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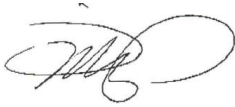
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(54) METHOD FOR ALLOCATING RANGING INTERVAL AND RANGING SUB-CHANNEL FOR INITIAL RANGING IN ORTHOGONAL FREQUENCY DIVISION MULTIPLE ACCESS SYSTEM

ABSTRACT

The present invention relates to a method for ranging interval and ranging sub-channel allocation for initial ranging in a multi-user orthogonal frequency division multiple access ("OFDMA") type wireless communication system in a point-to-multipoint broadband wireless access ("BWA") system. To this end, the present invention designates several specific time slots composed of a predetermined number of OFDM symbols as the initial ranging interval in the MAC in order to remove interference on the data sub-channel arising from the long ranging sub-channel during the initial ranging process. According to the ranging interval, four new initial ranging sub-channel allocation methods are presented to perform the initial ranging function. The new initial ranging structures are suitable for the cases of both frequency division duplex ("FDD") and time division duplex ("TDD").

Representative Drawing

FIG. 4

Index words

OFDM, ranging, initial ranging, ranging code, guard interval, initial ranging reception interval

SPECIFICATION

Brief Description of the Drawings

FIG. 1 is a channel structure of a typical frequency division duplex (“FDD”) mode OFDMA wireless communication system.

FIG. 2 is a channel structure of a typical time division duplex (“TDD”) mode OFDMA wireless communication system.

FIG. 3 is a diagram illustrating transmission and reception timing for initial ranging between a base station and a subscriber station of a general TDD mode OFDMA wireless communication system.

FIG. 4 is a diagram illustrating transmission and reception timing for initial ranging between a base station and a subscriber station in consideration of a cell radius and processing delay of a subscriber station according to the present invention.

FIG. 5 is a diagram illustrating a typical initial ranging procedure.

FIG. 6 is a first exemplary diagram illustrating an initial ranging sub-channel allocation structure according to the present invention.

FIG. 7 is a second exemplary diagram illustrating an initial ranging sub-channel allocation structure according to the present invention.

FIG. 8 is a third exemplary diagram illustrating an initial ranging sub-channel allocation structure according to the present invention.

FIG. 9 is a fourth exemplary diagram illustrating an initial ranging sub-channel allocation structure according to the present invention.

FIG. 10 is a flowchart illustrating the transmission operation of a base station according to the present invention.

FIG. 11 is a flowchart illustrating the reception operation of a base station according to the present invention.

FIG. 12 is a flowchart illustrating the transmission/reception operation of a subscriber station according to the present invention.

Detailed Description of the Invention

Object of the Invention

Technical Field of Invention and Conventional Art in the Field

The present invention relates to a method for ranging interval and ranging sub-channel allocation for initial ranging in a multi-user orthogonal frequency division multiple access (OFDMA) type wireless communication system in a point-to-multipoint broadband wireless access (BWA) system, and more particularly, to a ranging interval and ranging sub-channel allocation method for initial ranging of the multi-user OFDMA wireless communication system.

In IEEE 802.16ab, OFDMA wireless communication system is defined such that data can be transmitted between a base station (“BS”) and a subscriber station (“SS”) using a microwave frequency band between 2 GHz and 11 GHz. Such an OFDM wireless communication system can be defined as a two-dimensional access method that combines time division access and frequency division access technology, and each OFDMA symbol is carried on a subcarrier and bundled into a predetermined sub-channel. Ranging in the OFDMA wireless communication system as described above periodically adjusts an accurate time offset between the base station and the subscriber station, and performs a power correction process. Ranging for this purpose is defined as the following three types.

1. Initial Ranging
2. Bandwidth Request Ranging
3. Maintenance Ranging

Among these three, the initial ranging uses a long ranging method in which an SS within the area of the BS is transmitted in two OFDM symbols when a new call is established with the BS, and the bandwidth request ranging and the maintenance ranging are short ranging methods in which one OFDM symbol is used in a state in which the initial ranging is performed. Accordingly, the initial ranging is performed in an initial state in which transmission power and time offset are not adjusted between the base station and the subscriber station. It enables the transmission of the SS with a predetermined power required in the OFDMA wireless communication system in a state being synchronized with symbol marking the start of the burst boundary. The procedure for performing such initial ranging will be described with reference to FIG. 5 described below.

First, when the base station transmits system information necessary for initial ranging such as time offset, interval ID, and the like to the subscriber station, the subscriber station randomly selects one ranging code with reference to the information for the initial ranging and transmits it to the base station. When the base station detects a signal transmitted from the subscriber station, the base station transmits time control information and power control information to the subscriber station using a code randomly selected. The subscriber station performs time adjustment and power control with reference to the time control information and power control information. At this time, measurement of the data transmission time being transmitted from the subscriber station as well as the power at that time is performed by several sub-channels allocated as ranging sub-channels, and each user randomly selects one code from the binary code bank set as the ranging code, and transmits it through ranging sub-channel which is also randomly selected.

Meanwhile, the channel structure in the FDD mode OFDMA wireless communication system for transmitting the ranging information is as shown in FIG. 1.

Referring to FIG. 1, two “sub-channels” among the “sub-channels” composed of 53 carriers are always set as ranging sub-channels and being broadcasted to each user in a cell. Each user in the cell uses the ranging sub-channel when ranging is required. However, in this channel structure, it can be seen that only a carrier is used differently in the same time interval for a ranging transmission signal for time offset and transmission power control and a signal for data transmission. This has a problem in that inter-channel interference (“ICI”) occurs between the signal for ranging transmission and the signal for data transmission.

A channel structure of another TDD mode OFDMA wireless communication system for solving this problem is the same as illustrated in FIG. 2. As shown in FIG. 2, a ranging signal section for controlling accurate time offset and transmission power and a signal section for data transmission are temporally separated, so that only ranging information is received in the reception interval of the ranging signal. On the other hand, in the data signal transmission and reception section, a corresponding data transmission and reception operation can be performed. That is, all sub-channels of a predetermined size are periodically allocated for ranging, so that each user in the BS uses a ranging sub-channel within the ranging interval when necessary.

However, such a channel structure of the TDD mode OFDMA wireless communication system has a problem in that ICI is generated between the ranging symbols when performing initial ranging in which transmission power and time offset are not adjusted between the base station and the subscriber station.

In addition, in the channel structure of the TDD mode OFDMA wireless communication system, when the interval for receiving a response signal from the subscriber station for initial ranging is set to be too small or too large, it goes out of the reception interval of the initial ranging signal and thus there is a problem in that ICI is caused between the ranging signal and the data transmission and reception signal, or channel resource efficiency is reduced.

Technical Problems that the Invention Seeks to Solve

Accordingly, an object of the present invention to solve the above-described problems is to provide a ranging interval and ranging sub-channel allocation method for initial ranging in OFDMA wireless communication system capable of reducing the ICI between the ranging signals in the TDD mode OFDMA wireless communication system.

Another object of the present invention is to provide ranging interval and ranging sub-channel allocation method for initial ranging in OFDMA wireless communication system capable of reliably receiving the initial ranging response signal being transmitted from the subscriber station within the reception interval set by the base station.

Yet another object of the present invention is to provide ranging interval and ranging sub-channel allocation method for initial ranging in OFDMA wireless communication system capable of allowing the subscriber station to perform the transmission operation in advance of a predetermined transmission time by the processing delay of the subscriber station itself.

In the first aspect for achieving the above-noted object, the present invention, in a method of allocating a ranging interval for initial ranging with a subscriber station in a base station of a multi-user orthogonal frequency division multiple access method wireless communication system, is characterized by comprising the processes of: determining a reception interval of an initial ranging signal by reflecting the maximum delay expected when transmitting and receiving data to and from the subscriber station; broadcasting system information necessary for initial ranging, including the determined reception interval, to all subscriber stations in a cell through a predetermined broadcasting channel; and receiving an initial ranging signal from the subscriber stations in response to the system information for all symbols received from the subscriber station in the determined reception interval.

In the second aspect for achieving the above-noted object, the present invention, in a method of transmitting a ranging signal for initial ranging with a base station in a subscriber station of a multi-user orthogonal frequency division multiple access method wireless communication system, is characterized by including the processes of: receiving system information necessary for initial ranging including a reception interval of the ranging signal from the base station through a predetermined broadcast channel, and determining an arbitrary ranging sub-channel and a ranging code from the system information class; and adjusting the transmission time of the initial ranging signal considering the processing delay time for initial ranging, and transmitting the initial ranging signal by the ranging sub-channel and the ranging code at the adjusted transmission time.

In a third aspect for achieving the above-noted object, the present invention, in a method of transmitting a ranging signal for initial ranging with a base station in a subscriber station of a multi-user orthogonal frequency division multiple access wireless communication system, is characterized by including the processes of: receiving system information necessary for initial ranging including a reception interval of the ranging signal from the base station through a predetermined broadcast channel, and determining an arbitrary ranging sub-channel and a ranging code from the system information class; and adjusting a transmission time of an initial ranging signal in consideration of a processing delay time for initial ranging, and transmitting the initial ranging signal using the ranging sub-channel and the ranging code at the adjusted transmission time.

Construction and Operation of the Invention

Embodiments of the present invention will now be described in detail with reference to the accompanying drawings.

In the detailed description of the embodiment of the present invention to be described later, a device and a method for enabling the corresponding SS in the BS to perform ranging in the reception interval of the initial ranging response signal of the OFDMA wireless communication system without interference between ranging signals transmitted from multiple SSs will be reviewed in detail. Meanwhile, in the detailed description of the present invention to be described later, although specific details for performing initial ranging between a base station and a subscriber station are used for a more general understanding of the present invention, it will be apparent to one of ordinary skill in the art that the present invention may be readily practiced without these specific details and with modifications thereof as well.

First, the BS must be able to perform initial ranging by setting and broadcasting predetermined system parameter information in advance, all SSs in the cell take the information when setting up a call. That is, the BS should notify the member state in advance about the information on the data signal transmission interval for data transmission and reception and on initial ranging required to perform initial ranging, and for this, an initial ranging response signal transmitted from the SSs is detected within the ranging reception interval set by the base station, so that an initial ranging operation is enabled to perform for all SSs that want to establish a call with the BS. At this time, the response signal for the bandwidth request ranging and the maintenance ranging can be detected in the reception interval for the initial range, or can be detected by setting a separate reception interval.

Accordingly, the BS is required to efficiently set a reception period for detecting the response signals from the SSs. That is, in consideration of the cell radius and processing delay of the subscriber station, the MAC of the base station should set a ranging interval, which is a reception period for receiving the initial ranging signal, so that the initial ranging for all subscriber stations in the base station can be efficiently performed. This will be described in detail with reference to FIG. 4 described hereunder. FIG. 3 is a diagram illustrating transmission and reception timing for initial ranging between a base station and a subscriber station of a general TDD mode OFDMA wireless communication system, and FIG. 4 is a diagram illustrating transmission and reception timing for initial ranging between a base station and a subscriber station in consideration of a cell radius and processing delay of a subscriber station according to the present invention.

First, the SS uses only two consecutive symbols at a predetermined position to transmit an initial ranging signal for system information being transmitted from the BS to perform initial ranging. The BS performs a procedure of detecting a ranging signal for all received symbols when the ranging interval section is reached. At this time, in order to set an interval for how long the reception interval of the initial ranging signal, that is, the ranging interval length k should be at least not to cause interference to the data channel, an initial ranging detection operation is performed by adding an interval corresponding to the cell radius of BS. This will be described in detail hereunder.

In general, there are three types of delay appearing in data transmission and reception between BS transmission and SS: a delay consisting of the propagation delay between the BS and SS; and a processing delay at the BS and SS itself. Among them, the processing delay T_0 of the BS consists of a transmission delay T_{01} of the BS and a reception delay T_{02} of the BS as defined in <Mathematical Expression 1> below.

$$\text{<Mathematical Expression 1>} \\ T_0 = T_{01} + T_{02}$$

The processing delay T_0 of the BS is a constant value, and is a value known to the BS.

Similarly, the processing delay of the SS, T_2 , as defined in <Mathematical Expression 2> below, consists of the transmission delay T_{21} of the SS and the reception delay T_{22} of the SS.

$$\text{<Mathematical Expression 2>} \\ T_2 = T_{21} + T_{22}$$

Also, the processing delay T_2 of the SS is a constant value, and is a value known to the SS.

The propagation delay T_1 in data transmission consists of a downlink transmission delay T_{11} and an uplink response delay T_{12} as defined in <Mathematical Expression 3> below.

$$\text{<Mathematical Expression 3>} \\ T_1 = T_{11} + T_{12}$$

The delay time required for general data transmission and reception as described above was shown in <FIG. 3>.

After the BS processing delay T_0 , the SS processing delay T_2 , and the propagation delay T_1 , the MAC of the BS can know the initial time information, T_{t1} at time D. Accordingly, the initial time information in FIG. 3, which is a general data transmission and reception procedure, is the same as <Mathematical Expression 4> below.

$$\text{<Mathematical Expression 4>} \\ T_{t1} = T_{12} + T_0$$

Since the processing delay T_0 of the BS is a constant and the BS knows this value, T_{t1} can be easily obtained from the <Mathematical Expression 4> above. However, since the BS processing delay T_0 , does not have any effect on the time offset being set in consideration of the ranging interval length and propagation delay, only the processing delay and propagation delay of the SS are considered in the present invention.

As shown in <FIG. 3>, assuming that the BS can predict a time delay T_{t2} , the T_{t2} is the sum of the propagation delay T_1 and the processing delay T_2 of the SS, and is equal to the following <Mathematical Expression 5>.

$$\text{<Mathematical Expression 5>} \\ T_{t2} = T_1 + T_2$$

At this time, the maximum value of T_{t2} , $\text{Max_}T_{t2}$, occurs when the SS has the maximum propagation delay at the cell boundary. That is, it can be expressed as <Mathematical Expression 6> below.

$$\begin{aligned} &\text{<Mathematical Expression 6>} \\ &\text{Max_}T_{t2} = 2R/c + T_2 \end{aligned}$$

Here, c is the speed of light and R is the cell radius.

To avoid inter channel interference (ICI) to the data channel due to the initial ranging, when the BS processes the data sub-channel, the BS should not receive any initial ranging signal. At this time, since the bandwidth request ranging and the maintenance ranging are in a state in which synchronization has been made not only for transmission power but also for time offset by performing initial ranging, they are in a state in which compensation for the propagation delay and processing delay of the SS has been made.

Accordingly, when the time required for the initial ranging interval is converted to the number of OFDM symbols used in the MAC of the OFDM system k , the ranging interval length is the same as <Mathematical Expression 7> below.

$$\begin{aligned} &\text{<Mathematical Expression 7>} \\ &k = \text{ceil}\left(\frac{\text{Max_}T_{t2}}{T_u}\right) \\ &= \text{ceil}\left(\frac{\left(\frac{2R}{c} + T_2\right)}{T_u}\right) \end{aligned}$$

Here, T_u is the length of the OFDM symbol including the guard interval, and the function $\text{cell}(x)$ is the largest integer value closest to the element x .

However, the processing delay of each SS may be different depending on the manufacturer, and the BS does not know the processing delay of the SS in the initial ranging interval. On the other hand, the SS may know its own processing delay. Actually, the processing delay of SS may become larger than the ranging interval length k , since OFDM uses FFT and IFFT procedures, thereby increasing the computation amount. Accordingly, in the present invention, in order to avoid the influence of the processing delay of the SS on the ranging interval length, the SS transmits the ranging signal in advance by its own processing time.

In <FIG. 4>, after the transmission propagation delay and the processing delay of the SS are reflected, the SS may advance the initial ranging signal transmission time by the transmission propagation delay and the processing delay of the SS in advance and transmit it at point A. At this time, T_{AD} is the same as T_2 . Accordingly, the above-noted <Mathematical Expression 7> for obtaining the ranging interval section length considering even the processing delay of the SS can be obtained as shown in the <Mathematical Expression 8> below.

$$\begin{aligned} &\text{<Mathematical Expression 8>} \\ &k = \text{ceil}\left(\frac{2R}{c \cdot T_u}\right) + 2 \end{aligned}$$

Meanwhile, for a given cell, the BS may know its own cell radius after performing a cell plan. Accordingly, k is a constant for a given cell, and the BS periodically broadcasts ranging related information including a ranging interval, so that the ranging related information is transmitted to all subscriber stations in the cell. Accordingly, the SS that has been entered into the cell can obtain information necessary to access the system, such as a ranging interval, from ranging related information being broadcasted from the BS.

Therefore, when the SS wants to perform initial ranging to establish a new call with the BS, the BS increases the existing initial ranging signal reception interval by a delay amount corresponding to its cell radius in advance. By obtaining ranging interval set for ranging, sub-channel for ranging, and ranging code information from the system information returned from the BS, the SS can receive a ranging sub-channel and a ranging code. By determining transmission time in consideration of its own processing delay time, and transmitting the initial ranging signal at the determined transmission time, the SS can transmit earlier than the existing transmission time. In this case, the initial ranging signal uses the selected randomly ranging sub-channel and ranging code, and this is a response signal corresponding to the system information from the BS.

Meanwhile, a predetermined guard interval may be inserted into the carrier interval in order to prevent interference caused by using all carriers of a predetermined interval as ranging sub-channels as in the channel structure of the conventional TDD mode OFDMA wireless communication system. This will be described with reference to FIGS. 6, 7, 8, and 9 hereunder.

First, as the first embodiment, assuming a 2K mode OFDMA wireless communication system having a capacity of 1696 carriers, it is divided into 32 basic data sub-channels, that is, B_{ch_m} , as shown in <Mathematical Expression 9> below, and each of the basic sub-channels is composed of 53 carriers. Here, it is assumed that the present invention aims to allocate an initial ranging sub-channel in a 2K mode OFDMA system and not to use a DC carrier.

<Mathematical Expression 9>

$$B_{ch_m} = C_{mi}, \quad i=1, \dots, 53$$

Here, C_{mi} means the i -th carrier of the m -th basic sub-channel.

The 32 basic sub-channels, B_{ch_m} , are divided into 3 consecutive sub-channels to form 10 ranging sub-channels, and the 11th ranging sub-channel consists of two basic sub-channels. Accordingly, as shown in <Mathematical Expression 10> below, the first to 10 ranging sub-channels consist of a total of 159 carriers, and the 11th ranging sub-channel consists of 106 carriers. The configuration of such a ranging sub-channel is illustrated in <FIG. 6>.

<Mathematical Expression 10>

$$R_{ch_m} = \begin{cases} \{B_{ch_{(m-1) \cdot 3+1}}, B_{ch_{(m-1) \cdot 3+2}}, B_{ch_{(m-1) \cdot 3+3}}\} & \text{if } m=1, \dots, 10 \\ \{B_{ch_{31}}, B_{ch_{32}}\} & \text{if } m=11 \end{cases}$$

In this method, the ranging code consists of a code sequence made by cutting a PN code sequence generated by a Pseudo Random Binary Sequence ("PRBS") generator (not shown) described in section 8.3.5.3.4.3.1 of IEEE802.16ab-01/01r2 into bit length of 159 bits. The 11th ranging sub-channel of length 106 uses the first 106 bits of the bit sequence following 10 ranging codes of a length of 159.

Since this method uses the carrier allocation method of the existing TDD mode OFDMA wireless communication system as it is, it is compatible with the uplink pilot and data carrier allocation method, and the ranging code not only uses the existing PRBS generation code as it is, but also shows better correlation characteristics since the length of the used code is increased from the existing length of 53 bits to the length of 159 bits or 106 bits.

Another embodiment of the present invention will be described with reference to FIG. 7. When in 2K mode with 180 guard intervals on the left and right sides of the ranging sub-channel structure, a ranging sub-channel consisting of 128 or 127 adjacent carriers R_{ch_m} ($m = 1, \dots, 13$) is configured, and a ranging sub-channel allocation method in which a guard interval is provided between adjacent ranging sub-channels is presented. At this time, the guard interval between the ranging sub-channels provides 2 subcarriers for a length of 128 ranging sub-channel and 3 subcarriers for a length of 127.

Therefore, when the ranging sub-channel has a length of 127, only 1687 subcarriers C_k , are used for ranging signal transmission, and a guard interval with a length 3 between the ranging sub-channels of G_k is inserted. The configuration of each ranging sub-channel as described above is the same as <Mathematical Expression 11> below.

<Mathematical Expression 11>

$$R_ch_m = \{C_k, G_k\}, \quad m=1, \dots, 13$$

$$C_k = 180 + (R_ch_m - 1) \cdot 130 + k \quad k=1, \dots, 127$$

$$G_k = 180 + (R_ch_m - 1) \cdot 130 + k \quad k=128, \dots, 130, R_ch \leq 12$$

The ranging code used here is a gold code, and the length of the ranging code is 127, which is the length of one ranging sub-channel. The gold sequence generator is the same as the following <Mathematical Expression 12>.

<Mathematical Expression 12>

$$f_1(x) = x^7 + x^6 + x^3 + 1$$

$$f_2(x) = x^7 + x^6 + x^3 + x^2 + x^1 + 1$$

The above-noted <Mathematical Expression 12> generates 63 gold codes with a length of 127, and has a good balance property and correlation. That is, the number of 63 gold codes is sufficient for initial ranging, and an average balance property provides a low PAR.

When describing another embodiment of the present invention with reference to FIG. 8, as the ranging code, in addition to the Gold code, a Golay Complementary Sequence (“GCS”) or an M sequence may be used, and due to the nature of this code, a ranging sub-channel with a length of 128 is required. Hereinafter, a ranging sub-channel allocation method with a length of 128 using GCS and M sequences is presented.

The ranging sub-channel allocation method with a length of 128 is similar to the ranging sub-channel allocation method with a length of 127 using a Gold code. Since the ranging sub-channel is 128 in length, in the 2K mode, 1688 subcarriers can be used for ranging signal transmission, so 179 guard intervals are provided on the left and right sides, respectively. The configuration of such a ranging sub-channel is the same as <Mathematical Expression 13> below.

<Mathematical Expression 13>

$$R_ch_m = \{C_k, G_k\}, \quad m=1, \dots, 13$$

$$C_k = 179 + (R_ch_m - 1) \cdot 130 + k \quad k=1, \dots, 128$$

$$G_k = 179 + (R_ch_m - 1) \cdot 130 + k \quad k=129, \dots, 130, R_ch \leq 12$$

An interleaving allocation method as another ranging sub-channel structure of the present invention will be described with reference to FIG. 9 as described hereunder.

The subcarriers in the 2K mode OFDMA wireless communication system are divided into 26 basic groups, B_ch_m , $m = 1, \dots, 26$, and each basic group is composed of adjacent carriers having a length of 64, and a guard interval of one subcarrier length is placed between each of these adjacent basic groups. Therefore, since 1689 sub-carriers are used for ranging signal transmission, 179 guard intervals are provided on the left and right sides, respectively. The configuration of the carriers of the basic group and the guard interval carrier is the same as <Mathematical Expression 14> below.

<Mathematical Expression 14>

$$C_k = 179 + (B_ch - 1) \cdot 65 + k, \quad k=1, \dots, 64$$

$$C_{GI} = 179 + (B_ch - 1) \cdot 65 + k, \quad k=65, R_ch \leq 25$$

The basic group B_ch_m is combined with two basic blocks in the same method as block interleaving to make one ranging sub-channel. For example, the ranging sub-channel, R_ch_m , may be defined as in <Mathematical Expression 15> below.

<Mathematical Expression 15>

$$R_ch_m = \{B_ch_m, B_ch_{m+13}\}, \quad m=1, \dots, 13$$

Here, R_ch_m means the m-th ranging sub-channel.

In the above-noted ranging sub-channel allocation methods, since the SS performs initial ranging processing in consideration of the cell radius, the initial ranging signal does not affect the data sub-channel compared to the existing method. This is a very important feature when data is transmitted with hexadecimal quadrature amplitude modulation ("QAM") and high-level modulation such as 64-QAM. In addition, since there is a guard interval between adjacent ranging sub-channels, it is possible to significantly reduce multiple access interference ("MAI") due to frequency offset and time offset from different ranging signals.

As described above, the BS sets a ranging interval section in consideration of the cell radius, determines the initial ranging sub-channel allocation method and the ranging code, and broadcasts it within its own cell. After acquiring information being broadcasted by the BS to obtain information necessary for initial ranging, the SS transmits a ranging signal to the BS using a ranging sub-channel and a ranging code randomly selected in a ranging interval section. When the ranging interval section is reached, the BS detects a ranging signal from the SS by performing FFT with the ranging sub-channel structure, and the data sub-channel reception operation is performed outside of the ranging interval section, and such a BS transmission and reception operation procedure related to the BS ranging will be described in more detail with reference to FIGS. 10 and 11 as described hereunder.

First, as shown in FIG. 10, the BS determines whether to transmit system information for initial ranging in step 1010, and when the transmission of the initial ranging information is not required, proceeds to step 1030 to determine whether transmission of the ranging information is required. When the ranging information transmission is not required, it is determined that it is a data symbol transmission interval, and in step 1040, the transmission power and time offset being currently controlled are adjusted to transmit or receive a data symbol. However, if the BS, in step 1010, determines that it is the transmission interval of system information for initial ranging of an SS that attempts to establish a new call within its own cell, proceeds to step 1020. The BS, in the step 1020, in the reception interval of the initial ranging response signal of all SSs for the transmission of the system information, adds an interval corresponding to the cell radius of the SS and set as a reception interval of a new initial ranging response signal. When the reception interval is newly set, the BS transmits the system information including the newly set reception interval through a predetermined broadcasting channel so that it can be transmitted to all SSs in the BS in step 1050.

In addition, the reception operation of the BS will be described with reference to FIG. 11 as described hereunder.

First, in step 1110, the BS checks whether the next reception interval is the reception interval of the response signal of the SS for the initial ranging or the reception interval of general data being transmitted from the SS. In the step 1110, when it is confirmed that the reception interval is the reception interval of the SS response to the initial ranging, the BS proceeds to step 1120 to set the channel structure of the initial ranging reception interval in which the area corresponding to the cell radius is extended as a ranging sub-channel structure for ranging. Then, it is proceeded to step 1130, and a response signal to the initial ranging being received from the SS is received according to the predetermined ranging sub-channel structure to perform initial ranging. At this time, when the ranging interval section is reached, the BS detects a ranging signal from a ranging sub-channel on which FFT has been performed, calculates power, and compares the calculated power value with a preset reference value. When the received ranging signal power value is less than the reference value, it is determined that there is no ranging signal in the ranging sub-channel, and the above-noted operation is performed for another ranging sub-channel, and when the received ranging signal power value is greater than the reference value, a frequency correction operation is performed. In the frequency correction block above, the BS detects the ranging code used by the SS by multiplying the received ranging signal by each ranging code in the ranging code set, and then detect the delay time and reports it to the upper layer.

Meanwhile, when it is confirmed as the normal data reception interval in step 1110, it is proceeded to step 1140, and since it is in a step in which correction is being made not only for the transmission power but also for the time offset, data symbols are received according to the data reception frame without extending the reception interval.

The operation of the SS according to the transmission and reception operation of the BS of FIGS. 10 and 11 will be described with reference to FIG. 12

First, in step 1210, the SS checks whether it is in a state in which it is trying to establish a new call with the BS, or whether it is in a state in which it is currently transmitting a data symbol or a ranging symbol other than an initial ranging after completing the call establishment. If a new call setup is attempted in the step 1210, it is proceeded to step 1220 to determine whether the symbol being received is information necessary for ranging or general data information. If the information being received is general data, step 1220 is performed again, and if the information is necessary for ranging, in step 1250, the SS performs a ranging operation using the information necessary for the ranging. Meanwhile, if it is not the new call setup step in the step 1210, it is proceeded to step 1240, and since the periodic transmission power and time offset are currently being adjusted between the BS and the SS, corresponding data is received in a channel structure suitable for data or ranging transmission.

When the ranging signal is received by the SS in the step 1230, the SS sets the channel structure for the response signal of the ranging signal received in step 1250, and then proceeds to step 1260 to check whether the received information for ranging is for initial ranging, bandwidth request ranging, or maintenance ranging.

When system information for initial ranging is received in step 1260, the process proceeds to step 1270, and the SS transmits the ranging signal, on which the IFFT has been performed, in advance by its own processing delay from its pre-set transmission time point by randomly selecting a ranging sub-channel and code to be used in a ranging code set and a ranging sub-channel set with a channel structure for the ranging signal so that the ranging signal can be detected in the BS ranging interval reception interval. Meanwhile, if data related to maintenance ranging or bandwidth request ranging, not system information for initial ranging, is received in the step 1260, the process proceeds to step 1280, and after performing the BW response or maintenance ranging, the step 1220 is performed again.

Benefits of the Invention

As described above, the ranging interval and ranging sub-channel allocation method for initial ranging of the orthogonal frequency division multiple access system of the present invention suggests a method for setting the interval section of initial ranging in consideration of the cell radius and the processing delay time of the SS in the OFDMA system, and it not only prevents interference between a signal for initial ranging and a signal for data transmission, but also enables efficient management of resources, which reduces delay and overhead of the physical layer, thereby having the benefit of reducing overhead in MAC.

In addition, the above-noted ranging interval and ranging sub-channel allocation method for initial ranging of the orthogonal frequency division multiple access system of the present invention has a benefit of avoiding ICI between the guard and the data sub-channel between the ranging sub-channels, and there is no need to change the subcarrier allocation algorithm for data and pilot of the current IEEE802.16ab standard for data transmission and reception.

(57) What is claimed is:

Claim 1.

In a method of allocating a ranging interval for initial ranging with a subscriber station in a base station of a multi-user orthogonal frequency division multiple access wireless communication system,

the method comprising the processes of:

determining a reception interval of an initial ranging signal by reflecting the maximum delay expected when transmitting and receiving data with the subscriber station;

broadcasting system information necessary for initial ranging, including the determined reception interval, to all subscriber stations in a cell through a predetermined broadcasting channel; and

receiving an initial ranging signal from the subscriber stations in response to the system information for all symbols being received from the subscriber station at the determined reception interval.

Claim 2.

The method of claim 1, wherein the system information includes a ranging sub-channel and a ranging code for the initial ranging.

Claim 3.

The method of claim 1, wherein the maximum delay includes a maximum propagation delay between the base station and the subscriber station in consideration of the cell radius.

Claim 4.

The method of claim 3, wherein the maximum delay includes a processing delay occurring in the base station.

Claim 5.

The method of claim 4, wherein the maximum delay includes a processing delay occurring at the subscriber station.

Claim 6.

The method of claim 4, wherein the maximum propagation delay includes a downlink propagation delay with the subscriber station and an uplink propagation delay in consideration of the cell radius.

Claim 7.

The method according to claim 5, wherein the maximum propagation delay is proportional to twice the cell radius (R) and inversely proportional to the speed of light (c).

Claim 8.

The method of claim 5, wherein the processing delay occurring in the base station includes a processing delay according to transmission and a processing delay according to reception in the base station.

Claim 9.

The method of claim 8, wherein the processing delay occurring in the subscriber station includes a processing delay due to reception and a processing delay due to transmission in the subscriber station.

Claim 10.

The method of claim 7, wherein the number of OFDM symbols (k) corresponding to the maximum delay is determined by the following <Mathematical Expression 16>.

<Mathematical Expression 16>

$$k = \text{ceil} \left(\frac{\left(\frac{2R}{c} + T_2 \right)}{T_u} \right)$$

Here, T_u is the length of the OFDM symbol including the guard interval, T_2 is the processing delay occurring in the subscriber station, and $\text{ceil}(x)$ represents the largest integer value closest to x .

Claim 11.

The method of claim 7, wherein the maximum delay is determined by the following <Mathematical Expression 17>.

<Mathematical Expression 17>

$$k = \text{ceil} \left(\frac{2R}{c \cdot T_u} \right) + 2$$

Here, T_u is the length of the OFDM symbol including the guard interval, and $\text{ceil}(x)$ represents the largest integer value closest to x .

Claim 12.

In a method of transmitting a ranging signal for initial ranging with a base station in a subscriber station of a multi-user orthogonal frequency division multiple access wireless communication system,

the method characterized by comprising the processes of:

receiving system information necessary for initial ranging including a reception interval of the ranging signal from the base station through a predetermined broadcast channel, and determining an arbitrary ranging sub-channel and ranging code from the system information;

adjusting the transmission time of the initial ranging signal in consideration of the processing delay time for initial ranging, and transmitting the initial ranging signal by the ranging sub-channel and the ranging code at the adjusted transmission time.

Claim 13.

The method of claim 10, wherein the initial ranging signal is transmitted using two consecutive symbols at a predetermined position determined by the ranging sub-channel and the ranging code.

Claim 14.

In a method for allocating ranging sub-channels and ranging codes for initial ranging with a subscriber station in a base station of a multi-user orthogonal frequency division multiple access wireless communication system,

the method characterized by comprising the processes of:

dividing a predetermined number of basic sub-channels, each of which is composed of a predetermined number of carriers, into a continuous predetermined number and defining each as the ranging sub-channel; and

dividing the continuously generated orthogonal code sequence by the number of carriers corresponding to a predetermined number of basic sub-channels constituting the ranging sub-channel, and allocating it to the ranging code.

Claim 15.

The method of claim 14, wherein the number of carriers constituting the basic sub-channel is 53.

Claim 16.

The method of claim 14, wherein the number of basic sub-channels is 32.

Claim 17.

The method of claim 16, wherein each of the 1st to 30th ranging sub-channels among the ranging sub-channels consists of three consecutive basic sub-channels, and each of the 31st to 32nd ranging sub-channels consists of two consecutive basic sub-channels.

Claim 18.

The method of claim 17, wherein the ranging code corresponding to each of the 1st to 30th ranging sub-channels is allocated by cutting the continuously generated orthogonal code sequence into 159-bit length units, and the ranging code corresponding to each of the 31st to 32nd ranging sub-channels is allocated by cutting it into 106-bit length units.

Claim 19.

In a method for allocating ranging sub-channels and ranging codes for initial ranging with a subscriber station of a multi-user orthogonal frequency division multiple access wireless communication system,

the method characterized by comprising the processes of:

using 1687 subcarriers to transmit a ranging signal and allocating the ranging sub-channel of length 127 having 180 guard intervals at the left and right by the following <Mathematical Expression 18>; and

using the 1687 sub-carriers, and allocating the ranging code corresponding to each of the ranging sub-channels having the length of 127 according to the following <Mathematical Expression 19>.

<Mathematical Expression 18>

$$R_ch_m = \{C_k, G_k\}, \quad m=1, \dots, 13$$

$$C_k = 180 + (R_ch_m - 1) \cdot 130 + k \quad k=1, \dots, 127$$

$$G_k = 180 + (R_ch_m - 1) \cdot 130 + k \quad k=128, \dots, 130, R_ch \leq 12$$

Here, C_k is a ranging code used for ranging signal transmission, and G_k is a ranging code used to insert a 3-length guard band between ranging sub-channels.

<Mathematical Expression 19>

$$f_1(x) = x^7 + x^6 + x^3 + 1$$

$$f_2(x) = x^7 + x^6 + x^3 + x^2 + x^1 + 1$$

Claim 20.

In a method of allocating ranging sub-channels and ranging codes for initial ranging with a subscriber station in a base station of a multi-user orthogonal frequency division multiple access wireless communication system,

the method characterized by comprising the process of:

using 1688 subcarriers to transmit a ranging signal, and allocating the ranging sub-channel of 128 length with 179 guard intervals at the left and right according to the following <Mathematical Expression 20>.

<Mathematical Expression 20>

$$R_ch_m = \{C_k, G_k\}, \quad m=1, \dots, 13$$

$$C_k = 179 + (R_ch_m - 1) \cdot 130 + k \quad k=1, \dots, 128$$

$$G_k = 179 + (R_ch_m - 1) \cdot 130 + k \quad k=129, \dots, 130, R_ch \leq 12$$

DRAWINGS

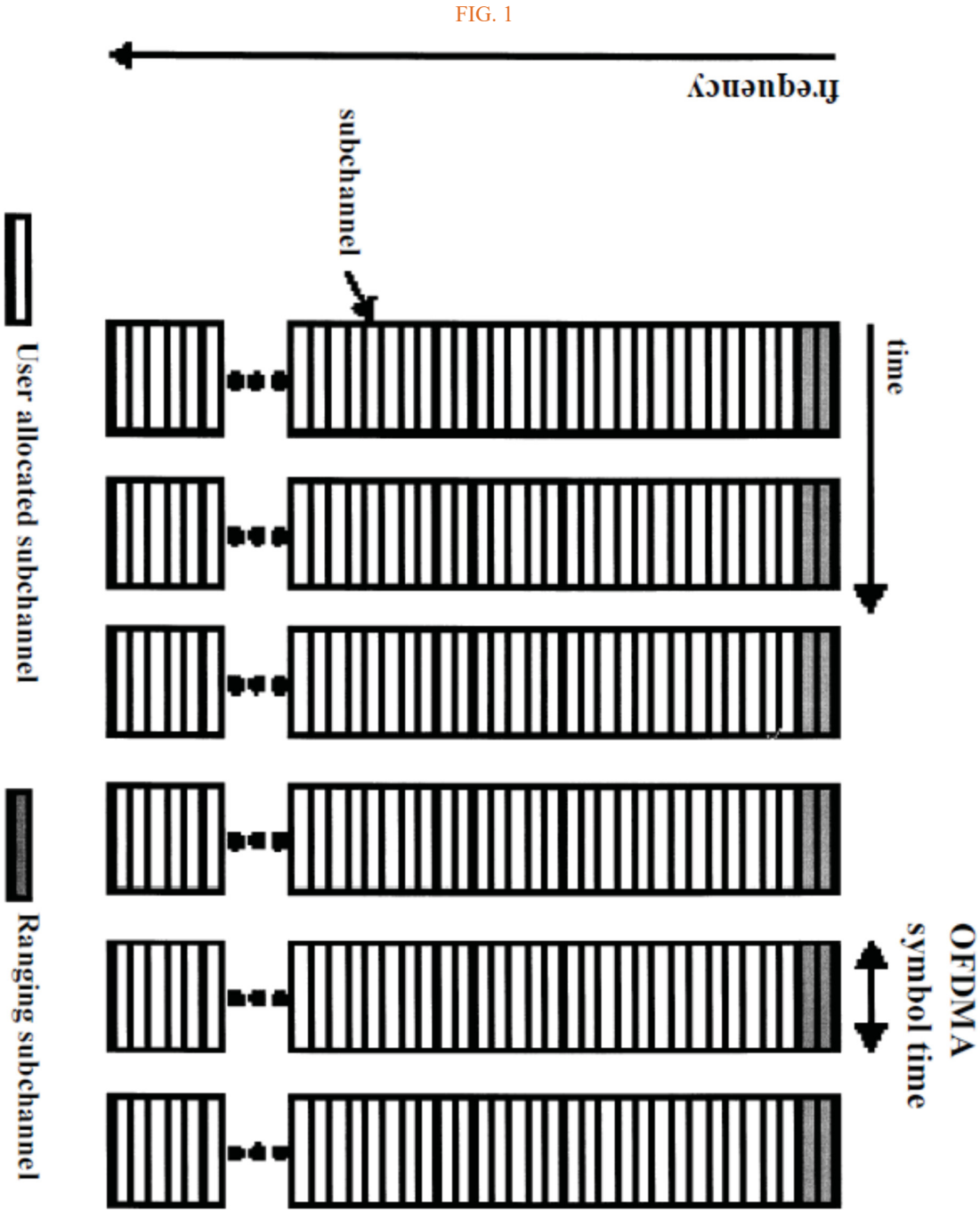


FIG. 2

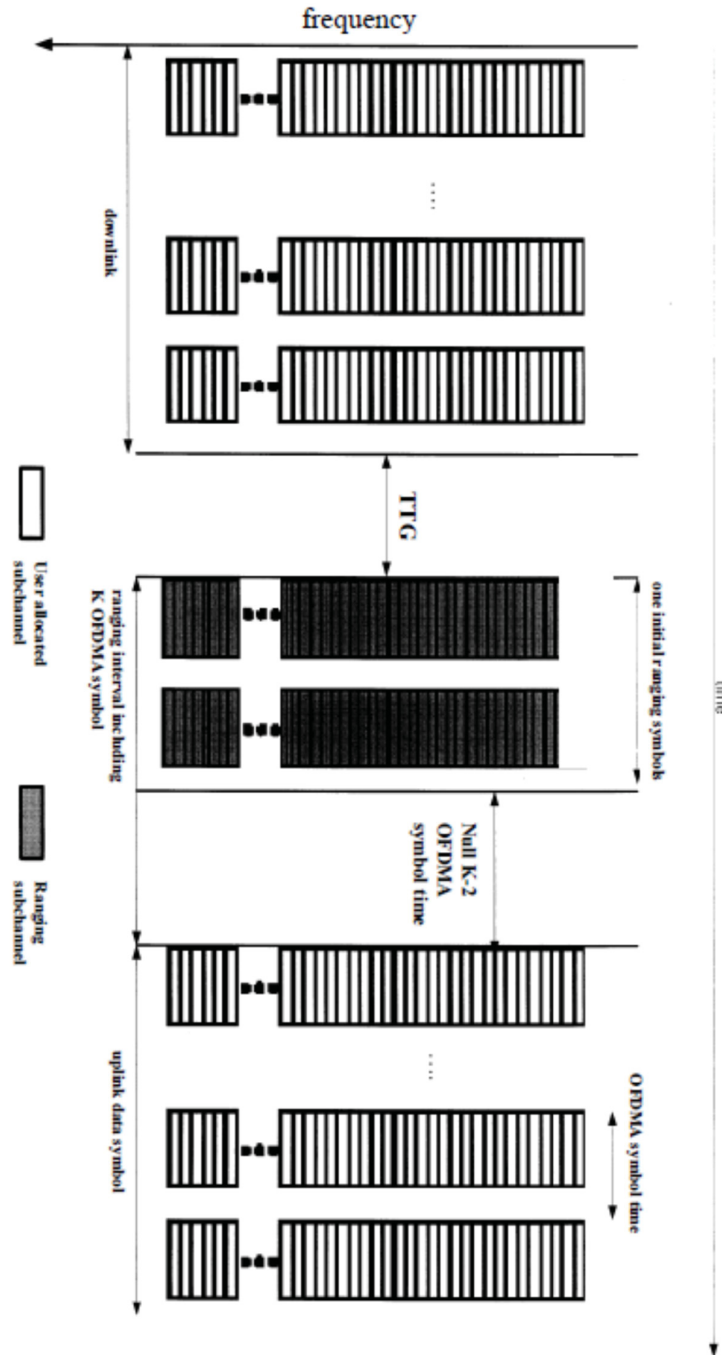


FIG. 3

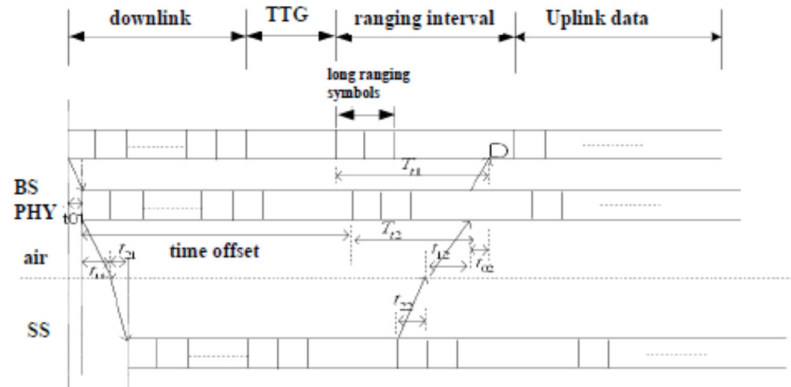


FIG. 4

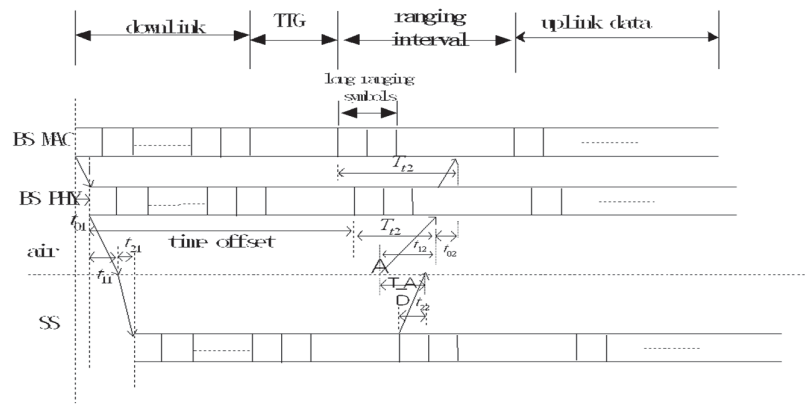


FIG. 5

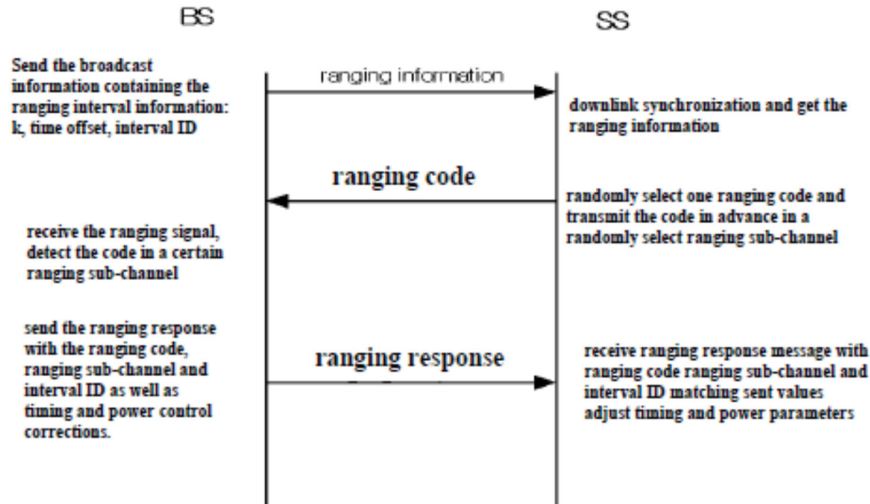


FIG. 6

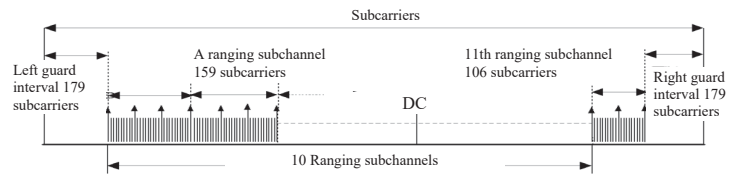


FIG. 7

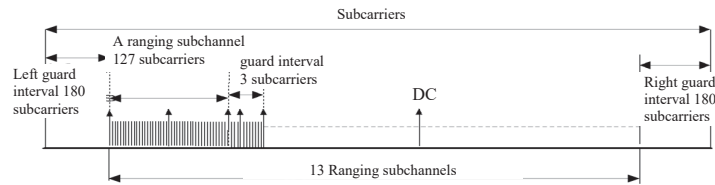


FIG. 8

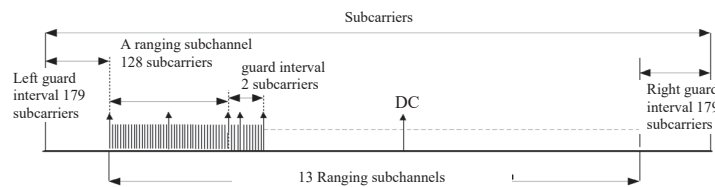


FIG. 9

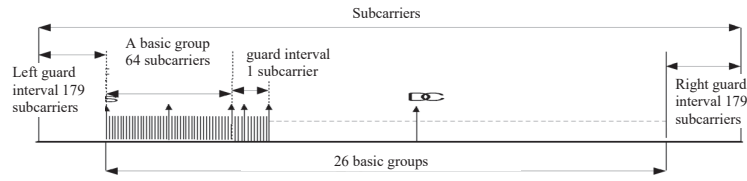


FIG. 10

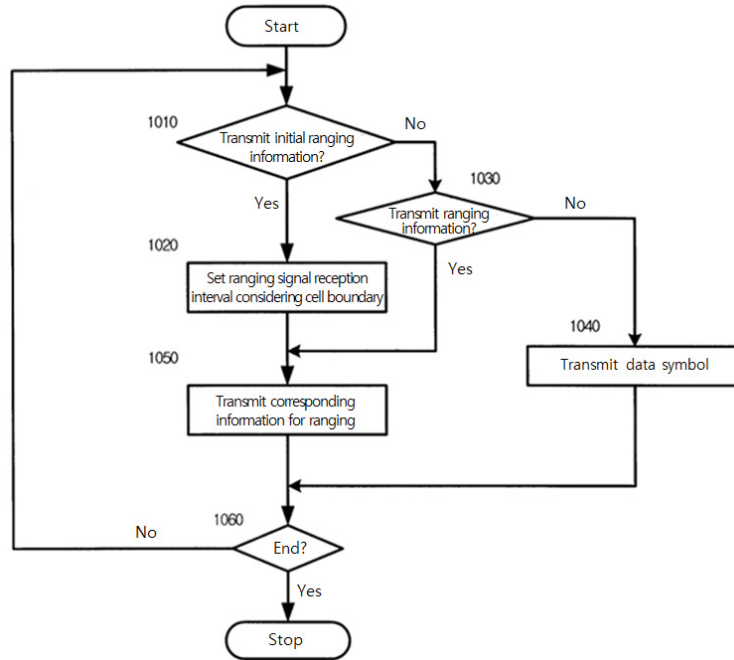


FIG. 11

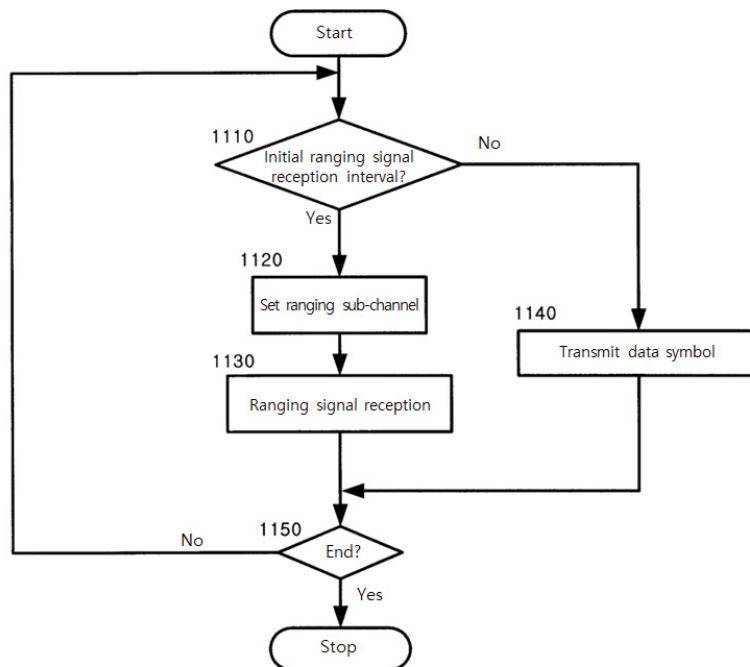


FIG. 12

