram illustrating a wireless communication system for which exemplary embodiments of the present invention can be achieved

#### DESCRIPTION OF SPECIFIC EMBODIMENTS

**[0046]** Detailed exemplary embodiments of the present invention will be described with reference to the accompanying drawings.

**[0047]** The present invention may be modified in various ways and implemented by various exemplary embodiments, so that specific exemplary embodiments are illustrated in the drawings and will be described in detail below. However, it is to be understood that the present invention is not limited to the specific exemplary embodiments, but includes all modifications, equivalents, and substitutions included in the spirit and the scope of the present invention.

**[0048]** Hereinafter, a system and a method for channel state information transmission on LTE dual connectivity according to the present invention will be described in detail with reference to the accompanying drawings.

**[0049]** FIG. 1 is a diagram illustrating the configuration of an LTE network according to an exemplary embodiment of the present invention and FIGS. 2 to 6 are diagrams illustrating the configuration of FIG. 1 in detail.

**[0050]** A system for channel state information transmission in LTE dual connectivity according to an exemplary embodiment of the present invention is described hereafter with reference to FIGS. 1 to 6.

**[0051]** Referring to FIG. 1 first, an LTE network structure according to an exemplary embodiment of the present invention is composed of base stations and terminals. In particular, new frequencies can be allocated and used for inter-terminal communication, when a macrocell and a D2D channel are specifically allocated.

**[0052]** When a macrocell and a D2D channel are both allocated, inter-terminal communication may be achieved by at least any one of adding a sub-channel and using the physical channel used by the macrocell, and at least any one of a channel allocation scheme, a channel management scheme, and a duplexing method may be used for interference between the macrocell and the D2D channel.

**[0053]** Further, synchronization between terminals may be provided from at least any one of an uplink, a downlink, and both of an uplink and a downlink.

**[0054]** In the LTE network structure, in detail, a first terminal 110 and a third terminal 130 are in the cellular link coverage of a first base station 310, and a fourth terminal 240 and a fifth terminal 250 are in the cellular link coverage of a second base station 320.

**[0055]** The third terminal 130 is positioned at a distance where D2D communication with the first terminal 110, the second terminal 120, and the fourth terminal 240 is available. The D2D link of the third terminal 130 and the first terminal 110 is in the same first base station 310, the D2D link of the third terminal 130 and the fourth terminal 240 is on another cellular coverage, the D2D link of the third terminal 130 and the second terminal 120 is formed by the second terminal 120 not positioned in any cellular coverage and the third terminal 130 positioned in the cellular coverage of the first base station 310.

**[0056]** The cellular link channel used between the first base station 310 and the third terminal 130 and the D2D link channel used by the third terminal 130 and the fourth terminal 240 may be separately or simultaneously allocated.

**[0057]** For example, when the cellular link channel used between the first base station 310 and the third terminal 130 and the D2D link channel used by the third terminal 130 and the fourth terminal 240 use the same frequency, OFDM symbols of PDSCH, PDCCH, PUSCH, and PUCCH may be separately allocated.

**[0058]** In particular, the first base station 310 can carry out an allocation schedule of time slots for transmitting a synchronization signal, a discovery signal, and an HARQ for the D2D link channel used by the third terminal 130 and the fourth terminal 240.

**[0059]** The synchronization signal transmitted by the first base station 310 may be used simultaneously with the information about the cellular link of the first base station 310, but the time slots for transmitting a synchronization signal, a discovery signal, and an HARQ for the third terminal 130 and the fourth terminal 240 may be scheduled not to overlap the time slots of the cellular link channels used between the first base station 310 and the third terminal 130.

[0060] When the cellular link channel used between the first base station 310 and the third terminal 130 and the D2D link channel used by the third terminal 130 and the fourth terminal 240 use different frequencies, the third terminal 130 and the fourth terminal 240 can exclusively use the OFDM symbols of PDSCH, PDCCH, PUSCH, and PUCCH, and the third terminal 130 or the fourth terminal 240 can perform scheduling.

[0061] D2D communication between the third terminal 130 and the fourth terminal 240 is performed, avoiding interference influenced by the first base station 310 and the first terminal 110. In particular, in the D2D communication between the third terminal 130 and the fourth terminal 240, the third terminal 130 uses any one of a way of transmitting a synchronization signal received from the first base station 310 to the fourth terminal 240 through the uplink channel used by the first base station 310, a way of transmitting the synchronization signal to the fourth terminal 240 through the downlink channel used by the first base station 310, and a way of transmitting the synchronization signal to the fourth terminal 240 through both of the uplink and downlink channels used by the first base station 310.

[0062] FIG. 2 is a diagram illustrating a configuration of dual connectivity when the first base station 310 of FIG. 1 operates as a main base station 101 and the second base station 320 operates independently as a sub-base station 201.

[0063] The main base station 101 (master eNB) and the sub-base station 201 (secondary eNB), which are used for dual connectivity, are individually connected with a core network.

[0064] Accordingly, all of protocols are independent from the main base station 101 and the sub-base station 201, and particularly, data to be transmitted to two base stations is not separated and combined at the base stations.

[0065] A PDCP (Packet Data Convergence Protocol) is one of wireless traffic protocol stacks in LTE which compresses and decompresses an IP header, transmits user data, and keeps a sequence number for a radio bearer.

[0066] RLC (Radio Link Control) is a protocol stack of controlling wireless connection between the PDCP and MAC.

[0067] MAC (Media Access Control) is a protocol stack supporting multi access on a wireless channel.

[0068] FIG. 3 is a diagram illustrating a configuration of dual connectivity when the first base station 310 of FIG. 1 operates as a main base station 101, the second base station 320 operates as a sub-base station 201, and data is separated and combined through the main base station 101.

[0069] That is, when the main base station 101 and the sub-base station 201, which are used for dual connectivity, are connected with a core network, only the main base station 101 is connected with the core network and the sub-base station 201 is connected with the core network through the main base station 101.

[0070] Accordingly, data transmitted/received on the core network is separated and combined by the main base station 101. That is, data separated from the main base station 101 is transmitted to the sub-base station 201 or data received from the sub-base station 201 is combined and transmitted/received on the core network.

[0071] FIG. 4 is a diagram illustrating a configuration in detail when the sub-base station 201 of FIGS. 2 and 3 is disconnected from a terminal 301.

[0072] That is, the system for channel state information transmission on LTE dual connectivity includes the main base station 101 that allocates a radio resource to the terminal 301 and performs data communication with the terminal 301, the sub-base station 201 that performs data communication with the terminal 301 simultaneously with the main base station 101, and the terminal 301 that simultaneously performs data communication with the main base station 101 and the sub-base station 201, and resets radio resource control when it unlinks from the sub-base station 201.

[0073] When the terminal 301 is not normally connected with the sub-base station 201, it informs the main base station 101 of connection state information and the main base station 101 informs the sub-base station 201 of the link state information between the sub-base station 201 and the terminal 301.

[0074] Similarly, when the terminal 301 is abnormally connected with the main base station 101, the terminal 301 resets radio resource control and reports it to the sub-base station 201 and the sub-base station 201 reports the abnormal connection to the main base station 101.

[0075] The communication between the main base station 101 and the sub-base station 201 may be performed by adding information to a frame in an X2 interface or by a broadband network, and when they are not connected by a wire, wireless backhaul may be used for the communication. A signal system including a link state header showing the link state of the main base station 101 and the sub-base station 201, a link state, a base station ID, and a terminal ID may be used for the information in the frame.

[0076] Accordingly, when there is a problem with connection in any one of the main base station 101 and the sub-base station 201, the terminal 301 reports it to any one of the main base station 101 and the sub-base station 201, which has no problem, and the base station receiving the report informs the base station with the problem with connection of the report so that the state of connection with the terminal 301 can be checked.

[0077] On the other hand, when there is a problem with connection in both of the main base station 101 and the sub-base station 201, similarly, the terminal 301 resets the radio resource control to allow for communication with the base stations.

[0078] FIG. 5 is a diagram illustrating a configuration in detail when transmission power for the terminal 301 is allocated to the main base station 101 or the sub-base station 201 of FIGS. 2 and 3.

[0079] That is, the system for channel state information transmission on LTE dual connectivity includes the main base station 101 that allocates a radio resource to the terminal 301 and performs data communication with the terminal 301, the sub-base station 201 that performs data communication with the terminal 301 simultaneously with the main base station 101, and the terminal 301 that sets an upper limit ratio of transmission power for the main base station 101 and the sub-base station 201 on the basis of statistic analysis on power sent out from the main base station 101 and the sub-base station 201.

[0080] The statistic analysis is analyzing a transmission power ratio on the basis of the average power sent out from the terminal 301 to the main base station 101 and the sub-base station 201, and the terminal 301 reports the upper limit ratio of transmission power to the main base station 101 and the sub-base station 201.

[0081] That is, the terminal 301 sets the power ratio to send out to the main base station 101 and the sub-base station 201 on the basis of the average value of the maximum power, which can be sent out by the terminal 301, and the transmission values sent out to the main base station 101 and the sub-base station 201.

[0082] For example, it sets the ratio of power to send out to the main base station 101 and the sub-base station 201 as 3:1, 2:2, and 1:3.

[0083] As another example, when power to be sent is distributed, first, it is very important to maintain connectivity with the main base station 101 or transmit a control signal, so, in order to transmit the signal, power may be allocated to the main base station 101 first and then the remaining power may be distributed for data transmission/reception with the sub-base station 201.

[0084] As another example, the power available for transmitting data to the sub-base station 201 may be dynamically changed. That is, an MCS (Modulation and Coding Scheme) value may depend on the available power, even if the wireless channel does not change.

[0085] A data transmission error may be generated, when the power distribution and the MCS value are simultaneously changed, so that a change of the power distribution and a change of the MCS value may not be simultaneously performed.

[0086] Alternatively, when the power distribution and the MCS value are simultaneously changed, a period of reporting a CQI (Channel Quality Indicator) for changing the MCS, which is a feedback signal system, may be set not to be generated simultaneously with the change of the power distribution, in order to prevent a data transmission error.

[0087] On the other hand, at least any one of the maximum value of a terminal, the ratio of power that is being used, the maximum transmission power for each base station according to a power ratio, and the margin of the maximum power, which can be transmitted to the base stations, to the power currently sent out to the terminal can be reported to the main base station 101 and the sub-base station 201.

[0088] FIG. 6 is a diagram illustrating a configuration in detail when the terminal 301 randomly accesses the main base station 101 or the sub-base station 201 of FIGS. 2 and 3.

[0089] That is, the system for channel state information transmission on LTE dual connectivity includes the main base station 101 that allocates a radio resource to the terminal 301 and performs data communication with the terminal 301, the sub-base station 201 that performs data communication with the terminal 301 simultaneously with the main base station 101, and the terminal 301 that sends out any one of random access to the main base station 101 and the sub-base station 201 by triggering and self random access to them without triggering to at least any one of the main base station 101 and the sub-base station 201.

[0090] The triggering is performed by any one triggering command of PDCCH, MAC, and RRC and the sub-base station 201 includes a base station, which can be accessed first, of base stations that can operate as the sub-base station 201.

[0091] The random access is transmitted in any one type of a preamble without contents, initial access, a radio resource control message, and a terminal ID>

[0092] That is, the random access, which is used for initial access to the main base station 101 or the sub-base station 201, establishment and re-establishment of radio resource

control, and handover, may be sent out to any one of the main base station 101 and the sub-base station 201 or simultaneously to the main base station 101 or the sub-base station 201.

[0093] Random access may be sent out by PDCCH, MAC, and RRC (Radio Resource Control) triggering from the main base station 101 or the sub-base station 201, but it may be sent out by triggering of a terminal itself.

[0094] Further, random access may be sent out by using the remaining power except for the power distributed to an uplink.

[0095] On the other hand, when the main base station 101 or the sub-base station 201 is newly turned on, an error may be generated in data communication due to simultaneous random access of surrounding terminals, including the terminal 301.

[0096] Accordingly, in order to reduce such influence, the terminal 301 may perform random access, additionally using a random time around ten seconds, when the main base station 101 or the sub-base station 201 is newly turned on. The 'ten seconds' is the maximum random access time that is variable in accordance with the number of terminals and the number of base stations and the maximum random access time may be any one in the range of one second to sixty seconds, depending on the environment.

[0097] Meanwhile, since the terminal 301 can use a multi-antenna, it is possible to minimize interference influence by finding the transmission position of the main base station 101 or the sub-base station 201 and performing random access toward the main base station 101 or the sub-base station 201.

[0098] Alternatively, when the exact positions of the main base station 101 and the sub-base station 201 are not found, the terminal 301 may perform random access by sweeping at 360 degrees.

[0099] FIG. 7 is a diagram illustrating a method of increasing the performance of a terminal in an area concentrated with small cell base stations according to another exemplary embodiment of the present invention.

[0100] The method of increasing the performance of a terminal includes at least any one of a cellular interference removal technique that reduces cellular interference between a base station 112 and a terminal 312, a frame rearrangement technique that efficiently uses the frame between a small cell base station 212 and a terminal 322, a TXOP (Transmit Opportunity) technology that schedules a transmission opportunity between the small cell base station 212 and the terminal 322, an efficient access technique that makes a method of accessing the small cell base station 212 from the terminal 322 efficient, an SDM (Spatial Domain Multiplexing) technique that improves the quality of service provided for the terminal 322 by spatially disposing an antenna between a small cell base station 220 and the terminal 322, an efficient handover technique that ensures efficient conversion when the terminal 322 in the service area of the small cell base station 212 enters the service area of the small cell base station 220 and converts small cell base station connection, an efficient duplex technique that uses more efficiently a duplex way between the small cell base station 220 and the terminal 330, an MIMO (Multiple Input Multiple Output) technique that improves data performance of a terminal 342, using several antennas between the small cell base station 220 and the terminal 342, a relay technique in which the terminal 342 within the service range of the small cell base station 220 relays the information about the small cell base station 220 to

a terminal **352** out of the service range of the small cell base station **220**, a D2D (Device to Device) technique that performs direct communication between the terminal **342** and a terminal **362**, an asymmetric technique that efficiently and differently uses the bandwidths of UL and DL between a small cell base station **232** and the terminal **362**, a bandwidth technique that adjusts the bandwidth between the terminal **362** and the small cell base station **232**, and a multicast technique that transmits the same data to common users from the small cell base station **232**.

**[0101]** The small cell base station **220** transmits PSS (Primary Synchronization Signal), PSS/SSS (Secondary Synchronization Signal), CRS (Cell Specific Reference Signal), CSI-RS (Channel State Indicator-Reference Signal), and PRS to the terminal **330**.

**[0102]** Then, PSS, PSS/SSS, CRS, CSI-RS, and PRS signals may be used for measuring time synchronization, frequency synchronization, Cell/TP (Transmission Points) identification, and RSRP (Reference Signal Received Power). CSI-RS is not used for the time synchronization, but RSSI measuring a symbol including/not including a discovery signal is used for measuring RSRQ (Reference Signal Received Power).

**[0103]** The measurement of RSRP and RSRQ may be used in various cases such as muting in a transmitter, and interference removal may be considered in a receiver.

**[0104]** UE can detect several cells by setting DRS for one frequency and may perform RSRP measurement based on CRS and RSRP measurement based on CSI-RS.

**[0105]** FIG. **8** is a diagram illustrating the configuration of a system for channel state information transmission on LTE dual connectivity according to another exemplary embodiment of the present invention. A system for channel state information transmission on LTE dual connectivity includes a main base station **100** that allocates a radio resource to a terminal **300** and performs data communication with the terminal **300** and a sub-base station **200** that performs data communication with the terminal **300** simultaneously with the main base station **100**.

**[0106]** According to an embodiment of the present invention, for simultaneous communication among the main base station **100**, the sub-base station **200**, and the terminal **300**, it is possible to determine a substitute value for power allocation in order to distribute power to the main base station **100** and the sub-base station **200** and the substitute value may be transmitted through RRC signaling.

**[0107]** The RRC signaling value for the power allocation may be expressed by percentage showing the ratio of the transmission power to the maximum power which can be ensured in a cell group. For example, when the RRC signaling value is set to 10%, power of 10% of the available power may be allocated to the sub-base station **200** and power of 90% of the available power may be allocated to the main base station **100**.

**[0108]** Further, for example, the RRC signaling value may be one of 0[%], 2[%], 5[%], 6[%], 8[%], 10[%], 13[%], 16[%], 20[%], 25[%], 32[%], 37[%], 40[%], 50[%], 60[%], 63[%], 68[%], 75[%], 80[%], 84[%], 87[%], 90[%], 92[%], 95[%], 98[%], and 100[%].

**[0109]** Since power control is the most important for high power and low power, it may be possible to take RRC signaling values distributed relatively densely (for example, distribution of 0, 2, 5, 6, and 8[%] or distribution of 100, 98, 95, and 92[%]) for detailed power control, but the RRC signaling

value is not limited to the values described above. In accordance with situations, a percentage between 0 and 100% may be freely selected for the RRC signaling value.

**[0110]** Further, according to an embodiment of the present invention, in order to show a specific number of RRC signaling values in a predetermined bits (for example, 4 bits), the terminal **300** may use sixteen values in the range of 0[%] to 100[%] as the RRC signaling value for the ratio of transmission power to the maximum power available in a cell group. In this case, the terminal **300** may select and use sixteen values of the twenty-six percentages as the RRC signaling value.

**[0111]** In addition, the terminal **300** may use sixteen combinations for showing values in 4 bits in the results of fifteen equal division and twenty equal division of 0 to 100 for the RRC signaling value for the ratio of transmission power to the maximum power available in a cell group.

**[0112]** In detail, as described above, since there is a need for detailed power control for high power and low power, the power ratio may be adjusted in twenty equal division, and the power ratio may be adjusted in fifteen equal division for the middle power.

**[0113]** According to this embodiment, the terminal **300** can use 0[%], 5[%], 10[%], 15[%], 20[%], 30[%], 37[%], 44[%], 50[%], 56[%], 63[%], 70[%], 80[%], 90[%], 95[%], and 100 [%] as the RRC signaling value for the ratio of transmission power to the maximum power available in a cell group. In this example, low power and high power may include 0[%], 5[%], 10[%], 15[%], and 20[%] obtained by twenty equal division, and middle power may include 30[%], 37[%], 44[%], and 50[%] obtained by fifteen equal division. Further, the value over 50[%] may include 56[%], 63[%], 70[%], 80[%], 85[%], 90[%], 95[%], and 100[%] which are symmetric to 0[%]~50 [%].

**[0114]** However, in order to show a specific number of RRC signaling values in predetermined bits (for example, 4 bits), in the above example, sixteen of the seventeen transmission power ratios may be selected and used, except for 85[%] that is the middle of 1/20 unit and 1/15 unit. Further, in order to show a specific number of RRC signaling values in predetermined bits (for example, 4 bits), unlike the above example, sixteen RRC signaling values except for 15[%], which is the middle of 1/20 unit and 1/15 unit, may be used. Further, in some cases, it can be understood by those skilled in the art that sixteen transmission power ratios except for any one of the seventeen transmission power ratio can be used for the RRC signaling value.

**[0115]** Since data is expressed in 4 bits, total sixteen items of data are required. Accordingly, it is possible to create and use sixteen items of data by equally dividing the values from 0 to 100 into fifteen. However, since it is required to discriminate in detail the highest value and the lowest value but not required to discriminate the middle value in detail, it is possible to effectively use 4 bits that can express a power ratio by using data equally divided into twenty for the highest value and the lowest value and data equally divided into ten for the middle value.

**[0116]** For example, when the power transmitted to the sub-base station **200** from the terminal **300** is 90[%] of the maximum power, the power transmitted to the main base station **100** may be 10[%].

**[0117]** FIG. **9** is a diagram illustrating the configuration of a system for priority data transmission on LTE dual connectivity according to another exemplary embodiment of the present invention.

[0118] The terminal 300 may limit the capacity of large-capacity uplink data to remove HARQ-ACK transmission influence (for example, transmission failure and transmission delay) due to large-capacity uplink data.

[0119] HARQ-ACK is feedback about the quality of PDSCH at the main base station 100 and the sub-base station 200 and can be transmitted from the terminal 300 to the main base station 100 and the sub-base station 200 through a PUCCH/PUSCH that is an uplink signal.

[0120] HARQ-ACK of the main base station 100 may be transmitted only to the Pcell (Primary cell) of the main base station 100 and HARQ-ACK of the sub-base station 200 may be transmitted only to the pScell (primary Secondary cell) of the sub-base station 200 in accordance with predetermined HARQ-ACK timing and multiplexing methods.

[0121] The HARQ-ACK may be sent with CSI (Convergence Sublayer Indication) and SR (Scheduling Request) signals and a PUCCH/PUSCH or may be sent in accordance with priority. That is, it is possible to allocate remaining power relating to at least HARQ-ACK for the PUCCH/PUSCH and there is a need for determining priority for the PUCCH/PUSCH throughout a cell group in order to use the remaining power in accordance with a synchronization signal and a non-synchronization signal.

[0122] On the other hand, when the main base station 100 and the sub-base station 200 are connected by a backhaul of over 5~10 [msec], such as in wireless transmission using a microwave for connection between base stations in CoMP (Cooperative Multi-point), which is inter-base station cooperative communication, in transmission using a cable TV network or a wire subscriber line using a DSL (digital subscriber line), and in transmission using an optical subscriber distribution device PON (passive optical network) that is a type of WDM (Wavelength Division Multiplexing), it is difficult to transmit HARQ in real time.

[0123] Accordingly, other than the method of transmitting HARQ-ACK in one frame of 10 [ms] in the related art, there is a need for a method capable of transmitting HARQ-ACK after one or more frames.

[0124] First, it is possible to measure a delay of the main base station 100 and the sub-base station 200 and define a delay of HARQ-ACK on the basis of the measured delay. In forward transmission, since the terminal 300 transmits HARQ-ACK to the main base station 100 and the sub-base station 200 in real time, it is not a problem.

[0125] However, in backward transmission, when the main base station 100 controls HARQ-ACK, the HARQ-ACK may be delayed over one frame due to a delay of backward data received through the sub-base station 200. In this case, the HARQ-ACK for the backward data received by the sub-base station 200 may not be transmitted. That is, when there is an error in both of the backward data received by the main base station 100 and the backward data received by the sub-base station 200, the main base station 100 transmits HARQ-ACK to the terminal 300 and the sub-base station 200 does not transmit HARQ-ACK.

[0126] Further, even if there is no error in both of the backward data received by the main base station 100 and the backward data received by the sub-base station 200, the main base station 100 transmits HARQ-ACK to the terminal 300, but the sub-base station 200 may not transmit HARQ-ACK to the terminal 300.

[0127] According to an embodiment of the present invention, in a synchronized cell group, the terminal 300 may

transmit a signal, using any one order of the order of periodic CSI, non-periodic CSI, and PUSCH without UCI, while considering HARQ-ACK in the highest priority as priority for PUCCH/PUSCH, or the order of non-periodic CSI, periodic CSI, and PUSCH without UCI, while considering HARQ-ACK in the highest priority, and may transmit a signal while considering HARQ-ACK in the highest priority than SR. Further, in a non-synchronized cell group, the terminal 300 may transmit a signal, using any one order of the order of periodic CSI, non-periodic CSI, and PUSCH without UCI, while considering HARQ-ACK in the highest priority as priority for PUCCH/PUSCH, or the order of non-periodic CSI, periodic CSI, and PUSCH without UCI, while considering HARQ-ACK in the highest priority.

[0128] Further, with the HARQ-ACK and SR in the same priority, and then signals may be transmitted in the order of CSI>data>SRS. The SRS (Sounding Reference Signal), which shows whether there is the terminal 300 or not, may be transmitted in the lowest priority or, if necessary, it may not be transmitted.

[0129] According to an embodiment of the present invention, the terminal 300 may transmit a signal with priority of HARQ-ACK=SR>CSI>PUSCH without UCI for PUCCH/PUSCH in a cell group. When there is collision of the same types of UCI, the PUCCH channel type may be set in higher priority than the PUSCH channel type. Further, when there is collision of the same types of UCI having the same channel type, an MCG (Master Cell Group) may be set in higher priority than an SCG (Secondary Cell Group).

[0130] The present invention can allow efficient allocation of remaining power for a cell group by determining priority for PUCCH/PUSCH.

[0131] On the other hand, the terminal 300 may determine the case when the terminal when the difference in transmission delay of data from the main base station 100 and the sub-base station 200 is within a predetermined range, the case when there is no interference between data from the main base station 100 and the sub-base station 200, and the case when it operates as a TDD, as a synchronized mode.

[0132] Further, the terminal 300 may determine it as a non-synchronized mode, when interference is periodically generated in the main base station 100 and the sub-base station 200.

[0133] The synchronized mode of the main base station 100 and the sub-base station 200 may be provided to the terminal 300 through the main base station 100 and the sub-base station 200. The terminal 300 can use a priority rule based on the UCI type.

[0134] Further, according to an embodiment, the terminal 300 can determine whether it is a synchronized mode, and in this case, the terminal 300 can determine whether it is a synchronized mode on the basis of data transmission of the main base station 100 and the sub-base station 200 without receiving synchronized mode information from the main base station 100 and the sub-base station 200.

[0135] For example, when the difference in data transmission between the main base station 100 and the sub-base station 200 is within 0.033 msec, the main base station 100 and the sub-base station 200 are synchronized and may be considered as performing data communication with the terminal 300.

[0136] The present invention can determine a synchronization state by analyzing the communication state of the two

base stations **100** and **200** by means of the terminal **300**, using the method of determining whether it is a synchronized mode.

[0137] FIG. 10 is a diagram illustrating the configuration of a system for channel state information transmission on LTE dual connectivity according to another exemplary embodiment of the present invention. The system for channel state information transmission on LTE dual connectivity includes a main base station **100** that allocates a radio resource to a terminal **300** and the terminal **300** that simultaneously performs wireless data communication through a sub-base station **200** connected to the main base station **100**.

[0138] The terminal **300** may distribute spare power of the terminal **300** to the main base station **100** and the sub-base station **200**, when an uplink signal from the terminal **300** and an uplink signal from another terminal **400** are received to the main base station **100** and the sub-base station **200** with a difference of a specific value or less, under 0.33 [msec], may distribute spare power of the terminal **300** to the main base station **100** and the sub-base station **200**, when signals from the main base station **100** and the sub-base station **200** are received to the terminal **300** as downlink signals, with a difference of a specific value or less, under 0.33 [msec], and may change the largest signal of the signals from the main base station **100** or the sub-base station **200** to the main base station **100**.

[0139] The main base station **100** and the sub-base station **200** are widely installed to provide various communication services such as a voice and packet data to an LTE (Long Term Evolution) or LTE-A (Advanced) system.

[0140] Further, the multi-access technique used herein is not limited and various multi-access technique such as CDMA (Code Division Multiple Access), TDMA (Time Division Multiple Access), FDMA (Frequency Division Multiple Access), OFDMA (Orthogonal Frequency Division Multiple Access), SC-FDMA (Single Carrier-FDMA), OFDM-FDMA, OFDM-TDMA, and OFDM-CDMA may be used.

[0141] A TDD (Time Division Duplex) technique that uses different times for uplink transmission and downlink transmission may be used, or an FDD (Frequency Division Duplex) technique that transmits data using different frequencies may be used.

[0142] The main base station **100** and the sub-base station **200** communicate with the terminal **300** in a control plane and a user plane, in which the user plane is a protocol stack for data transmission from users and the control plane is a protocol stack for control signal transmission.

[0143] The main base station **100** and the sub-base station **200** may be called other names such as an eNodeB (evolved-NodeB), a BTS (Base Transceiver System), an access point, a femto-eNB, a pico-eNB, a Home eNB, and a relay.

[0144] Further, the main base station **100** and the sub-base station **200** may be connected through an X2 interface. Layers of a radio interface protocol between the terminal **300** and a network may be classified into a first layer L1, a second layer L2, and a third layer L3 on the basis of three lower layers of a standard model of OSI (Open System Interconnection) that is well known in the field of communication system, in which the physical layer in the first layer provides an information transfer service using a physical channel and an RRC (Radio Resource Control) layer in the third layer controls radio resources between the terminal **300** and a network. To this

end, the RRC layer exchanges RRC message among the terminal **300**, and the main base station **100** and the sub-base station **200**.

[0145] The physical layer provides an information transfer service to upper hierarchies, using a physical channel.

[0146] The physical layer is connected to a MAC (Medium Access Control) layer, which is an upper layer, through a transport channel. Data is transported between the MAC layer and the physical layer through the transport channel. The transport channel is classified in accordance with how and with which characteristic data is transmitted through a radio interface. Data is transported through a physical channel between different physical layers, that is, between the physical layers of a transmitter and a receiver.

[0147] The physical channel may be modulated by OFDM (Orthogonal Frequency Division Multiplexing) and uses time and a frequency as radio resources. The PDCCH (physical downlink control channel), which is a physical control channel, informs the terminal **300** of the information about resource allocation of a PCH (paging channel) and a DL-SCH (downlink shared channel) and HARQ (hybrid automatic repeat request) associated with the DL-SCH.

[0148] The PDCCH may transmit an uplink scheduling grant saying resource allocation in uplink transmission to the terminal **300**. A PCFICH (physical control format indicator channel) informs the terminal **300** of the number of OFDM symbols for PDCCHs and transmits it at each sub-frame. A PHICH (physical Hybrid ARQ Indicator Channel) transmits a HARQ ACK/NAK signal in response to uplink transmission. A PUCCH (Physical uplink control channel) shows uplink control information such as HARQ ACK/NAK, a scheduling request, and CQI in downlink transmission. A PUSCH (Physical uplink shared channel) transmits an UL-SCH (uplink shared channel).

[0149] In a heterogeneous network environment with macrocells and small cells, the small cells provide services for a smaller area than that of the macrocells, so they are advantageous in throughput, which can be provided for a single terminal **300**, as compared with the macrocells.

[0150] A dual connectivity technique has been introduced as one of cell planning techniques for distributing excessive load or load requiring specific QoS in the small cell without a process of handover and efficiently transmitting data in a heterogeneous network environment. For the terminal **300**, the dual connectivity may be a technique for providing a more efficient way in terms of transmission/reception rates.

[0151] For example, the terminal **300** can transmit/receive services to/from two or more serving cells. The serving cells may pertain to different base stations. On the basis of the dual connectivity technique, the terminal **300** can transmit/receive services through wireless communication with two or more different base stations (for example, a macro base station for macrocells and a small base station for small cells) at different frequency bands. Alternatively, the terminal **300** may transmit/receive services through wireless communication with two or more different base stations at the same frequency band.

[0152] In the dual connectivity, one terminal **300** performs a mobile communication service to two base stations, so the terminal **300** needs to control power on the basis of the distance difference from the main base station **100** and the sub-base station **200** and it determines the maximum power that the terminal **300** can transmit, and then distributes and transmits power not over the maximum power. Further, the main

base station **100** and the sub-base station **200** can receive data equally to another terminal **400** or in accordance with the priority.

[0153] The remaining power after the terminal **300** transmits power to any one of the main base station **100** and the sub-base station **200** can be distributed to the main base station **100** and the sub-base station **200** and this distribution can increase the transfer rate by maximally using the remaining power of the terminal.

[0154] Power control may be classified into a first power control mode sharing remaining power after the terminal **300** transmits power and a second power control mode using all the remaining power.

[0155] The first power control mode determines priority for remaining power on the basis of the type of UCI (Uplink Control Information) of a base station.

[0156] Further, the first power control mode is used between the terminal **300** and the terminal **400** that are synchronized. Since the terminal **300** is synchronized, the transmission difference between the terminal **300** and the terminal **400** should not exceed a specific value under 0.33 [msec].

[0157] Uplink power control of the terminal **300** may be classified into a synchronization type and a non-synchronization type on the basis of a network signal. That is, the timing difference between the main base station **100** and the sub-base station **200** is less than a specific value under 0.33 [msec], the first power control mode is performed, or when it is larger than the value, the second power control mode is performed.

[0158] The time '0.33 [msec]' corresponding to the distance [km] that the main base station **100** can transmit data, considering the speed of an electric wave, or it may correspond to the distance difference between the terminal **300** and the terminal **400** or the distance difference between the main base station **100** and the sub-base station **200**. However, a specific value under 0.33 [msec] should be considered in a building due to much reflection of electric waves. In particular, in a service for several kilometers such as a highway, the distance difference between the terminal **300** and the terminal **400** should be considered as a specific value within the distance [km] to the main base station **100** in accordance with the transmission power. For example, when 0.033 [msec] is considered as a specific value, it may be considered that the main base station **100** and the sub-base station **200** have been synchronized within 10 [km] or the terminal **300** and the terminal **400** have been synchronized within 10 [km].

[0159] When a parameter relating to the synchronization is set larger than 0.33 [msec], radio signal interference is large when signals are received simultaneously from the main base station **100** and the sub-base station **200**, and radio interference is large when signals are received simultaneously from the terminal **300** and the terminal **400**, so it becomes a problem in demodulation. In particular, considering one slot period, which is a unit transmission period in LTE, is 0.5 [ms], a parameter relating to synchronization should be within 0.5 [ms] and a specific value that can be considered for synchronization should be determined within 0.33 [ms] in consideration of a margin.

[0160] The first power control mode that separately uses remaining power for the main base station **100** and the sub-base station **200** is used when synchronization is made, or when synchronization is not made, they may interfere with each other, so the second power mode only for any one of the main base station **100** and the sub-base station **200** is used.

[0161] The power control may fall into a forward power control that controls a transmission channel from a base station to the terminal **300** and a backward power control that controls the power of a transmission signal from the terminal **300**.

[0162] In the forward power control, the main base station **100** and the sub-base station **200** distribute and efficiently transmit power of PDCCH, PDSCH (Physical Downlink Shared Channel), EPDCCH (Enhanced Physical Downlink Control Channel), PHICH, PCFICH, PMCH (Physical Multicast Channel), and PBCH (Physical Broadcast Channel) in accordance with the terminal **300**.

[0163] On the other hand, in the backward power control, power is controlled so that it can be received at the same level in consideration of equality of several terminals **300** of which power is received to the main base station **100** and the sub-base station **200**, in which information such as HARQ-ACK, SR (Scheduling Request), CSI (Convergence Sublayer Indication), and data that is payload, other than PUCCH, PUSCH transmitting payload, SRS (Sounding Reference Signal) showing whether there is the terminal **300** or not, and PRACH (Physical Random Access Channel) requesting connection with the main base station **100** and the sub-base station **200**, is transmitted and power for the information is controlled.

[0164] FIG. 11 is a timing diagram illustrating a method of controlling power of a terminal communicating with a plurality of base stations on LTE dual connectivity according to another exemplary embodiment of the present invention.

[0165] A method of controlling power of a terminal communicating with a plurality of LTE base stations according to an embodiment of the present invention may include: an uplink power control reception step of receiving uplink power control of a terminal **300** from a main base station **100** by means of the terminal **300** (S100); an uplink power increment request reception step of receiving an uplink power increment request of the terminal **300** from a sub-base station **200** by means of the terminal **300** (S130); an uplink power increment permission request step of requesting the main base station **100** to permit uplink power increment of the terminal **300** (S140); an uplink power increment permission response reception step of receiving a response to the uplink power increment permission request step (S140) from the main base station **100** by means of the terminal **300** (S150); and an uplink power increment step of increasing uplink power of the terminal **300** on the basis of the uplink power control in the uplink power increment permission response reception step (S150) and the uplink power increment request reception step (S130)(S160).

[0166] Further, a method of controlling power of a terminal communicating with a plurality of LTE base stations according to another embodiment of the present invention may include: an uplink power control reception step of receiving uplink power control of a terminal **300** from a main base station **100** (S100); an uplink power reduction request reception step of receiving an uplink power reduction request of the terminal **300** from a sub-base station **200** (S110); and an uplink power reduction step of reducing uplink power of the terminal **300** on the basis of the uplink power control in the uplink power control reception step (S100) and the uplink power reduction request reception step (S110) (S120). The terminal **300** can receive uplink power control simultaneously from the main base station **100** and the sub-base station **200** and can adjust its own uplink power in order not to influence data reception from the main base station **100**. For

example, when the sub-base station 200 requests uplink power increment, the terminal 300 can determine not increasing uplink power in consideration of reception interference with the main base station 100.

[0167] Further, the terminal 300 can perform transmission in order of priority of each transmission channel and is controlled not to exceed its maximum power transmission level.

[0168] On the other hand, the sub-base station 200 does not perform power control to the terminal 300, so equality for another terminal 400 is not considered in the reception level about the sub-base station 200, and thus, it may influence the reception performance of the sub-base station 200.

[0169] Accordingly, when a matter that influences the reception performance is detected, the sub-base station 200 may request the terminal 300 to control power in person or may request the main base station 100 to control power of the terminal 300.

[0170] When the sub-base station 200 requests the terminal 300 to control power in person, the power can be rapidly controlled, but when the terminal 300 simultaneously receives power control of the main base station 100 and the sub-base station 200 but the terminal 300 has no priority about power control, it may be confused.

[0171] Accordingly, the terminal 300 controls transmission with the power control of the main base station 100 in priority in order to prevent confusion, but when it receives a request for reducing power from the sub-base station 200, it reduces power, considering the main base station 100 and the request in priority.

[0172] Meanwhile, when the terminal 300 receives a request for increasing power from the sub-base station 200, it may increase power for the sub-base station 200 after receiving permission from the main base station 100 without immediately increasing the power.

[0173] That is, increasing and decreasing the uplink power of the terminal 300 are based on control and permission by the main base station 100 and the sub-base station 200 can control only uplink power reduction of the terminal 300.

[0174] FIG. 12 is a timing diagram illustrating a method of channel state information transmission on LTE dual connectivity according to another exemplary embodiment of the present invention. A method of channel state information transmission on LTE dual connectivity may include: a first downlink signal reception step of receiving a first downlink signal from a main base station 100 by means of a terminal 300 (S410); a second downlink signal reception step of receiving a second downlink signal from a sub-base station 200 by means of the terminal 300 (S420); a downlink channel state analysis step of analyzing downlink channel states of the first downlink signal received in the first downlink signal reception step (S410) and the second downlink signal received in the second downlink signal reception step (S420) (S430); a first downlink channel state information transmission step of transmitting first downlink channel state information analyzed on the basis of the first downlink signal reception in the downlink channel state analysis step (S430) to the main base station 100 (S440); and a second downlink channel state information transmission step of transmitting second downlink channel state information analyzed on the basis of the second downlink signal reception in the downlink channel state analysis step (S430) to the sub-base station 200 (S450).

[0175] In the first downlink channel state information transmission step (S440), the first downlink channel state

information can be transmitted to the main base station 100 in higher priority than the second downlink channel state information transmission step (S450).

[0176] In the second downlink channel state information transmission step (S450), when it has lower priority than the first downlink channel state information transmission step (S440) and has insufficient channels for transmitting the second downlink channel state information to the sub-base station 200, at least one of the terminal 300 and the sub-base station 200 requests the main base station 100 to additionally secure five or more channels to be able to transmit the second downlink channel state information, so the second downlink channel state information can be transmitted to the sub-base station 200.

[0177] It is necessary to feedback the channel information for efficient communication, and in generally, the channel information of a downlink is sent up to an uplink, while the channel information of the uplink is sent down to the downlink. The channel information may be called a channel information indicator, that is, a CQI (Channel Quality Indicator).

[0178] The CQI may be created in various ways. For example, there are a method of quantizing and sending up a channel state, a method of calculating SINR and sending up a channel state, and a method of showing a state to which a channel is actually applied, such as an MSC (Modulation Coding Scheme).

[0179] The channel state information (CSI) that the terminal 300 is to report to the main base station 100 or the sub-base station 200 includes not only CQI, but a rank indicator (RI) showing the numbers of precoding matrix indexes (PMI) and the independent channels.

[0180] The channel state information, in general, can be periodically or non-periodically transmitted through PUCCH or PUSCH. That is, the terminal 300 receives a signal from the main base station 100 or the sub-base station 200, analyzes the downlink channel state between the main base station 100 and the terminal 300, and reports the channel state to the main base station 100. Further, the terminal 300 analyzes the channel state between the sub-base station 200 and the terminal 300 and reports it to the sub-base station 200. The information analyzed by the terminal 300 shows influence by scattering, fading, and delay of transmission power, which are generated in a wireless channel environment.

[0181] It is possible to transmit reliable data at a high speed by enabling the downlink channel state information to be transmitted to the terminal 300 from the main base station 100, optimally in the current wireless channel environment.

[0182] When the downlink channel state information is transmitted, a large amount of data cannot be transmitted to the main base station 100 from the terminal 300, so the number of items of data is limited to five or less for each current sub-frame. However, the terminal 300 has to communicate with not only the main base station 100, but the sub-base station 200, so transmission through five channels is actually insufficient. In this case, it is required to skip reporting a channel state, in which it is impossible to analyze wireless channels in real time.

[0183] Accordingly, channel state report may be performed in highest priority in communication between the main base station 100 and the terminal 300, while communication between the sub-base station 200 and the terminal 300 may be performed in lower priority. However, when it is required to further report a channel state due to bad channel analysis in communication between the sub-base station 200 and the



terminal 300, at least one of the sub-base station 200 and the terminal 300 may request the main base station 100 to secure a channel and then the terminal 300 may report a channel state to the sub-base station 200.

[0184] The number of channels through which channel state information can be transmitted in a non-synchronized state between the terminal 300 and the main base station 100 is standardized to maximum five per sub-frame, but the terminal 300 may use total ten channels because it has to transmit channel state information to the sub-base station 200 as well, other than the main base station 100. In this case, when ten channels are always prepared, the channel efficiency may be reduced, so the number of channels is increased to ten when a request for increasing the number of channels is received while five channels are used. For increasing the number of channels, at least any one of the sub-base station 200 and the terminal 300 determines whether to increase the number of channels and then transmits information to the main base station 100.

[0185] FIG. 13 is a timing diagram illustrating a method of channel state information transmission on LTE dual connectivity according to another exemplary embodiment of the present invention. A method of channel state information transmission on LTE dual connectivity includes: a first uplink signal reception step of receiving a first uplink signal of a terminal 300 by means of a main base station 100 (S510); a second uplink signal reception step of receiving a second uplink signal of another terminal 400 after the first uplink signal by means of the main base station 100 (S520); an uplink channel state analysis step of analyzing the uplink channel states of the first uplink signal received in the first uplink signal reception step (S510) and the second uplink signal received in the second uplink signal reception step (S520) (S530); a first uplink channel state information transmission step of transmitting first uplink channel state information analyzed on the basis of the reception of the first uplink signal in the uplink channel state analysis step (S530) to the terminal 300 (S540); and a second uplink channel state information transmission step of transmitting second uplink channel state information analyzed on the basis of the reception of the second uplink signal in the uplink channel state analysis step (S530) to the terminal 400 (S550).

[0186] In the first uplink channel state information transmission step (S540), the first uplink channel state information can be transmitted to the terminal 300 in higher priority than the second uplink channel state information transmission step (S550).

[0187] Further, in the second uplink channel state information transmission step (S550), when it has lower priority than the first uplink channel state information transmission step (S540) and channels for transmitting the second uplink channel state information to the terminal 400 are insufficient, it is possible to transmit the second uplink channel state information to the terminal 400 by additionally securing five or more channels to be able to transmit the second uplink channel state information.

[0188] The channel state information to be transmitted to the terminal 300 or the terminal 400 from the main base station 100 includes a rank indicator showing the numbers of precoding matrix indexes and the independent channels, in addition to CQI.

[0189] The channel state information, in general, can be periodically or non-periodically transmitted through PDCCCH or PDSCH. That is, the terminal 300 or the terminal 400

receives a signal from the main base station 100, it analyzes the uplink channel state between the terminal 300 and the main base station 100, and the main base station 100 reports the uplink channel state to the terminal 300. Further, it analyzes the uplink channel state between the terminal 400 and the main base station 100 and then the main base station 100 reports it to the terminal 400. The information analyzed by the main base station 100 shows influence by scattering, fading, and delay of transmission power, which are generated in a wireless channel environment.

[0190] It is possible to transmit reliable data at a high speed by enabling the downlink channel state information to be transmitted to the terminal 300 or the terminal 400 from the main base station 100, optimally in the current wireless channel environment.

[0191] When the uplink channel state information is transmitted, a large amount of data cannot be transmitted to the terminal 300 from the main base station 100, so the number of items of data is limited to five or less for each current sub-frame. However, the main base station 100 has to communicate with not only the terminal 300, but the terminal 400, so transmission through five channels is actually insufficient. In this case, it is required to skip reporting a channel state, in which it is impossible to analyze wireless channels in real time.

[0192] Accordingly, for the terminal 300 first that has accessed first to the main base station 100, channel state report may be performed first in communication between the terminal 300 and the main base station 100 and the communication between the terminal 400 and the main base station 100 may be given lower priority. However, when it is required to further report a channel state due to bad channel analysis in the communication between the terminal 400 and the main base station 100, the main base station 100 can report a channel state to the terminal 400 by securing more channels.

[0193] The number of channels through which channel state information can be transmitted in a non-synchronized state between the terminal 300 and the main base station 100 is standardized to maximum five per sub-frame, but the main base station 100 may use total ten channels because it has to transmit channel state information to the terminal 400 as well, other than the terminal 300. In this case, when ten channels are always prepared, the channel efficiency may be reduced, so the number of channels is increased to ten when a request for increasing the number of channels is received while five channels are used. Increasing the number of channels is determined and set by the main base station 100.

[0194] FIG. 14 is a timing diagram illustrating a method of channel state information transmission on LTE dual connectivity according to another exemplary embodiment of the present invention. A method of channel state information transmission on LTE dual connectivity includes: a third uplink signal reception step of receiving a third uplink signal of a terminal 300 by means of a sub-base station 200 (S610); a fourth uplink signal reception step of receiving a fourth uplink signal of another terminal 400 after the third uplink signal by means of the main base station 200 (S620); an uplink channel state analysis step of analyzing the uplink channel states of the third uplink signal received in the third uplink signal reception step (S610) and the fourth uplink signal received in the fourth uplink signal reception step (S620) (S630); a third uplink channel state information transmission step of transmitting third uplink channel state information analyzed on the basis of the reception of the third

uplink signal in the uplink channel state analysis step (S630) to the terminal 300 (S640); and a fourth uplink channel state information transmission step of transmitting fourth uplink channel state information analyzed on the basis of the reception of the fourth uplink signal in the uplink channel state analysis step (S630) to the terminal 400 (S650).

[0195] In the third uplink channel state information transmission step (S640), the third uplink channel state information can be transmitted to the terminal 300 in higher priority than the fourth uplink channel state information transmission step (S650).

[0196] In the fourth uplink channel state information transmission step (S650), when it has lower priority than the third uplink channel state information transmission step (S640) and has insufficient channels for transmitting the fourth uplink channel state information to the terminal 400, at least one of the terminal 400 and the sub-base station 200 requests the main base station 100 to additionally secure five or more channels to be able to transmit the fourth downlink channel state information, so the fourth downlink channel state information can be transmitted to the terminal 400.

[0197] The channel state information to be transmitted to the terminal 300 or the terminal 400 from the sub-base station 200 includes a rank indicator showing the numbers of precoding matrix indexes and the independent channels, in addition to CQI.

[0198] The channel state information, in general, can be periodically or non-periodically transmitted through PDCCH or PDSCH. That is, the terminal 300 or the terminal 400 receives a signal from the sub-base station 200, it analyzes the uplink channel state between the terminal 300 and the sub-base station 200, and the sub-base station 200 reports the uplink channel state to the terminal 300. Further, it analyzes the uplink channel state between the terminal 400 and the sub-base station 200 and then the sub-base station 200 reports it to the terminal 400. The information analyzed by the sub-base station 200 shows influence by scattering, fading, and delay of transmission power, which are generated in a wireless channel environment.

[0199] It is possible to transmit reliable data at a high speed by enabling the downlink channel state information to be transmitted to the terminal 300 or the terminal 400 from the sub-base station 200, optimally in the current wireless channel environment.

[0200] When the uplink channel state information is transmitted, a large amount of data cannot be transmitted to the terminal 300 from the sub-base station 200, so the number of items of data is limited to five or less for each current sub-frame. However, the sub-base station 200 has to communicate with not only the terminal 300, but the terminal 400, so transmission through five channels is actually insufficient. In this case, it is required to skip reporting a channel state, in which it is impossible to analyze wireless channels in real time.

[0201] Accordingly, for the terminal 300 first that has accessed first to the sub-base station 200, channel state report may be performed first in communication between the terminal 300 and the sub-base station 200 and the communication between the terminal 400 and the sub-base station 200 may be given lower priority. However, when it is required to further

report a channel state due to bad channel analysis in communication between the terminal 400 and the sub-base station 200, at least one of the sub-base station 200 and the terminal 400 may request the main base station 100 to secure a channel and then the sub-base station 200 may report a channel state to the terminal 400.

[0202] The number of channels through which channel state information can be transmitted in a non-synchronized state between the terminal 300 and the sub-base station 200 is standardized to maximum five per sub-frame, but the sub-base station 200 may use total ten channels because it has to transmit channel state information to the terminal 400 as well, other than the terminal 300. In this case, when ten channels are always prepared, the channel efficiency may be reduced, so the number of channels is increased to ten when a request for increasing the number of channels is received while five channels are used. For increasing the number of channels, at least any one of the sub-base station 200 and the terminal 400 determines whether to increase the number of channels and then transmits information to the main base station 100.

[0203] FIG. 15 is a block diagram illustrating a wireless communication system for which exemplary embodiments of the present invention can be achieved. The wireless communication system shown in FIG. 15 may include at least one base station 800 and at least one terminal 900.

[0204] The base station 800 may include a memory 810, a processor 820, and an RF unit 830. The memory 810 is connected with the processor 820 and can keep commands and various terms of information for activating the processor 820. The RF unit 830 is connected with the processor 820 and can transmit/receive wireless signals to/from an external entity. The processor 820 can execute the operations of the base stations in the embodiments described above. In detail, the operations of the base stations 100, 101, 112, 200, 201, 212, 220, 232, 310, and 320 etc. in the embodiments described above may be achieved by the processor 820.

[0205] The terminal 900 may include a memory 910, a processor 920, and an RF unit 930. The memory 910 is connected with the processor 920 and can keep commands and various terms of information for activating the processor 920. The RF unit 930 is connected with the processor 920 and can transmit/receive wireless signals to/from an external entity. The processor 920 can execute the operations of the terminals in the embodiments described above. In detail, the operations of the terminals 110, 120, 130, 240, 250, 300, 312, 322, 330, 342, 352, 362, 400 etc. in the embodiments described above may be achieved by the processor 920.

[0206] The present invention may be modified in various ways and implemented by various exemplary embodiments, so that specific exemplary embodiments are shown in the drawings and will be described in detail.

[0207] However, it is to be understood that the present invention is not limited to the specific exemplary embodiments, but includes all modifications, equivalents, and substitutions included in the spirit and the scope of the present invention.

[0208] Terms used in the specification, 'first', 'second', etc., may be used to describe various components, but the components are not to be construed as being limited to the terms. The terms are used to distinguish one component from another component. For example, the 'first' component may be named the 'second' component, and vice versa, without

departing from the scope of the present invention. The term ‘and/or’ includes a combination of a plurality of items or any one of a plurality of terms.

**[0209]** It should be understood that when one element is referred to as being “connected to” or “coupled to” another element, it may be connected directly to or coupled directly to another element or be connected to or coupled to another element, having the other element intervening therebetween. On the other hand, it is to be understood that when one element is referred to as being “connected directly to” or “coupled directly to” another element, it may be connected to or coupled to another element without the other element intervening therebetween.

**[0210]** Terms used in the present specification are used only in order to describe specific exemplary embodiments rather than limiting the present invention. Singular forms are intended to include plural forms unless the context clearly indicates otherwise. It will be further understood that the terms “comprises” or “have” used in this specification, specify the presence of stated features, numerals, steps, operations, components, parts, or a combination thereof, but do not preclude the presence or addition of one or more other features, numerals, steps, operations, components, parts, or a combination thereof.

**[0211]** Unless indicated otherwise, it is to be understood that all the terms used in the specification including technical and scientific terms has the same meaning as those that are understood by those skilled in the art. It must be understood that the terms defined by the dictionary are identical with the meanings within the context of the related art, and they should not be ideally or excessively formally defined unless the context clearly dictates otherwise.

**[0212]** Hereinafter, exemplary embodiments of the present invention will be described in more detail with reference to the accompanying drawings. In order to facilitate the general understanding of the present invention in describing the present invention, through the accompanying drawings, the same reference numerals will be used to describe the same components and an overlapped description of the same components will be omitted.

**[0213]** In one or more exemplary embodiments, the described functions may be achieved by hardware, software, firmware, or combinations of them. If achieved by software, the functions can be kept or transmitted as one or more orders or codes in a computer-readable medium. The computer-readable medium includes all of communication media and computer storage media including predetermined media facilitating transmission of computer programs from one place to another place.

**[0214]** If achieved by hardware, the functions may be achieved in one or more ASICs, DSPs, DSPDs, PLDs, FPGAs, processors, controllers, microcontrollers, microprocessors, other electronic units designed to perform the functions, or combinations of them.

**[0215]** If achieved by software, the functions may be achieved by software codes. The software codes may be kept in memory units and executed by processors. The memory units may be achieved in processors or outside processors, in which the memory units may be connected to processors to be able to communicate by various means known in the art.

**[0216]** Although the present invention was described above with reference to exemplary embodiments, it should be understood that the present invention may be changed and

modified in various ways by those skilled in the art, without departing from the spirit and scope of the present invention described in claims.

What is claimed is:

1. A method of controlling power of a terminal communicating with a plurality of base stations, the method comprising:

an uplink power control reception step of receiving uplink power control of a terminal from a main base station by means of the terminal;

an uplink power increment request reception step of receiving an uplink power increment request of the terminal from a sub-base station by means of the terminal;

an uplink power increment permission request step of requesting the main base station to permit uplink power increment of the terminal;

an uplink power increment permission response reception step of receiving a response to the uplink power increment permission request step from the main base station by means of the terminal; and

an uplink power increment step of increasing uplink power of the terminal on the basis of the uplink power control in the uplink power increment permission response reception step and the uplink power increment request reception step.

2. The method of claim 1, further comprising:

an uplink power reduction request reception step of receiving an uplink power reduction request of the terminal from the sub-base station; and

an uplink power reduction step of reducing uplink power of the terminal on the basis of the uplink power control in the uplink power control reception step and the uplink power reduction request reception step.

3. A method of channel state information transmission of a plurality of base stations, the method comprising:

a first downlink signal reception step of receiving a first downlink signal from a main base station by means of a terminal;

a second downlink signal reception step of receiving a second downlink signal from a sub-base station by means of the terminal;

a downlink channel state analysis step of analyzing downlink channel states of the first downlink signal received in the first downlink signal reception step and the second downlink signal received in the second downlink signal reception step;

a first downlink channel state information transmission step of transmitting first downlink channel state information analyzed on the basis of the first downlink signal reception in the downlink channel state analysis step to the main base station; and

a second downlink channel state information transmission step of transmitting second downlink channel state information analyzed on the basis of the second downlink signal reception in the downlink channel state analysis step to the sub-base station.

4. The method of claim 3, wherein in the first downlink channel state information transmission step, the first downlink channel state information is transmitted to the main base station in higher priority than the second downlink channel state information transmission step.

5. The method of claim 3, wherein in the second downlink channel state information transmission step, when the step has lower priority than the first downlink channel state infor-

mation transmission step and has insufficient channels for transmitting the second downlink channel state information to the sub-base station, at least one of the terminal and the sub-base station requests the main base station to additionally secure five or more channels to be able to transmit the second downlink channel state information, so the second downlink channel state information is transmitted to the sub-base station.

6. A method of channel state information transmission of a plurality of base stations, the method comprising:

a first uplink signal reception step of receiving a first uplink signal of a first terminal by means of a main base station;  
a second uplink signal reception step of receiving a second uplink signal of a second terminal after the first uplink signal by means of the main base station;

an uplink channel state analysis step of analyzing the uplink channel states of the first uplink signal received in the first uplink signal reception step and the second uplink signal received in the second uplink signal reception step;

a first uplink channel state information transmission step of transmitting first uplink channel state information analyzed on the basis of the reception of the first uplink signal in the uplink channel state analysis step to the first terminal; and

a second uplink channel state information transmission step of transmitting second uplink channel state information analyzed on the basis of the reception of the second uplink signal in the uplink channel state analysis step to the second terminal.

7. The method of claim 6, wherein in the first uplink channel state information transmission step, the first uplink channel state information is transmitted to the first terminal in higher priority than the second uplink channel state information transmission step.

8. The method of claim 6, wherein in the second uplink channel state information transmission step, when the second uplink channel state information transmission step has lower priority than the first uplink channel state information transmission step and channels for transmitting the second uplink channel state information to the second terminal are insufficient, the second uplink channel state information transmission step transmits the second uplink channel state informa-

tion to the second terminal by additionally securing five or more channels to be able to transmit the second uplink channel state information.

9. A method of channel state information transmission of a plurality of base stations, the method comprising:

a third uplink signal reception step of receiving a third uplink signal of a first terminal by means of a sub-base station;

a fourth uplink signal reception step of receiving a fourth uplink signal of a second terminal after the third uplink signal by means of the main base station;

an uplink channel state analysis step of analyzing the uplink channel states of the third uplink signal received in the third uplink signal reception step and the fourth uplink signal received in the fourth uplink signal reception step;

a third uplink channel state information transmission step of transmitting third uplink channel state information analyzed on the basis of the reception of the third uplink signal in the uplink channel state analysis step to the first terminal; and

a fourth uplink channel state information transmission step of transmitting fourth uplink channel state information analyzed on the basis of the reception of the fourth uplink signal in the uplink channel state analysis step to the second terminal.

10. The method of claim 9, wherein in the third uplink channel state information transmission step, the third uplink channel state information is transmitted to the first terminal in higher priority than the fourth uplink channel state information transmission step.

11. The method of claim 9, wherein in the fourth uplink channel state information transmission step, when the fourth uplink channel state information transmission step has lower priority than the third uplink channel state information transmission step and has insufficient channels for transmitting the fourth uplink channel state information to the second terminal, at least one of the second terminal and the sub-base station requests the main base station to additionally secure five or more channels to be able to transmit the fourth downlink channel state information, so the fourth downlink channel state information is transmitted to the second terminal.

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