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(54) **SYNCHRONIZATION METHOD OF FEMTOCELL BASE STATION AND FEMTOCELL BASE STATION USING THE SAME**

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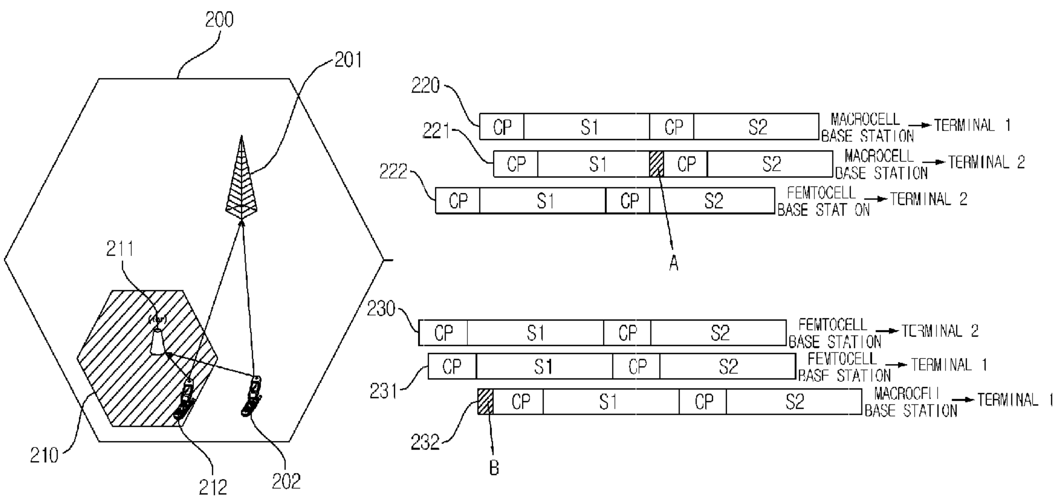
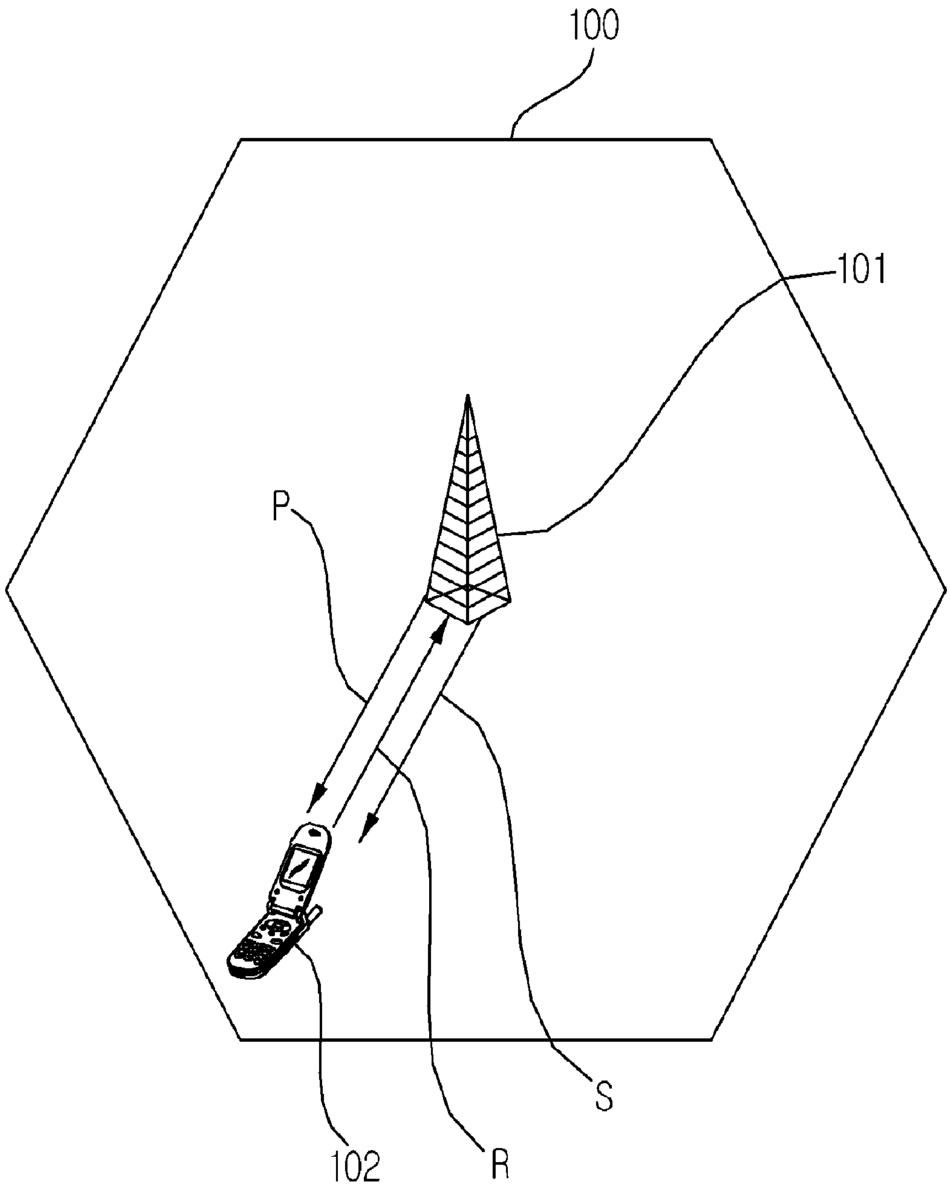
(57) **ABSTRACT**

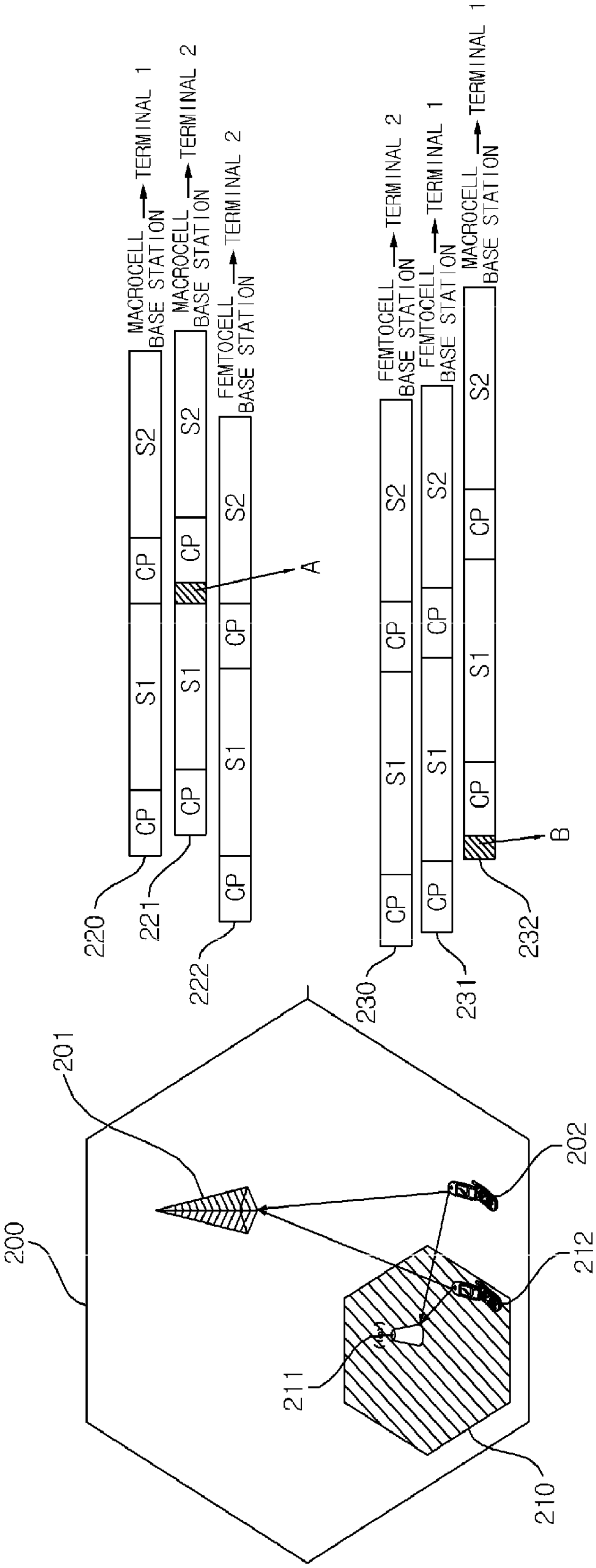
The exemplary embodiment of the present invention provides a method of synchronizing a femtocell base station securing time synchronization of a femtocell base station by allowing the femtocell base station to transmit a symbol to a terminal belonging to the femtocell by performing the time synchronization with a preamble signal when the femtocell base station receives the preamble signal from the macrocell base station in an orthogonal frequency division multiple access (OFDMA) communication system in which a femtocell is present in a macrocell.



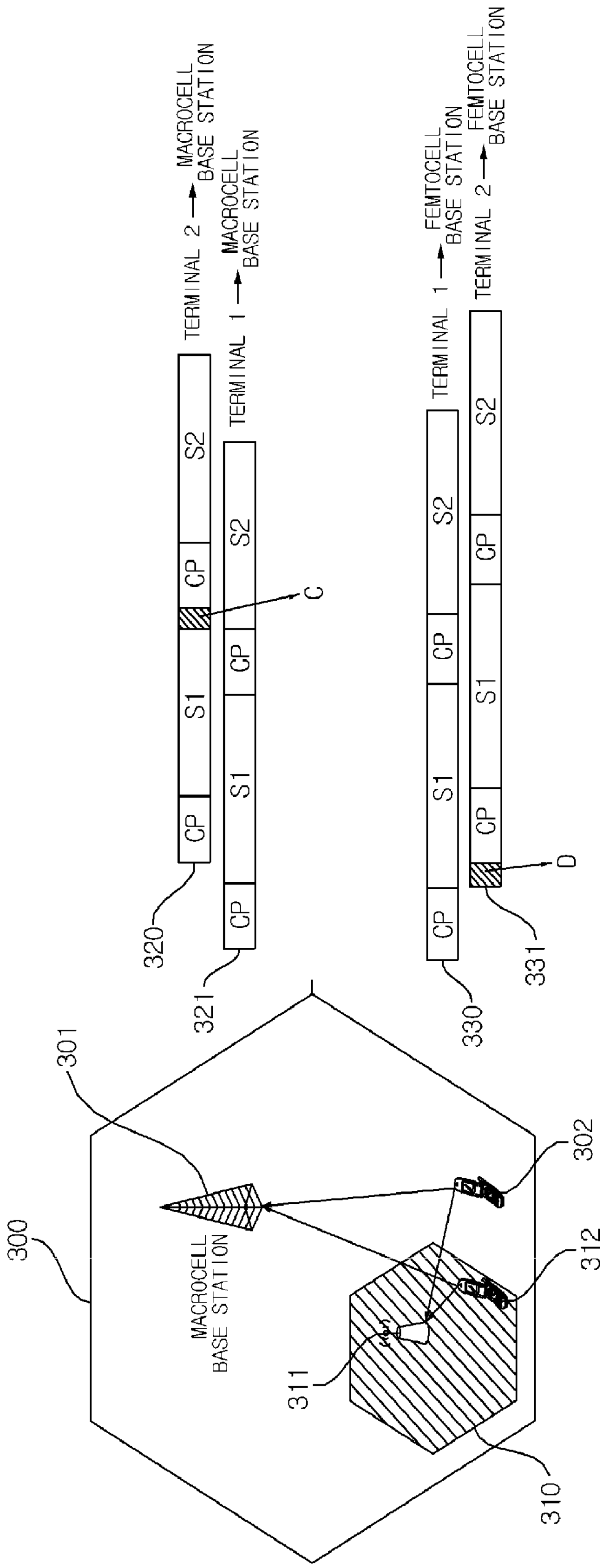
[FIG. 1]



[FIG. 2]

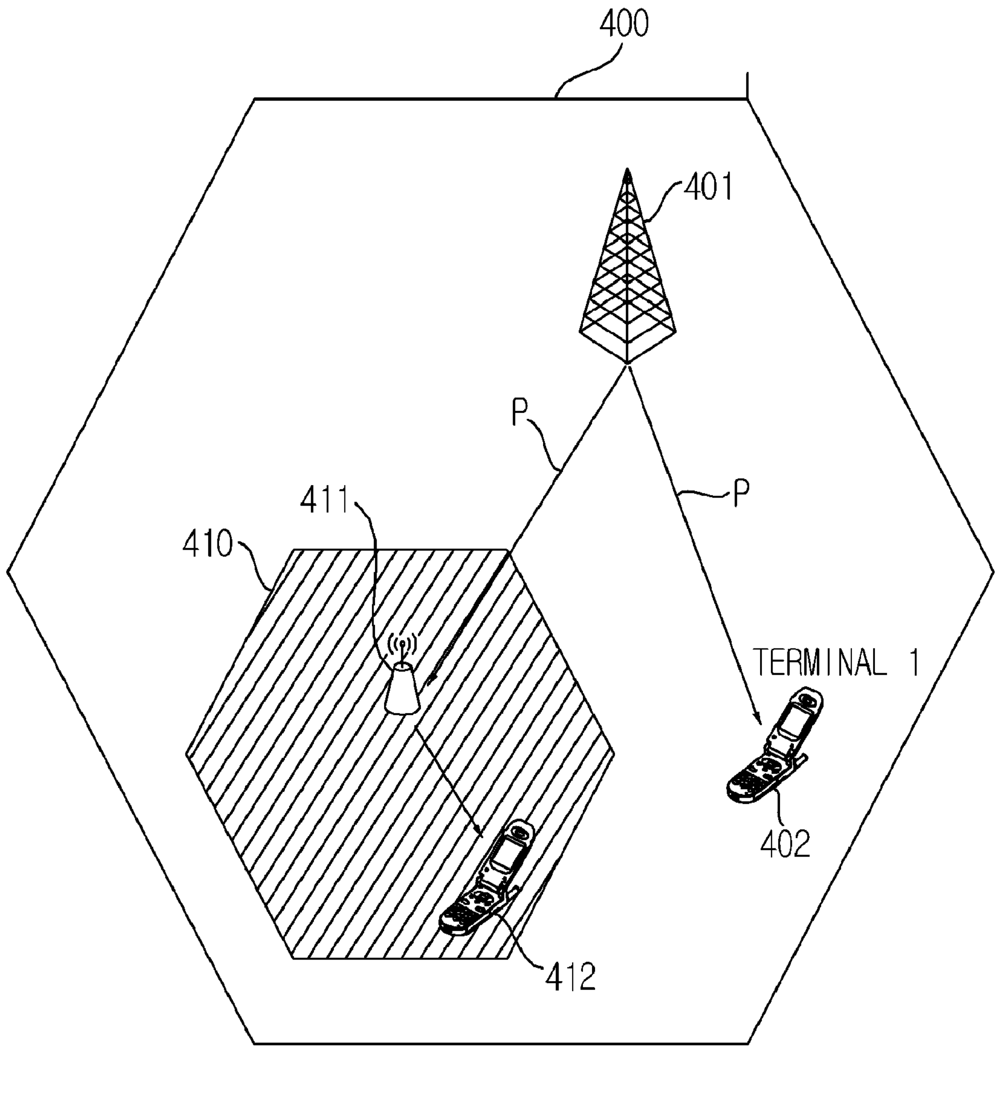

MACROCELL BASE STATION → TERMINAL 1
MACROCELL BASE STATION → TERMINAL 2
FEMTOCELL BASE STATION → TERMINAL 2
FEMTOCELL BASE STATION → TERMINAL 2
FEMTOCELL BASE STATION → TERMINAL 1
MACROCELL BASE STATION → TERMINAL 1
CP
S1
S2
A
B
200
201
202
210
211
212
220
221
222
230
231
232

[FIG. 3]

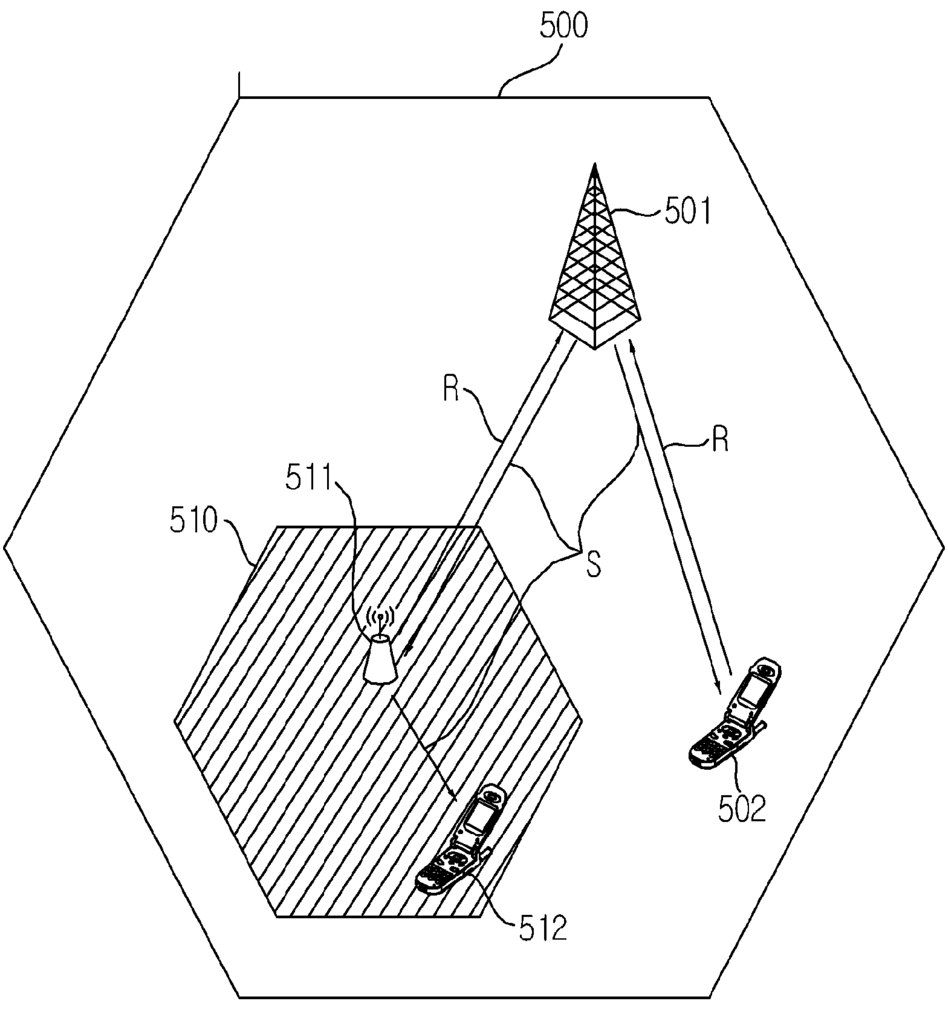


TERMINAL 2 → MACROCELL BASE STATION
TERMINAL 1 → MACROCELL BASE STATION
TERMINAL 1 → FEMTOCELL BASE STATION
TERMINAL 2 → FEMTOCELL BASE STATION
CP
S1
S2
C
D
320
321
330
331
300
301
302
310
311
312
MACROCELL BASE STATION

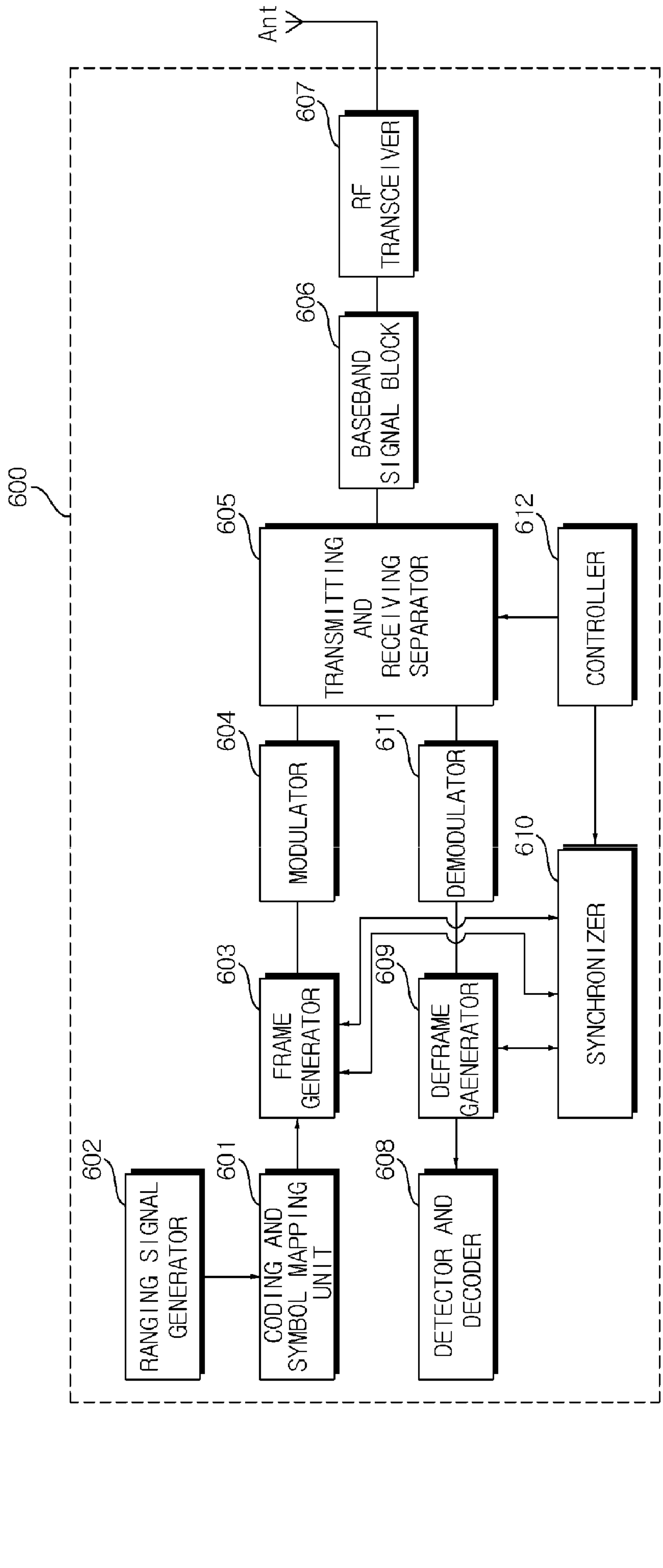
[FIG. 4]



[FIG. 5]



[FIG. 6]


Ant
600
607
RF TRANSCEIVER
606
BASEBAND SIGNAL BLOCK
605
TRANSMITTING AND RECEIVING SEPARATOR
612
CONTROLLER
604
MODULATOR
611
DEMODULATOR
610
SYNCHRONIZER
603
FRAME GENERATOR
609
DEFRAME GAENERATOR
602
RANGING SIGNAL GENERATOR
601
CODING AND SYMBOL MAPPING UNIT
608
DETECTOR AND DECODER

SYNCHRONIZATION METHOD OF FEMTOCELL BASE STATION AND FEMTOCELL BASE STATION USING THE SAME

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to and the benefit of Korean Patent Application No. 10-2008-0092092 filed in the Korean Intellectual Property Office on Sep. 19, 2008, the entire contents of which are incorporated herein by reference.

TECHNICAL FIELD

[0002] The present invention relates to a method of synchronizing a femtocell base station and a femtocell base station using the same. In more detail, the present invention relates to a method of synchronizing a femtocell base station and a femtocell base station using the same capable of allowing the femtocell base station to receive preamble signals and synchronizing downlinks based on the received preamble signals while introducing femtocells in order to cover a shadow area in the room or existing cells and allowing the femtocell base station to transmit ranging signals to a macrocell base station and receive uplink synchronization information to secure uplink synchronization of terminals in order to maintain inter-carrier orthogonality while using different subcarriers or the same subcarriers having the same frequency band as macrocells, thereby excluding interference of unwanted signals.

BACKGROUND

[0003] An orthogonal frequency division multiple access system (hereinafter, referred to as "OFDMA") implements multiple access by providing a portion of subcarriers usable in OFDM, which is a special type of multicarrier transmission, to each user. A basic principle of the OFDM divides data streams having a high transmission rate into a large number of data streams having a low transmission rate and simultaneously transmits the data streams using a plurality of subcarriers. Symbol duration of the subcarriers having the low transmission rate is increased, such that relative signal dispersion is reduced over time occurring due to multipath delay spread. Inter-symbol interference may be removed by inserting a longer guard interval than delay spread of a channel between the OFDM symbols and when replicating a portion of OFDM signals in the guard interval and disposing the replicated OFDM signal at a start portion of the symbol, the OFDM symbol is cyclically expanded to avoid inter-carrier interference.

[0004] The existing wideband code division multiple access system (hereinafter, referred to "WCDMA") does not cause any problem even though it is operated without synchronizing between the base station and the user.

[0005] However, in the OFDMA environment, time synchronization of transmitting and receiving ends has a great effect on performance of the system. In the OFDMA environment, when the time synchronization of the transmitting and receiving ends are not performed, the orthogonality between respective subcarriers is lost, thereby deteriorating the performance of the system. Meanwhile, in the mobile communication environment, when there is a shadow area in the room or the existing macrocell in the state where the exiting macrocell base station is present, a need exists for a base station having low power and short coverage in order to solve the problem. The base station is referred to as a femtocell base station.

[0006] When the femtocell base station uses the same frequency band as the macrocell base station, there may be a problem in that the orthogonality between the OFDMA subcarriers are lost due to the difference in the receiving and transmitting timing between the femtocell terminal and the macrocell base station.

[0007] FIG. **1** is a conceptual diagram for describing a general process of synchronizing between a base station and a terminal at a downlink and an uplink in the OFDMA environment.

[0008] Referring to FIG. **1**, terminal **1 102** performs time synchronization of the downlink based on a timing when the terminal **1** receives a preamble signal P from a base station **101**. In addition, the terminal **1 102** transmits a ranging signal R to the base station **101** and the base station **101** measures the ranging signal to transmit uplink synchronization information S to the terminal **1 102**, thereby performing the time synchronization of the uplink.

[0009] FIG. **2** is a conceptual diagram for describing interference occurring due to inter-carrier asynchronization at the downlink when the femtocell is present in the macrocell region. In FIGS. **2** and **3**, CP implies Cyclic Prefix replicating a portion of an OFDM signal.

[0010] A femtocell **210** is present at any position within a macrocell **200**.

[0011] A terminal **1 202** communicates with a macrocell base station **201** and a terminal **2 212** communicates with a femtocell base station **211**. In this case, the terminal **1 202** and the terminal **2 212** use different subcarriers and the same subcarriers having the same frequency band to communicate with each corresponding base station.

[0012] In this case, the terminal **2 212** may also receive a signal **221** transmitted from the macrocell base station **201** in addition to a signal **222** transmitted from the femtocell base station **211** and the interference of the signal **221** transmitted from the macrocell base station **201** should be removed. However, when the time synchronization between both signals **221** and **222** is not performed (represented by area A), there are problems in that the inter-carrier orthogonality is lost and the inter-carrier interference occurs.

[0013] In addition, the terminal **1 202** may also receive a signal **231** transmitted from the femtocell base station **211** in addition to a signal **232** transmitted from the macrocell base station **201** and the interference of the signal **231** transmitted from the femtocell base station **211** should be removed. However, when the time synchronization between both signals **231** and **232** is not performed (represented by area B), there are problems in that the inter-carrier orthogonality is lost and the inter-carrier interference occurs.

[0014] FIG. **3** is a conceptual diagram for describing interference occurring due to inter-carrier asynchronization at the uplink when the femtocell is present in the macrocell region.

[0015] Similarly, a femtocell **310** is present at any position within a macrocell **300**.

[0016] The macrocell base station **301** may receive a signal **320** transmitted from terminal **2 312** in addition to a signal **321** transmitted from terminal **1 302** and the interference of the signal **320** transmitted from the terminal **2 312** should be removed. However, when the time synchronization between both signals **320** and **321** is not performed (represented by area C), there are problems in that the inter-carrier orthogonality is lost and the inter-carrier interference occurs.

[0017] In addition, the femtocell base station **311** may also receive a signal **330** transmitted from the terminal **1 302** in addition to a signal **331** transmitted from the terminal **2 312** and the interference of the signal **330** transmitted from the terminal **1 302** should be removed. However, when the time synchronization between both signals **330** and **331** is not performed (represented by area D), there are problems in that the inter-carrier orthogonality is lost and the inter-carrier interference occurs.

SUMMARY

[0018] The present invention has been made in an effort to provide a method of synchronizing a femtocell base station and a femtocell base station using the same capable of excluding unwanted interference of signals by maintaining inter-carrier orthogonality while introducing a femtocell in order to cover a shadow area in the room or existing cells and using different subcarriers or the same subcarriers having the same frequency band as a macrocell.

[0019] An exemplary embodiment of the present invention provides a method of synchronizing a femtocell base station, including: allowing a femtocell base station to receive preamble signals from a macrocell base station in an orthogonal frequency division multiple access (OFDMA) communication system in which a femtocell is present in a macrocell; and allowing the femtocell base station to transmit a symbol to a terminal belonging to the femtocell by performing time synchronization with the preamble signal to secure the time synchronization of the femtocell base station.

[0020] The femtocell may use the same frequency band as the macrocell.

[0021] The femtocell may perform transmission using subcarriers different from the macrocell.

[0022] The femtocell may perform transmission using the same subcarriers as the macrocell.

[0023] Another exemplary embodiment of the present invention provides a method of synchronizing a femtocell base station, including: allowing a femtocell base station to transmit a ranging signal to a macrocell base station in an orthogonal frequency division multiple access (OFDMA) communication system in which a femtocell is present in a macrocell; allowing the macrocell base station to transmit uplink synchronization information to the femtocell base station; and allowing the femtocell base station to instruct uplink synchronization to a terminal belonging to the femtocell to secure time synchronization of the femtocell base station.

[0024] The femtocell may use the same frequency band as the macrocell.

[0025] The femtocell may perform transmission using subcarriers different from the macrocell.

[0026] The femtocell may perform transmission using the same subcarriers as the macrocell.

[0027] Yet another exemplary embodiment of the present invention provides a femtocell base station present in a macrocell, including: a deframe generator extracting a preamble signal from a symbol received from a macrocell base station; and a synchronizer performing downlink synchronization to a terminal belonging to the femtocell based on the preamble signal, which is an output of the deframe generator.

[0028] The femtocell base station may further include: a ranging signal generator generating a ranging signal to be transmitted to the macrocell base station; and a frame generator configuring a frame using the transmitted data and the ranging signal, wherein the synchronizer acquires uplink synchronization information from the macrocell base station according to the ranging signal to further perform the uplink synchronization to a terminal belonging to the femtocell.

[0029] The femtocell base station may further include: a demodulator demodulating the symbol received from the macrocell base station and transmitting the demodulated symbol to the deframe generator, and a detector and decoder detecting and decoding data output from the deframe generator.

[0030] The femtocell base station may further include a coding and symbol mapping unit transmitting the transmitted data and the ranging signal output from the ranging signal generator to the frame generator.

[0031] The femtocell base station may further include a modulator modulating a frame output from the frame generator to configure a transmitting symbol.

[0032] As set forth above, the exemplary embodiments of the present invention allows the femtocell base station to receive the preamble signals and performs the downlink synchronization based on the received preamble signals while introducing the femtocells in order to cover the shadow area in the room or existing cells, thereby making it possible to exclude the interference of unwanted signals by maintaining orthogonality between subcarriers while using different subcarriers or the same subcarriers having the same frequency band as the macrocells.

[0033] Further, the exemplary embodiments of the present invention allows the femtocell base station to transmit the ranging signal to the macro cell base station and receive the uplink synchronization information to secure the uplink synchronization of the terminal in order to the inter-carrier orthogonality, thereby making it possible to exclude the unwanted interference of signals.

BRIEF DESCRIPTION OF THE DRAWINGS

[0034] FIG. **1** is a conceptual diagram for describing a general process of synchronizing between a base station and a terminal at a downlink and an uplink in an OFDMA environment;

[0035] FIG. **2** is a conceptual diagram for describing interference occurring due to inter-carrier asynchronization at the downlink when a femtocell is present in a macrocell region;

[0036] FIG. **3** is a conceptual diagram for describing interference occurring due to inter-carrier asynchronization at the uplink when the femtocell is present in the macrocell region;

[0037] FIG. **4** is a conceptual diagram for describing a method of allowing a femtocell base station to perform synchronization at a downlink, according to an exemplary embodiment of the present invention;

[0038] FIG. **5** is a conceptual diagram for describing a method of allowing a femtocell base station to perform synchronization at an uplink, according to an exemplary embodiment of the present invention; and

[0039] FIG. **6** is a block diagram of a femtocell base station according to an exemplary embodiment of the present invention.

DETAILED DESCRIPTION

[0040] Exemplary embodiments of the present invention allows a femtocell base station to perform synchronization to reduce deterioration in performance due to asynchronization between a user of a femtocell and a user of a macrocell.

[0041] The femtocell base station according to the exemplary embodiments of the present invention performs synchronization so as not to be affected by interference from the user of the macrocell or so as to minimize the influence of the interference from the user of the macrocell when communicating with the user of the femtocell. That is, a downlink start timing of the femtocell base station matches a receiving timing from the macrocell base station and an uplink start timing of a terminal present in the femtocell matches a timing similar to a terminal present in the macrocell.

[0042] Hereinafter, exemplary embodiments of the present invention will be described in detail with reference to the accompanying drawings. First of all, it is to be noted that in giving reference numerals to elements of each drawing, like reference numerals refer to like elements even though like elements are shown in different drawings. Further, in describing the present invention, well-known functions or constructions will not be described in detail since they may unnecessarily obscure the understanding of the present invention. Hereinafter, the exemplary embodiment of the present invention will be described, but it will be understood to those skilled in the art that the spirit and scope of the present invention are not limited thereto and various modifications and changes can be made.

[0043] The present invention relates to a method of synchronizing a femtocell base station and a femtocell base station using the same capable of allowing the femtocell base station to receive preamble signals and synchronizing downlinks based on the received preamble signals while introducing femtocells in order to cover a shadow area in the room or existing cells and allowing the femtocell base station to transmit ranging signals to a macrocell base station and receive uplink synchronization information to secure uplink synchronization of terminals in order to maintain inter-carrier orthogonality while using different subcarriers or the same subcarriers having the same frequency band as macrocells, thereby excluding interference of unwanted signals.

[0044] To this end, the exemplary embodiment of the present invention provides a method of synchronizing a femtocell base station securing time synchronization of a femtocell base station by allowing the femtocell base station to transmit a symbol to a terminal belonging to the femtocell by performing the time synchronization with a preamble signal when the femtocell base station receives the preamble signal from the macrocell base station in an orthogonal frequency division multiple access (OFDMA) communication system in which a femtocell is present in a macrocell.

[0045] FIG. **4** is a conceptual diagram for describing a method of allowing a femtocell base station to perform synchronization at a downlink, according to an exemplary embodiment of the present invention.

[0046] A femtocell **410** is present at any position within a macrocell **400**.

[0047] A terminal **1 402** communicates with a macrocell base station **402** and a terminal **2 412** communicates with a femtocell base station **411**. In this case, the terminal **1 402** and the terminal **2 412** use different subcarriers and the same subcarriers having the same frequency band to communicate with each corresponding base station.

[0048] In this case, the terminal **2 412** may also receive a signal transmitted from the macrocell base station **401** in addition to a signal transmitted from the femtocell base station **411** and the interference of a signal transmitted from the macrocell base station **401** should be removed. In order for the terminal **2 412** to remove the interference of the signal transmitted from the macrocell base station **401**, the starting point of signal transmitted from the macrocell base station **401** is to be in the CP of the signal transmitted from the femtocell base station **411**.

[0049] To this end, the femtocell base station **411** receives a preamble signal P from the macrocell base station **401** and performs time synchronization with the received preamble signal P to transmit a symbol to the terminal **2 412**, thereby securing the time synchronization. That is, the femtocell base station **411** performs a role of a kind of terminal present in the macrocell **400**.

[0050] A distance between the femtocell base station **411** and the terminal **2 412** is relatively very short as compared to a distance between the macrocell base station **401** and the terminal **1 402**. Therefore, when the downlink start timing of the femtocell base station **411** for the terminal **2 412** matches the receiving timing of the preamble signal P from the macrocell base station **401**, the signal transmitted from the femtocell base station **411** synchronizes with the signal transmitted from the macrocell base station **401** in view of the terminal **2 412**. That is, in the case of the terminal **2 412**, the CP interval of the signal received from the femtocell base station **411** and the signal received from the macrocell base station **401** overlaps with each other, such that the receiving timing of both signals is present in a guard interval of an OFDM symbol. As a result, both signals maintains inter-carrier orthogonality, such that the terminal **2 412** may remove the interference of the signal received from the macrocell base station **401** at the signal received from the femtocell base station **411**.

[0051] When the terminal **1 402** and the terminal **2 412** use different subcarriers, they do not cause interference with each other if there is the inter-carrier orthogonality. Even when the terminal **1 402** and the terminal **2 412** use the same subcarriers, they use a method such as an interference cancellation method, thereby making it possible to successfully perform communication.

[0052] FIG. **5** is a conceptual diagram for describing a method of allowing a femtocell base station to perform synchronization at an uplink, according to an exemplary embodiment of the present invention.

[0053] A femtocell **510** is present at any position within a macrocell **500**. When the terminal **1 502** and the terminal **2 512** transmit the signal to different base stations at a position adjacent to each other, a case where synchronization is not performed at different base stations may occur.

[0054] The macrocell base station **501** may receive a signal transmitted from terminal **2 512** in addition to a signal transmitted from terminal **1 502** and the interference of the signal transmitted from the terminal **2 512** should be removed. To this end, both signals transmitted from the terminal **1 502** and the terminal **2 512** may be synchronized in terms of the macrocell base station **501** by adjusting the uplink transmitting timing of the terminal **2 512** to be similar to the uplink transmitting timing of the terminal **1 502**.

[0055] To this end, the femtocell base station **511** serves as a kind of terminal. That is, the femtocell base station **511** transmits the ranging signal R to the macrocell base station **501** to transmit the uplink signal. Through this, the macrocell base station **501** recognizes that the terminal belonging to the femtocell base station **511** has data to be transmitted to the uplink and transmits the uplink synchronization information S to the femtocell base station **511** in consideration of the transmitting timing of the terminal **1 502**. The femtocell base station **511** transmits the uplink synchronization information S to the terminal **2 512** to instruct the uplink synchronization to the terminal **2 512**. The terminal **2 512** holds the uplink transmitting timing according to the received uplink synchronization information S to transmit data.

[0056] As a result, the uplink transmitting timing of the terminal **2 512** is similar to the uplink transmitting time of the terminal **1 502** at a position adjacent thereto. That is, in the case of the macrocell base station **501**, the CP interval of the signal received from the terminal **1 502** and the signal received from the terminal **2 512** overlaps with each other, such that the receiving timing of both signals is present in the guard interval of an OFDM symbol. As a result, both signals maintains inter-carrier orthogonality, such that the macrocell base station **501** may remove the interference of the signal received from the terminal **2 512** at the signal received from the terminal **1 502**.

[0057] When the macrocell **500** and the femtocell **510** uses different subcarriers, they do not cause interference with each other if there is the inter-carrier orthogonality. Even when the macrocell **500** and the femtocell **510** use the same subcarriers, it is already mentioned that they can successfully perform the communication by using the method such as the interference cancellation method.

[0058] FIG. **6** is a block diagram of a femtocell base station according to an exemplary embodiment of the present invention.

[0059] A femtocell base station **600** according to the exemplary embodiment of the present invention, referring to FIG. **6**, is configured to include a coding and symbol mapping unit **601**, a ranging signal generator **602**, a frame generator **603**, a modulator **604**, a transmitting and receiving separator **605**, a baseband signal block **606**, and an RF transceiver **607**. In addition, the femtocell base station **600** is configured to include a detector and decoder **608**, a deframe generator **609**, a synchronizer **610**, a demodulator **611**, and a controller **612**.

[0060] The ranging signal generator **602** is a device that generates the transmitted ranging signal to allow the femtocell base station **600** to receive the uplink synchronization information from the macrocell base station.

[0061] The coding and symbol mapping unit **601** codes the transmitted data and the ranging signal output from the ranging signal generator **602** and performs the symbol mapping thereon to output it to the frame generator **603**. The frame generator **603** uses the transmitted data and the ranging signal to configure the frame and then, output it to the modulator **604**.

[0062] The modulator **604** modulates the frame output from the frame generator **603** and uses the pulse shaping filter to configure the transmitting symbol and then, output it to the transmitting and receiving separator **605**.

[0063] The synchronizer **610** obtains the uplink synchronization information of the terminal from the uplink synchronization information obtained from the macrocell base station.

[0064] The transmitting and receiving separator **605** transmits the transmitting symbol to the terminal through the RF transceiver **607** via the baseband signal block **606** according to the transmitting and receiving time information received from the controller **612**.

[0065] Meanwhile, the symbol transmitted from the terminal and received in the RF transceiver **607** is transmitted to the transmitting and receiving separator **605** through the baseband signal block **606**. Thereafter, the received symbol is demodulated through the demodulator **611** and is then transmitted to the deframe generator **609**. The deframe generator **609** extracts the preamble signal from the receiving symbol and transmits it to the synchronizer **610**.

[0066] The synchronizer **610** performs the downlink synchronization to the terminal based on the preamble signal, which is an output of the deframe generator **609**. The detector and decoder **608** detects and decodes the data signal and the control signal output through the deframe generator **608**.

[0067] The exemplary embodiment of the present invention relates to the femtocell base station actively introduced by the mobile communication service providers and can solve the interference problem between the femtocell base station and the existing cell, such that it can be prevalently applied to a mobile communication field.

[0068] As described above, the exemplary embodiments have been described and illustrated in the drawings and the specification. Herein, specific terms have been used, but are just used for the purpose of describing the present invention and are not used for defining the meaning or limiting the scope of the present invention, which is disclosed in the appended claims. Therefore, it will be appreciated to those skilled in the art that various modifications are made and other equivalent embodiments are available. Accordingly, the actual technical protection scope of the present invention must be determined by the spirit of the appended claims.

What is claimed is:

1. A method of synchronizing a femtocell base station, comprising:

allowing a femtocell base station to receive preamble signals from a macrocell base station in an orthogonal frequency division multiple access (OFDMA) communication system in which a femtocell is present in a macrocell; and

allowing the femtocell base station to transmit a symbol to a terminal belonging to the femtocell by performing time synchronization with the preamble signal to secure the time synchronization of the femtocell base station.

2. The method of claim **1**, wherein the femtocell uses the same frequency band as the macrocell.

3. The method of claim **2**, wherein the femtocell performs transmission using subcarriers different from the macrocell.

4. The method of claim **2**, wherein the femtocell performs transmission using the same subcarriers as the macrocell.

5. A method of synchronizing a femtocell base station, comprising:

allowing a femtocell base station to transmit a ranging signal to a macrocell base station in an orthogonal frequency division multiple access (OFDMA) communication system in which a femtocell is present in a macrocell;

allowing the macrocell base station to transmit uplink synchronization information to the femtocell base station; and

allowing the femtocell base station to instruct uplink synchronization to a terminal belonging to the femtocell to secure time synchronization of the femtocell base station.

6. The method of claim **5**, wherein the femtocell uses the same frequency band as the macrocell.

7. The method of claim **6**, wherein the femtocell performs transmission using subcarriers different from the macrocell.

8. The method of claim **6**, wherein the femtocell performs transmission using the same subcarriers as the macrocell.

9. A femtocell base station present in a macrocell, comprising:

a deframe generator extracting a preamble signal from a symbol received from a macrocell base station; and

a synchronizer performing downlink synchronization to a terminal belonging to the femtocell based on the preamble signal, which is an output of the deframe generator.

10. The femtocell base station of claim **9**, further comprising:

a ranging signal generator generating a ranging signal to be transmitted to the macrocell base station; and

a frame generator configuring a frame using the transmitted data and the ranging signal,

wherein the synchronizer acquires uplink synchronization information from the macrocell base station according to the ranging signal to further perform the uplink synchronization to a terminal belonging to the femtocell.

11. The femtocell base station of claim **9**, further comprising:

a demodulator demodulating the symbol received from the macrocell base station and transmitting the demodulated symbol to the deframe generator; and

a detector and decoder detecting and decoding data output from the deframe generator.

12. The femtocell base station of claim **10**, further comprising a coding and symbol mapping unit transmitting the transmitted data and the ranging signal output from the ranging signal generator to the frame generator.

13. The femtocell base station of claim **12**, further comprising a modulator modulating a frame output from the frame generator to configure a transmitting symbol.

* * * * *