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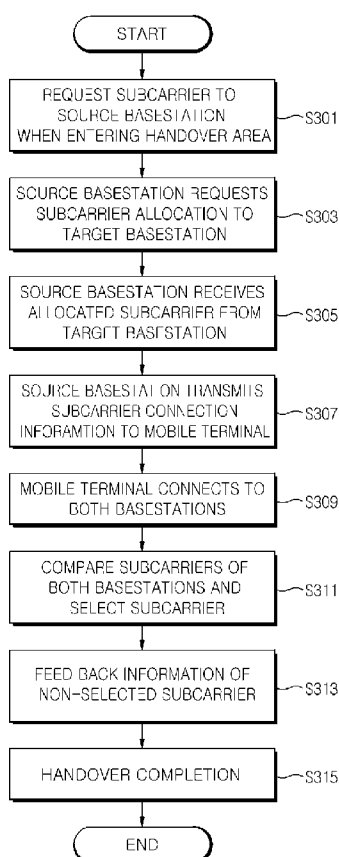
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(54) Title: METHOD FOR HANDOVER IN MULTICARRIER-BASED MOBILE COMMUNICATION SYSTEM AND MOBILE COMMUNICATION TERMINAL THEREFOR



(57) Abstract: The present invention relates to a method for handover in a multicarrier-based mobile communication system and a mobile communication terminal therefor, and the method for handover of a mobile communication terminal in a multicarrier-based mobile communication system according to the present invention includes the steps for receiving subcarriers allocated from a target base station when the mobile communication terminal enters a handover area; comparing subcarriers allocated from a source base station with the subcarriers allocated from the target base station to select a subcarrier having a strong channel gain; and feeding back information of a unselected subcarrier to a base station which has allocated the corresponding subcarrier. Accordingly, the present invention obtains a channel gain for each subcarrier and eliminates an interference amount to improve performance of the system.



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Description

METHOD FOR HANDOVER IN MULTICARRIER-BASED MOBILE COMMUNICATION SYSTEM AND MOBILE COMMUNICATION TERMINAL THEREFOR

Technical Field

- [1] The present invention relates to a handover technique in a multicarrier-based mobile communication system, and in particular, to a method for handover in a multicarrier-based mobile communication system having different channel gain for each subcarrier and a mobile communication terminal therefor.

Background Art

- [2] When a mobile communication terminal moves from a serving cell (or sector) to another cell (or sector), a process of transferring a traffic channel to the second cell so as to maintain a call is referred to as handover or handoff.
- [3] In a mobile communication service system, a handoff determining standard includes a received signal strength, an averaging dimension, a threshold, or a hysteresis margin. A handoff determining algorithm is suggested by combination of these standards and used in the mobile communication service system.
- [4] First, a relative signal strength comparing method selects a strongest signal among signals which have reached a base station in any case. The strongest signal is selected using an averaged value of the received signals.
- [5] Next, a signal strength comparing method including a threshold performs handover in the case that a received signal strength of a currently connected base station is smaller than a threshold and a received signal strength of another base station is larger than the received signal strength of the currently connected base station.
- [6] Next, a signal strength comparing method including a hysteresis performs handover only in the case that a received signal strength of a new base station is sufficiently larger than a received signal strength of a currently connected base station. This method may prevent a ping-pong effect (i.e. a repetitive handover phenomenon) caused by rapid vibration of received signal strength of the two base stations.
- [7] Next, a signal strength comparing method including a hysteresis and a threshold performs handover in the case that a received signal strength of a currently connected base station is smaller than a threshold, and a received signal strength of a new base station is larger than the received signal strength of the currently connected base station by a preset hysteresis margin.
- [8] As such, in a cellular mobile communication system, handover supports mobility of a user and increases the capacity of a system according to techniques, and thus is

handled as an important issue.

[9] However, conventional studies related to handover are mainly about a CDMA (Code Division Multiple Access) system, and in the case of a CDMA system, a characteristic by frequency selective fading is averaged out in a despreading process, and thus there is a limitation in applying a handover technique used in the CDMA to an OFDMA (Orthogonal Frequency Division Multiple Access) system.

[10] A conventional CDMA mobile communication system uses a single carrier, and thus uses an averaged value of received signal strength over the whole bandwidth so as to determine whether to perform handover. However, an OFDMA mobile communication system uses a plurality of subcarriers having orthogonal frequencies and different channel gains, and thus different received signal strength for each subcarrier should be individually considered, but if the above-mentioned handover technique used in CDMA is applied to the OFDMA mobile communication system, an unnecessary power loss is disadvantageously generated at every handover.

[11] Therefore, it requires development of a handover method available for different channel gain for each subcarrier in an OFDMA mobile communication system having different channel gain for each subcarrier.

Disclosure of Invention

Technical Problem

[12] The present invention is designed to solve the above-mentioned problems, and therefore it is an object of the present invention to provide a method for handover in a multicarrier-based mobile communication system which performs handover by each subcarrier to obtain a channel gain and reduce an interference amount, thereby improving performance of the system, and a mobile communication terminal therefor.

Technical Solution

[13] In order to achieve the above-mentioned objects, a method for handover of a mobile communication terminal in a multicarrier-based mobile communication system according to the present invention includes the steps for the mobile communication terminal receiving subcarriers allocated from a target base station when entering a handover area; comparing subcarriers allocated from a source base station with the subcarriers allocated from the target base station to select a subcarrier to be used during handover; and feeding back information of a unselected subcarrier to a base station which has allocated the corresponding subcarrier.

[14] And, a mobile communication terminal for performing handover in a multicarrier-based mobile communication system according to the present invention includes a received power measuring means for measuring channel gains of subcarriers received from a source base station and channel gains of subcarriers received from a target base

station; a subcarrier selecting means for comparing the subcarriers received from the source base station with the subcarriers received from the target base station to select a subcarrier to be used during handover; and a feedback means for feeding back information of a subcarrier not selected by the subcarrier selecting means to a base station that has transmitted the corresponding subcarrier.

- [15] Further, a recording medium for recording a program readable by a mobile communication terminal for performing handover in a multicarrier-based mobile communication system according to the present invention has a first function for receiving subcarriers allocated from a target base station when the mobile communication terminal enters a handover area; a second function for comparing subcarriers allocated from a source base station with the subcarriers allocated from the target base station to select a subcarrier to be used during handover; and a third function for feeding back information of a unselected subcarrier to a base station that has allocated the corresponding subcarrier.

Brief Description of the Drawings

- [16] Preferred embodiments of the present invention will be more fully described in the following detailed description, taken accompanying drawings. However, it should be understood that the description proposed herein is just a preferable example for the purpose of illustrations only, not intended to limit the scope of the invention. In the drawings:
- [17] FIG. 1 is a view of an example illustrating signals received from interference base stations of IIG and OIG.
- [18] FIG. 2 is a graph of an example illustrating a normalized relative interference amount according to traffic load.
- [19] FIG. 3 is a flowchart illustrating a method for handover in accordance with a preferred embodiment of the present invention.
- [20] FIG. 4 is a block diagram illustrating a main configuration of a mobile communication terminal in accordance with an exemplary embodiment of the present invention.

Best Mode for Carrying Out the Invention

- [21] Hereinafter, preferred embodiments of the present invention will be described in detail with reference to the accompanying drawings. Prior to the description, it should be understood that the terms used in the specification and the appended claims should not be construed as limited to general and dictionary meanings, but interpreted based on the meanings and concepts corresponding to technical aspects of the present invention on the basis of the principle that the inventor is allowed to define terms appropriately for the best explanation. Therefore, the description proposed herein is just a

preferable example for the purpose of illustrations only, not intended to limit the scope of the invention, so it should be understood that other equivalents and modifications could be made thereto without departing from the spirit and scope of the invention.

- [22] A method for handover in an OFDMA cellular system according to the present invention uses the facts (1) that an interference amount affecting each subcarrier is in proportion to traffic load, and (2) that channel gains are different by each subcarrier in the OFDMA cellular system.
- [23] First of all, a characteristic of a multi-cell interference in an OFDMA cellular system is described.
- [24] Interference base stations are defined as all base stations to which a mobile communication terminal is not connected. A signal transmitted to a mobile communication terminal from an interference base station ρ separated by distance r_p experiences propagation delay of $\Delta_p = r_p / c$, where c is a velocity of propagation of electromagnetic waves.
- [25] The interference base stations in an OFDMA system may be divided into two groups according to a relation between Δ_p and T_{CP} (length of Cyclic Prefix).
- [26] A first interference group is located relatively close to a mobile communication terminal, and thus a propagation delay time is shorter than T_{CP} even though a multi-path delay time is added to the propagation delay time. Such interference group is referred to as an inner interference group (hereinafter referred to as 'IIG'). A base station ρ of IIG satisfies
- [27] $\Delta_p + \tau_{\max} \leq T_{CP}$ for $\rho \in \text{IIG}$
- [28] where Δ_p is a propagation time, and $\tau_{\max}$ is a multi-path delay time.
- [29] A second interference group is separated from a mobile communication terminal, and thus a propagation delay time (Δ_p) is longer than T_{CP} . Such interference group is referred to as an outer interference group (hereinafter referred to as 'OIG'). A base station ρ of OIG satisfies
- [30] $\Delta_p > T_{CP}$ for $\rho \in \text{OIG}$
- [31] FIG. 1 is a view of an example illustrating signals received from interference base stations of IIG and OIG, and (a) of FIG. 1 represents a signal received from a currently connected base station (hereinafter referred to as 'a source base station'), (b) represents a signal received from an inner interface base station, and (c) represents a signal received from an outer interface base station.
- [32] As shown in (b) of FIG. 1, a sum of a propagation delay time and a multi-path delay time of a signal transmitted from an interference base station ρ of IIG to a mobile communication terminal is smaller than a time length of CP (Cyclic Prefix), and thus there is no interference between adjacent data symbols ($X_{\rho,0}, X_{\rho,-1}$), and as shown in (c) of FIG. 1, a sum of a propagation delay time and a multi-path delay time of a signal

transmitted from an interference base station ρ of OIG to a mobile communication terminal is larger than a time length of CP, and thus an interference is generated between adjacent data symbols ($x_{\rho,0}, x_{\rho,1}$).

[33]

[34] (1) Interference from interference base station of IIG

[35] A signal from an interference base station ρ of IIG is received within T_{CP} , and thus the received signal is given by

[36] [Formula 1]

[37]

$$Y_{p,i}(m) = \sqrt{L_i(r_p)} H_{p,i}(m) X_{p,i}(m) e^{-2\pi\Delta_p m} + N(k).$$

[38]

where m is an identifier of a subcarrier, Δ_p is a propagation delay time taken to receive a signal from an interference base station ρ to a mobile communication terminal, $X_{p,i}$ is a signal that the interference base station ρ carries on the subcarrier m , $H_{p,i}$ is a channel gain that the subcarrier m is experienced by an ambient microwave reflective environment, $L_i(r_p)$ is attenuation and shadow fading of a signal according to distance when the interference base station ρ is separated from the mobile communication terminal by distance r , and $N(k)$ is a white noise in the mobile communication terminal.

[39]

As described above, a signal from the interference base station of IIG is received within T_{CP} , and thus an Inter Symbol Interference (ISI) is not generated, but a co-channel interference (hereinafter referred to as 'CCI') affecting subcarrier-to-subcarrier is generated. At this time, the total interference amount that the interference base station of IIG affects the subcarrier m in use, which is allocated from the interference base station to which the mobile communication terminal is currently connected, is given by

[40]

[Formula 2]

[41]

$$I_{IIG}(m) = E \left[\left| \sum_p^{P_{IIG}} \sqrt{L_i(r_p)} H_{p,i}(m) X_{p,i}(m) e^{-2\pi\Delta_p m} \right|^2 \right]$$

[42]

where P_{IIG} is the number of all base stations of IIG.

[43]

If signals transmitted from different base stations have no correlation to each other, and even though signals are transmitted from the interference base station ρ , the signals have no correlation between OFDMA symbols, the total interference amount received from the interference base stations of IIG is given by

[44]

[Formula 3]

[45]

$$I_{\text{IG}}(m) = \sum_p F[\eta_p]$$

[46] where η_p is a channel gain of the subcarrier m when the interference base station p carries data on the subcarrier m .

[47]

[48] (2) Interference from interference base station of OIG

[49] As illustrated in FIG. 1, a signal received from an interference base station of OIG is different from a signal received from an interference base station of IIG. Δ_p is longer than T_{CP} , and thus besides an i th symbol being currently received, a portion of an $i-1$ th symbol affects. Both of a portion of an i th symbol and a portion of an $i-1$ th symbol are included in a fast fourier transform (FFT) integral calculus area, and thus the i th symbol and the $i-1$ th symbol affect each other, thereby generating an Inter Symbol Interference (hereinafter referred to as 'ISI'). Further, ISI in an OFDMA system breaks orthogonality between subcarriers, thereby generating interference between signals carried on the subcarriers, which is referred to as Inter Channel Interference (hereinafter referred to as 'ICI'). ICI means that leakage of power carried on a subcarrier affects all of the other subcarriers. This is different from the interference of interference base stations of IIG, in that the interference of interference base stations of IIG is CCI affecting subcarrier-to-subcarrier.

[50] Assuming that OIG has the total P_{OIG} number of interference base stations, a signal received from the interference base station p of OIG in time domain is given by

[51] [Formula 4]

[52]

$$y_{p,i}(t) = \sqrt{L_i(r_p)} \sum_{l=0}^{L_i-1} h_{p,i,l}(t - \Delta_p) x_{p,i}(t - \Delta_p - \tau_l) + n(t)$$

[53] where $n(t)$ is a complex gaussian noise and has $N_0/2$ of power spectral density, L is a L st channel among the L number of multi-path, and i is time of a transmitted symbol. A value which is carried on the m th subcarrier and transmitted during a demodulation process of $y_{p,i}(t)$, is given by

[54] [Formula 5]

[55]

$$Y_{p,i}(m) = \frac{1}{\sqrt{T_u}} \int_{T_s}^{T_s+T_u} y_{p,i}(t) e^{-j2\pi f_m(t-T_s)} dt$$

[56] where T_s is a length of an OFDM symbol including CP, T_u is a length of an OFDM symbol with CP subtracted from T_s , and f_m is a frequency of the m th subcarrier.

[57] At this time, Δ_p is larger than T_{CP} , and thus a portion of an i th symbol and a portion of an $i-1$ th symbol among two consecutive transmitted symbols enter a fast fourier transform (FFT) integral calculus area. Accordingly, $y_{p,i}(t)$ is separately expressed into

an i th symbol part and an $i-1$ th symbol part. To check influence that a subcarrier k has ICI by ISI on the subcarrier m , a signal of time domain corresponding to the subcarrier k is given by

[58] [Formula 6]

[59]

$$y_p(t - \tau_l) | -\Delta_p \leq t \leq -T_{CP} + \tau_l = \frac{1}{\sqrt{T_u}} X_{p,-1}(k) e^{j2\pi f_k(t - \tau_l + T_s)} \quad , \quad p \in OIG$$

$$y_p(t - \tau_l) | -T_{CP} + \tau_l \leq t \leq T_u - \Delta_p = \frac{1}{\sqrt{T_u}} X_{p,0}(k) e^{j2\pi f_k(t - \tau_l)} \quad , \quad p \in OIG$$

[60] When the above [Formula 6] is substituted for [Formula 5], influence that power carried on the k th subcarrier by the interference base station p has on the m th subcarrier of the mobile communication terminal connected to the source base station, is given by

[61] [Formula 7]

[62]

$$I_{OIG}(m)$$

$$= \frac{1}{\sqrt{T_u}} \sqrt{L_{-1}(r_p)} \int_{-\Delta_p}^{-T_{CP} + \tau_l} \left[\sum_{l=0}^{L-1} h_{p,-1,l} X_{p,-1}(k) e^{j2\pi f_k(t - \tau_l + T_s)} \right] e^{-j2\pi f_m(t - \Delta_p)} dt$$

$$+ \frac{1}{\sqrt{T_u}} \sqrt{L_0(r_p)} \int_{-T_{CP} + \tau_l}^{T_u - \Delta_p} \left[\sum_{l=0}^{L-1} h_{p,0,l} X_{p,0}(k) e^{j2\pi f_k(t - \tau_l)} \right] e^{-j2\pi f_m(t - \Delta_p)} dt$$

[63] From [Formula 7], interference from the base stations of OIG is given by

[64] [Formula 8]

[65]

$$I_{OIG}(m) = E[|Y_{OIG}(m)|^2]$$

$$= \sum_{p=0}^{P_{OIG}} \sum_{k \in S_p} \sum_{l=0}^{L-1} L_{-1}(r_p) |H_{p,-1,l}(k)|^2 \frac{1 - \cos(2\pi(f_k - f_m)(T_{CP} - \tau_l - \Delta_p))}{2\pi^2(k - m)^2}$$

$$+ \sum_{p=0}^{P_{OIG}} \sum_{k \in S_p} \sum_{l=0}^{L-1} L_0(r_p) |H_{p,0,l}(k)|^2 \frac{1 - \cos(2\pi(f_k - f_m)(T_{CP} - \tau_l - \Delta_p))}{2\pi^2(k - m)^2}$$

$$+ \sum_{l=0}^{L-1} (\Delta_p - T_{CP} + \tau_l)^2 L_{-1}(r_p) |H_{p,-1,l}(m)|^2 + \sum_{l=0}^{L-1} (T_u - \Delta_p - \tau_l)^2 L_0(r_p) |H_{p,0,l}(m)|^2$$

[66] In conclusion, an interference amount affecting the subcarrier m being used in the mobile communication terminal is given by [Formula 3] in the case of an interference base station of IIG, and is given by [Formula 8] in the case of an interference base station of OIG.

[67]

[68] (3) Traffic Dependent Interference Model

[69] An average traffic load ρ is defined as percentage of the number of subcarriers being currently used on the average to the number of the whole available subcarriers.

Thus, a value of ρ is between 0 and 1. A base station allocates a subcarrier to a mobile communication terminal at random, and thus assuming that a specific subcarrier is not used intensively, and instead all subcarriers are selected and allocated in an equal probability. On such an assumption, a probability that a specific subcarrier m is selected and allocated in a base station of $\rho = \rho_0$ is given by

[70] [Formula 9]

[71]

$$P\{m | \rho = \rho_0\} = 1 - \frac{\binom{N-1}{\rho_0 N}}{\binom{N}{\rho_0 N}} = \rho_0$$

[72] where N is the number of the whole subcarriers.

[73] [Formula 9] is calculated on the basis of an arbitrary subcarrier m , and thus can be applied to all of the subcarriers. In the case that all interference base stations have the equal ρ , an average interference amount is given by

[74] [Formula 10]

[75]

$$I(m) = \rho(I_{\text{IIG}}(m) + I'_{\text{OIG}}(m))$$

[76] [Formula 10] shows the whole interference amount increases in proportion to ρ . If a statistical information on a fading channel is given and the current distance between the mobile communication terminal and the interference base station is known, an interference amount can be calculated. It is possible to check an upward movement of interference according to traffic load more clearly through normalization of the interference amount. The normalized interference amount may be given by

[77] [Formula 11]

[78]

$$r_{\text{IIG}}(\rho) \cong A_{\text{IIG}} \cong \frac{I_0}{2}$$

$$r_{\text{OIG}}(\rho) = I_0 \left(\frac{10^{-\frac{\rho}{10}}}{1 + 10^{-\frac{\rho}{10}}} \right), 0 < \rho < \infty$$

[79] [Formula 11] shows a relative interference amount, i.e. a normalized relative interference amount in the case that a traffic load to an interference amount generated when the whole subcarriers are all used, is ρ . FIG. 2 is a graph of an example illustrating a normalized relative interference amount according to traffic load, and as shown in FIG. 2, as a value of a traffic load ρ increases, a normalized relative interference amount increases.

[80]

[81] In conclusion, interference is caused in an OFDMA system by a co-channel interference (CCI) from a subcarrier used by a base station of IIG, and an inter channel interference (ICI) by inter symbol interference (ISI) generated by a signal transmitted

from a base station of OIG that affects all subcarriers allocated from a source base station to a mobile communication terminal due to leakage of power. And, it is noted that an interference amount taken an affect of such interference into consideration increases linearly according to traffic load ρ .

[82]

[83] Therefore, the present invention selects a subcarrier having a strong channel gain among subcarriers allocated from a source base station and a target base station to obtain a gain, and feeds back information of a subcarrier unselected in a subcarrier selecting step to a base station so that the corresponding base station may not transmit data to the corresponding subcarrier to reduce the whole interference amount of a system, thereby improving performance of handover .

[84]

[85] (4) Handover Area

[86] An handover area where handover is performed according to the present invention, is determined by measuring a received signal strength (RSS) of a signal received from an adjacent base station.

[87]

A channel gain for each subcarrier between a source base station and a mobile communication terminal, and a channel gain for each subcarrier between a target base station and a mobile communication terminal are given by the following Formula 12]. In an OFDMA cellular system, a base station transmits a symbol, in which the whole front portion of each frame is composed of a pilot signal, so that the mobile communication terminal can measure a channel gain for each subcarrier, and when data is transmitted, the mobile communication terminal can estimate a channel gain of the other subcarrier using interpolation by a channel gain measured through a subcarrier carrying a pilot signal.

[88]

[Formula 12]

[89]

$$G_i(r_s; m) = L_i(r_s) R_{s,i}(m)$$

$$G_i(r_t; m) = L_i(r_t) R_{t,i}(m)$$

[90]

where $G_i(r_s; m)$ and $G_i(r_t; m)$ are channel gains of the subcarrier m allocated to the mobile communication terminal separated from the source base station and the target base station by distance r , respectively, $L_i(r_s)$ and $L_i(r_t)$ are attenuation and shadow fading of a signal according to distance when the mobile communication terminal is separated from the source base station and the target base station by distance r , respectively, and $R_{s,i}(m)$ and $R_{t,i}(m)$ are channel gains by Rayleigh fading from the source base station and the target base station, respectively.

[91]

An averaged channel gain for each subcarrier is given by the following [Formula

13]. In [Formula 13], a change in a channel gain by shadow fading and Rayleigh fading is averaged out, and thus a value of channel gain by the distance attenuation remains.

[92] [Formula 13]

[93]

$$\bar{G}_i(r_s) = \frac{1}{NF} \sum_{f=i-F-1}^i \sum_{m=0}^{N-1} G_f(r_s; m)$$

$$\bar{G}_i(r_t) = \frac{1}{NF} \sum_{f=i-F-1}^i \sum_{m=0}^{N-1} G_f(r_t; m)$$

[94] where N is the number of the whole subcarriers, and F is a length of a filter tap for averaging.

[95] A handover position is determined by comparing an averaged channel gain from the source base station with an averaged channel gain of the target base station. The mobile communication terminal is downloaded with the same signal from the source base station and the target base station while the mobile communication terminal satisfies

[96] [Formula 14]

[97]

$$\left| 10 \log_{10} \frac{\bar{G}_i(r_s)}{\bar{G}_i(r_t)} \right| \leq h [dB]$$

[98] where h is a handover critical value and determines the size of a handover area.

[99] To make sure of [Formula 14], a handover area A_{HO} is given by

[100] [Formula 15]

[101]

$$r_{HO}(h) \leq A_{HO} \leq \frac{D}{2}$$

$$r_{HO}(h) = D \left(\frac{10^{\frac{h}{10\alpha}}}{1 + 10^{\frac{h}{10\alpha}}} \right), 0 < h < \infty$$

[102] where $r_{HO}(h)$ is a distance between the mobile communication terminal and the source base station that the mobile communication terminal starts handover, and α is a distance attenuation coefficient.

[103]

[104] Hereinafter, a method for handover according to the present invention is described with reference to the accompanying drawings.

[105] FIG. 3 is a flowchart illustrating a method for handover in accordance with a preferred embodiment of the present invention.

[106] Referring to FIG. 3, when a mobile communication terminal moves from a cell

covered by a source base station toward a target base station and then enters a handover area, the mobile communication terminal transmits a subcarrier connection information request signal to the source base station (S301).

[107] That is to say, an OFDMA based mobile communication system is a communication version that a single user uses a plurality of subcarriers, and each base station allocates a subcarrier over the whole bandwidth in a frequency domain according to a transmission rate required by each user. When entering the handover area A_{HO} determined in the [Formula 15], the mobile communication terminal transmits a subcarrier connection information request signal to the source base station so that the mobile communication terminal is allocated with a subcarrier from the target base station.

[108] The source base station transmits a subcarrier allocation request to the target base station in response to the subcarrier connection information request of the mobile communication terminal (S303), and the target base station allocates a subcarrier set accessible by the mobile communication terminal and transmits a subcarrier allocation response including information of the allocated subcarrier to the source base station (S305). It is obvious that data may be transmitted and received between the source base station and the target base station through a base station controller or a switching center, in the same manner as a conventional soft handover method.

[109] Subsequently, the source base station receives the subcarrier allocation response from the target base station, and then generates a subcarrier connection information including the information of the subcarrier allocated by the target base station and transmits the subcarrier connection information to the mobile communication terminal so that the mobile communication terminal can perform handover by each subcarrier (S307). The mobile communication terminal connects to the target base station using the subcarrier connection information received from the source base station, and simultaneously maintains a connection state with the source base station and the target base station (S309). That is, the mobile communication terminal enables diversity reception.

[110] Next, the mobile communication terminal compares the subcarriers allocated by the source base station with the subcarriers allocated by the target base station to select a subcarrier to be used during handover (S311). At this time, where the number of subcarriers of a subcarrier group (S_s) allocated by the source base station and the number of subcarriers of a subcarrier group (S_t) allocated by the target base station are $N(S_s)$ and $N(S_t)$, respectively, the mobile communication terminal uses all methods suggested in the following examples 1, 2 and 3 as a method for comparing and selecting subcarriers of each subcarrier group.

[111] Example 1 of Subcarrier Selection

[112] In the case that the subcarriers can be compared one-to-one as $N(S_s)$ is equal to

$N(S_T)$, a method for selecting a subcarrier is given by

[113] [Formula 16]

[114]

$$S_S(m) = \arg \max_m \{G_S(m), G_T(m')\}$$

$$S_T(m') = \arg \max_{m'} \{G_S(m), G_T(m')\}$$

[115] where $G(m)$ is a channel gain of the subcarrier m , $S(m)$ is a subcarrier selected by the mobile communication terminal, a subscript S is the source base station, and a superscript T is the target base station.

[116] Example 2 of Subcarrier Selection

[117] The N_{required} number of subcarriers are selected in order of strength of channel gain among the subcarriers of the subcarrier group (S_S) allocated from the source base station and the subcarriers of the subcarrier group (S_T) allocated from the target base station. At this time, in the case that only a single subcarrier among the N_{required} number of subcarriers belongs to the subcarrier group (S_S) and the subcarrier group (S_T) at the same time, a base station having a stronger channel gain is selected and a subcarrier having an $N_{\text{required}+1}$ th strong channel gain is additionally selected, and thus a step for selecting the N_{required} number of subcarriers is completed. In the case that an arbitrary n number of subcarriers simultaneously belong to the subcarrier group (S_S) and the subcarrier group (S_T), an $N_{\text{required}+1}$ th subcarrier, an $N_{\text{required}+2}$ th subcarrier,..., an $N_{\text{required}+n}$ th subcarrier are additionally selected in the same manner as the above-mentioned step so that any subcarrier among the finally selected $N_{\text{required}+1}$ number of subcarriers does not belong to the subcarrier group (S_S) and the subcarrier group (S_T) at the same time.

[118] Example 3 of Subcarrier Selection

[119] All subcarriers having a channel gain beyond a critical value preset in a terminal to receive a corresponding demodulation technique are selected among the subcarriers of the subcarrier group (S_S) allocated from the source base station and the subcarriers of the subcarrier group (S_T) allocated from the target base station. At this time, in the case that any subcarrier among the selected subcarriers belongs to the subcarrier group (S_S) and the subcarrier group (S_T) at the same time, a base station having a stronger channel gain for a corresponding subcarrier is selected.

[120] After the mobile communication terminal selects a subcarrier to be used during handover among the subcarriers allocated from the source base station and the target base station, the mobile communication terminal transmits information of a unselected subcarrier to a corresponding base station (S313). That is, the mobile communication terminal feeds back information of the excluded subcarrier to a base station that has allocated the corresponding subcarrier, so that the corresponding base station may not transmit data to the corresponding subcarrier.

[121] In the step S309, in the case that the mobile communication terminal receives the same data from both of the base stations, the mobile communication terminal receives diversity when performing handover, thereby reducing a probability of signal outage in a cell boundary. However, both of the base stations transmit the same data for diversity, and thus double subcarriers are used, thereby increasing an interference amount as described above. In an aspect of a normalized interference amount defined in [Formula 11], the increasing interference amount is given by

[122] [Formula 17]

[123]

$$I_{\rho(h)}(m) = \left[\frac{r_{HO}^2(h)}{(D/2)^2} + \frac{(D/2)^2 - r_{HO}^2(h)}{D^2/2} \right] I_{\rho_0}(m)$$

[124] where $r_{HO}(h)$ is a distance between the mobile communication terminal and the source base station that the mobile communication terminal starts handover, D is a distance between the source base station and the target base station, and $I_{\rho_0}(m)$ is an interference amount affecting the subcarrier m in the case that a diversity technique is not used.

[125] Referring to the above [Formula 17], an interference amount increases $2 \cdot r_{HO}^2(h)/(D/2)^2$ times as much under the influence of diversity.

[126] However, in the step S313, the mobile communication terminal feeds back information of the unselected subcarrier among the subcarriers allocated from both base stations when handover, so that a corresponding base station does not transmit data to the corresponding subcarrier, thus an interference amount is not increased as suggested in the above [Formula 17].

[127] Referring to FIG. 3, the mobile communication terminal repeatedly performs the step S413 in the handover area (A_{HO}) to perform handover, and when the mobile communication terminal moves from the handover area, the mobile communication terminal stops a connection with the source base station to complete a final handover (S315).

[128]

[129] FIG. 4 is a block diagram illustrating a main configuration of a mobile communication terminal in accordance with an exemplary embodiment of the present invention. A mobile communication terminal shown in FIG. 4 includes a wireless receiving unit 401, a GI (Guard Interval) removing unit 403, a FFT unit 405, a demodulating unit 407, an encoding unit 409, a received power measuring unit 411, a handover controlling unit 413, a subcarrier allocation request signal generating unit 415, a subcarrier information generating unit 417, and a wireless transmitting unit 419. Hereinafter, operation of the above components is described based on a process for

handover of the mobile communication terminal of FIG. 4 while the mobile communication terminal moves from the source base station to the target base station.

[130] The wireless receiving unit 401 receives a signal from a base station through an antenna and performs signal processing including frequency downconversion or analogue-digital conversion, and the GI (Guard Interval) removing unit 403 removes a guard interval from a received signal processed by the wireless receiving unit 401.

[131] The FFT (Fast Fourier Transform) unit 405 performs a fast fourier transformation of an OFDM signal exclusive of the guard interval, and separates data carried on each subcarrier.

[132] The demodulating unit 407 demodulates data carried on each subcarrier that is performed of a fast fourier transformation and separated, and the encoding unit 409 encodes the demodulated data to output a received data.

[133] The received power measuring unit 411 measures a received power i.e. a channel gain for each subcarrier of the received signal, and outputs a measurement result to the handover controlling unit 413.

[134] The handover controlling unit 413 averages the received power of the subcarriers of the source base station and the target base station input by the received power measuring unit 411 to determine a handover area. That is, the handover controlling unit 413 determines the handover area based on the above [Formula 15].

[135] And, after the handover controlling unit 413 determines the handover area, the handover controlling unit 413 controls the subcarrier allocation request signal generating unit 415 to generate a subcarrier allocation request signal. The subcarrier allocation signal generated by the subcarrier allocation request signal generating unit 415 is transmitted to the source base station through the wireless transmitting unit 419. The source base station requests subcarrier allocation to the target base station, receives a response thereto and transmits subcarrier information allocated by the target base station to the mobile communication terminal. Accordingly, the mobile communication terminal of FIG. 4 connects to the source base station and the target base station in the handover area to receive the same data.

[136] Meanwhile, in the handover area, the handover controlling unit 413 compares channel gains the subcarriers of the source base station with channel gains of the subcarriers of the target basestataion input by the received power measuring unit 411 to select a subcarrier to be used during handover and feeds back information of a unselected subcarrier to a corresponding base station. That is, the handover controlling unit 413 notifies the unselected subcarrier to the subcarrier information generating unit 417. Here, a subcarrier selection method uses the above-mentioned examples 1, 2 and 3.

[137] The subcarrier information generating unit 417 generates information of the

subcarrier notified by the handover controlling unit 413, and transmits the information to a corresponding base station through the wireless transmitting unit 419. Accordingly, this allows the source base station or the target base station not to use the excluded subcarrier, thereby reducing an interference amount in the handover area to obtain a high gain.

[138] The above-mentioned method of the present invention may be realized into a program and be stored in a recording medium (CD-ROM, RAM, ROM, a floppy disc, a hard disc or a magneto-optical disc) in a type readable by a computer. This process will become apparent to those skilled in the art, and thus a further detailed description is omitted.

[139] As such, exemplary embodiments of the present invention have been described in detail with reference to the accompanying drawings. However, it should be understood that the detailed description and specific examples, while indicating preferred embodiments of the invention, are given by way of illustration only, since various changes and modifications within the spirit and scope of the invention will become apparent to those skilled in the art from this detailed description.

Industrial Applicability

[140] As described above, the present invention selects a subcarrier having a strong channel gain among subcarriers allocated from a source base station and a target base station when performing handover in a mobile communication system using a multicarrier, thereby obtaining a received power gain.

[141] And, the present invention feeds back information of a subcarrier excluded in a subcarrier selecting step to a corresponding base station so that the corresponding base station does not use the information, thereby reducing the whole interference amount of the system to improve performance of the system.

[142]

Claims

- [1] A method for handover of a mobile communication terminal in a multicarrier-based mobile communication system, the method comprising:
- (a) the mobile communication terminal being allocated with subcarriers from a target base station (a base station for handover) when entering a handover area;
 - (b) comparing subcarriers allocated from a source base station (a previously connected base station) with the subcarriers allocated from the target base station to select a subcarrier to be used during handover; and
 - (c) feeding back information of a unselected subcarrier to a base station that has allocated the corresponding subcarrier.
- [2] The method for handover of a mobile communication terminal in a multicarrier-based mobile communication system according to claim 1, wherein the step (b) compares the subcarriers allocated from the source base station with the subcarriers allocated from the target base station one-to-one to select a subcarrier having a strong channel gain.
- [3] The method for handover of a mobile communication terminal in a multicarrier-based mobile communication system according to claim 1, wherein the step (b) selects a predetermined number of subcarriers in order of strength of channel gain among the subcarriers allocated from the source base station and the subcarriers allocated from the target base station.
- [4] The method for handover of a mobile communication terminal in a multicarrier-based mobile communication system according to claim 1, wherein the step (b) selects a subcarrier having a channel gain beyond a preset critical value among the subcarriers allocated from the source base station and the subcarriers allocated from the target base station.
- [5] The method for handover of a mobile communication terminal in a multicarrier-based mobile communication system according to any one of claims 2 to 4, wherein the base station having the subcarrier information fed back in the step (c) does not transmit data to the corresponding subcarrier.
- [6] The method for handover of a mobile communication terminal in a multicarrier-based mobile communication system according to any one of claims 2 to 4, wherein the handover area is determined by the following formula:

[Formula]

$$r_{HO}(h) \leq A_{HO} \leq \frac{D}{2}$$

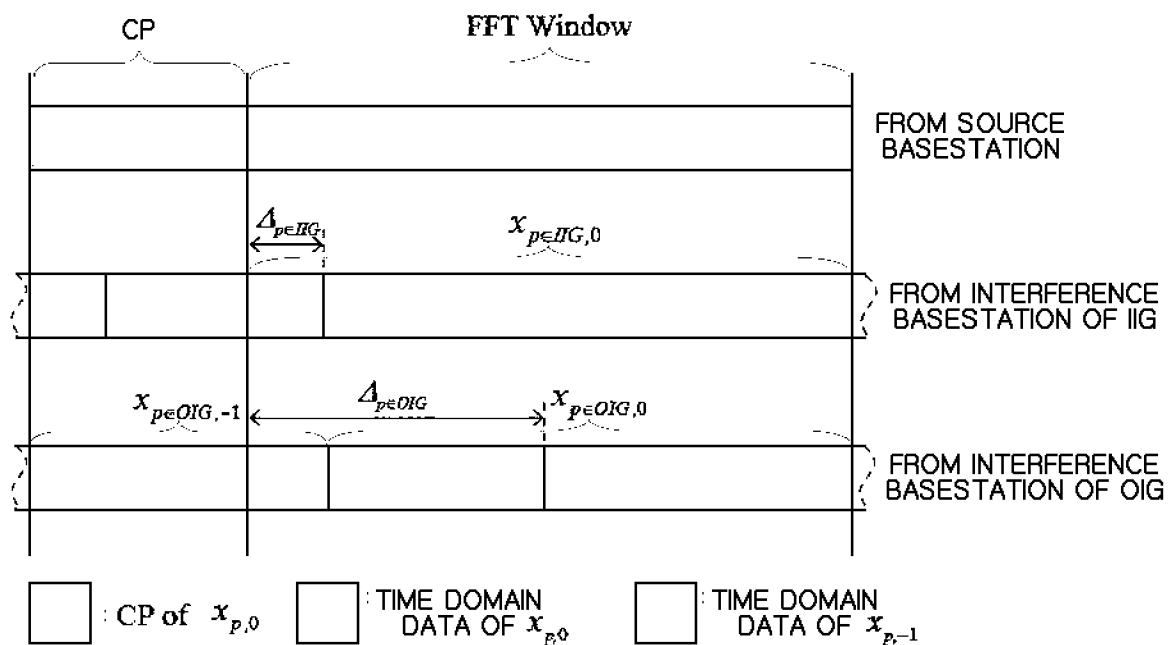
$$r_{HO}(h) = D \left(\frac{10^{\frac{h}{10\alpha}}}{1 + 10^{\frac{h}{10\alpha}}} \right), 0 < h < \infty$$

where A_{HO} is a handover area, $r_{HO}(h)$ is a distance between the mobile communication terminal and the source base station that the mobile communication terminal starts handover, h is a handover critical value, α is a distance attenuation coefficient, and D is a distance between the source base station and the target base station.

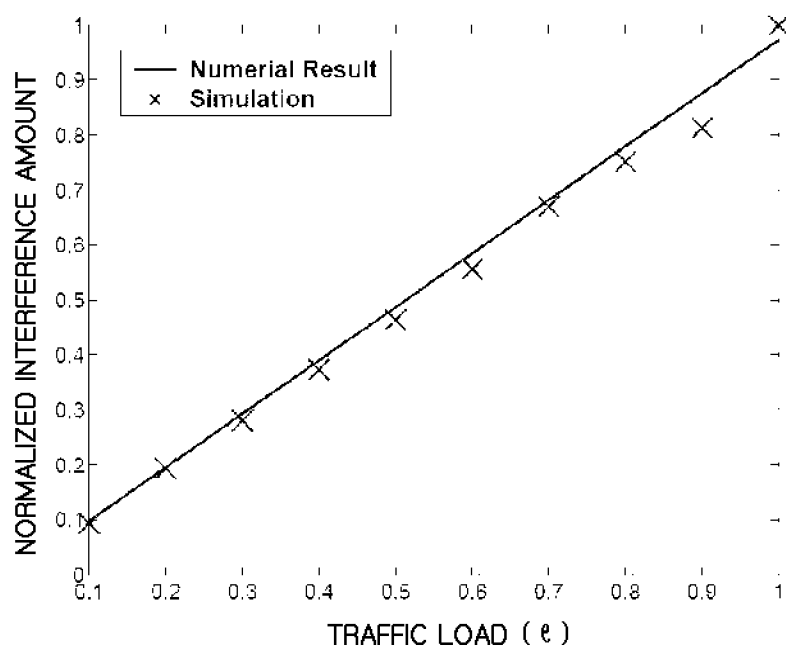
- [7] A mobile communication terminal for performing handover in a multicarrier-based mobile communication system, the mobile communication terminal comprising:
 a received power measuring means for measuring channel gains of subcarriers received from a source base station (a previously connected base station) and channel gains of subcarriers received from a target base station (a base station for handover);
 a subcarrier selecting means for comparing the subcarriers received from the source base station with the subcarriers received from the target base station to select a subcarrier to be used during handover; and
 a feedback means for feeding back information of a subcarrier not selected by the subcarrier selecting means to a base station that has transmitted the corresponding subcarrier.
- [8] The mobile communication terminal for performing handover in a multicarrier-based mobile communication system according to claim 7,
 wherein the subcarrier selecting means compares the subcarriers allocated from the source base station with the subcarriers allocated from the target base station one-to-one to select a subcarrier having a strong channel gain.
- [9] The mobile communication terminal for performing handover in a multicarrier-based mobile communication system according to claim 7,
 wherein the subcarrier selecting means selects a predetermined number of subcarriers in order of strength of channel gain among the subcarriers allocated from the source base station and the subcarriers allocated from the target base station.
- [10] The mobile communication terminal for performing handover in a multicarrier-based mobile communication system according to claim 7,
 wherein the subcarrier selecting means selects a subcarrier having a channel gain beyond a preset critical value among the subcarriers allocated from the source base station and the subcarriers allocated from the target base station.
- [11] The mobile communication terminal for performing handover in a multicarrier-based mobile communication system according to any one of claims 8 to 10,
 wherein a base station that has received the feedback subcarrier information from the feedback means does not transmit data to the corresponding subcarrier.

- [12] A recording medium for recording a program readable by a mobile communication terminal for performing handover in a multicarrier-based mobile communication system, the recording medium recording a program for realizing functions including:
- a first function for receiving subcarriers allocated from a target base station (a base station for handover) when the mobile communication terminal enters a handover area;
 - a second function for comparing subcarriers allocated from a source base station (a previously connected base station) and the subcarriers allocated from the target base station to select a subcarrier to be used during handover; and
 - a third function for feeding back information of a unselected subcarrier to a base station that has allocated the corresponding subcarrier.

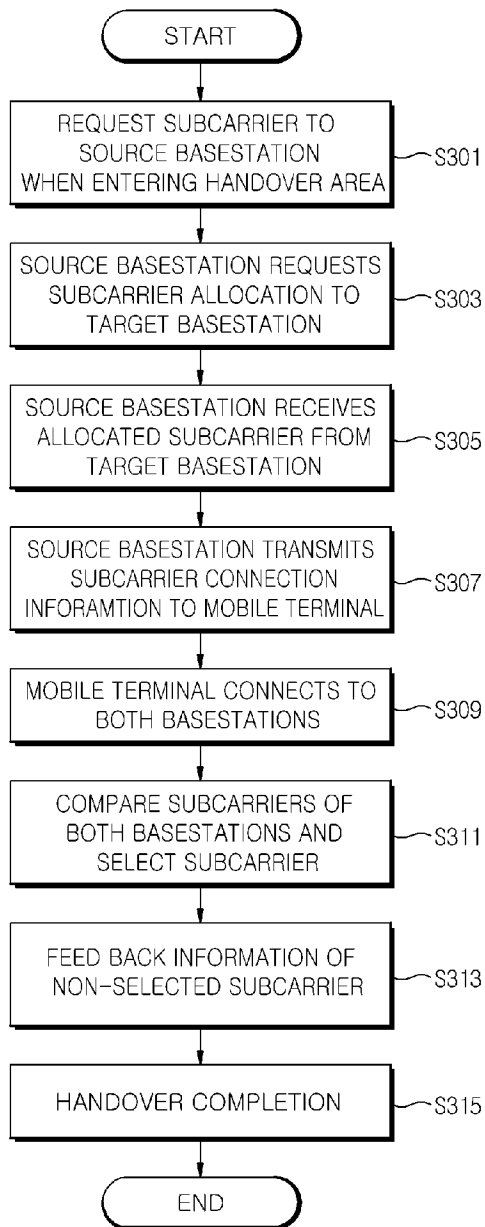
[Fig. 1]



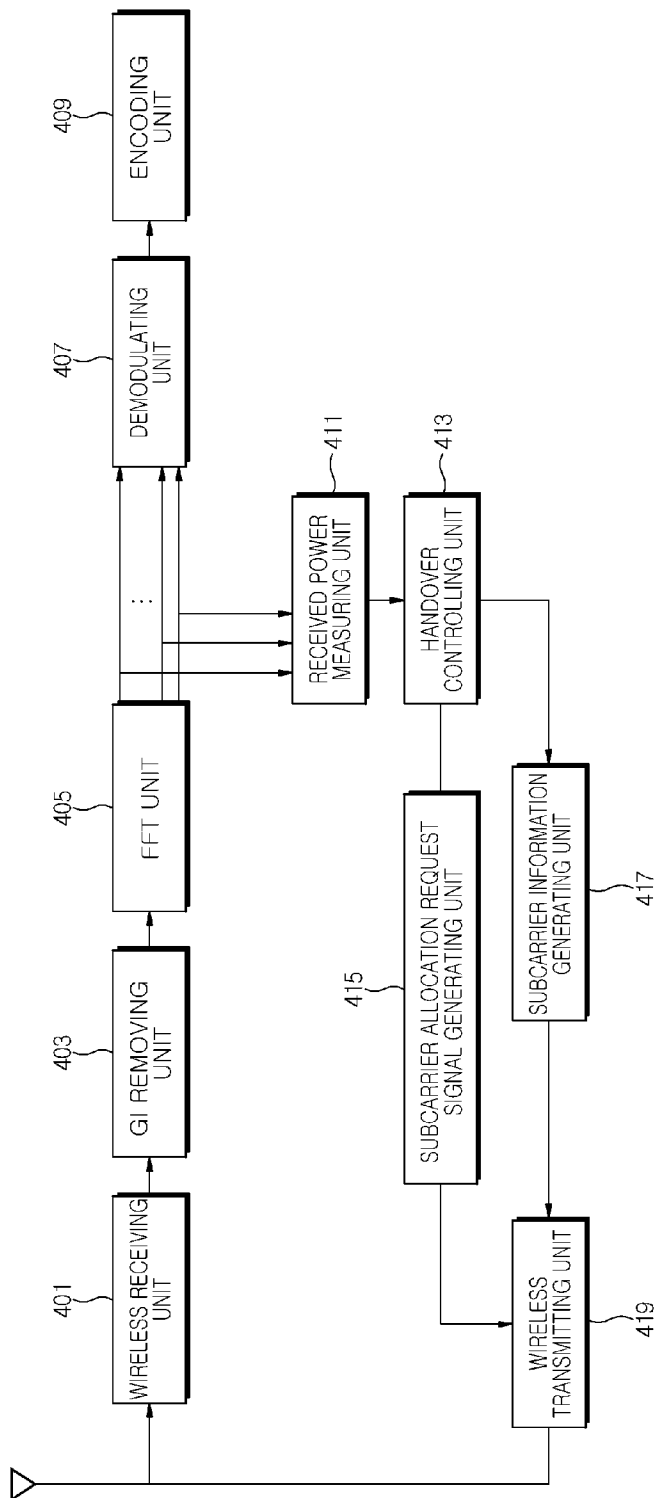
[Fig. 2]



[Fig. 3]



[Fig. 4]



A. CLASSIFICATION OF SUBJECT MATTER**H04B 7/26(2006.01)i**

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC8 H04B 7/26, H04Q 7/20, 7/38, H04J 11/00

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

KOREAN UTILITY MODELS AND APPLICATIONS FOR UTILITY MODELS SINCE 1975

JAPANESE UTILITY MODELS AND APPLICATIONS FOR UTILITY MODELS SINCE 1975

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

eKIPASS, DELPHION, ESPACENET & Keywords : OFDM(A), subcarrier, handover, channel, feedback and similar terms.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 902,551 A2 (LUCENT TECHNOLOGIES INC.) 17 March 1999 * abstract, paragraph [0018], figure 3 *	1-12
A	US2004-185852 A1 (SON et al.) 23 September 2004 * abstract, paragraphs [0069]-[0086], figure 7 *	1-12
A	US2005-143072 A1 (YOON et al.) 30 June 2005 * abstract, paragraphs [0042]-[0053], figure 4 *	1-12



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/KR2007/000899

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