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(54) **METHOD AND APPARATUS FOR TRANSMITTING RANGING SIGNAL IN WIRELESS COMMUNICATION SYSTEM**

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H04L 5/00 (2006.01)
H04L 27/26 (2006.01)

(52) **U.S. Cl.**
CPC ***H04L 5/0053*** (2013.01); ***H04L 5/0066*** (2013.01); ***H04L 5/0094*** (2013.01); *H04L 27/261* (2013.01)

(58) **Field of Classification Search**
CPC H04W 72/0453; H04L 5/0053; H04L 5/0007; H04L 5/0023; H04L 5/0039; H04L 5/0041; H04L 5/0044; H04L 5/0048
USPC 370/310–350
See application file for complete search history.

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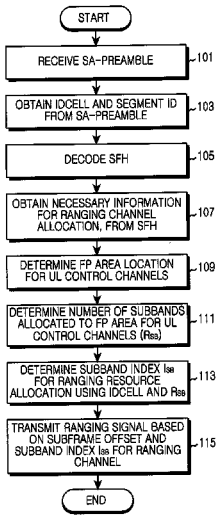
(74) *Attorney, Agent, or Firm* — Jefferson IP Law, LLP

(57) **ABSTRACT**

A method of a mobile station for transmitting a ranging signal in a wireless communication system which supports Fractional Frequency Reuse (FFR) and an apparatus for performing the method are provided. The method includes receiving information of ranging resource allocation, from a base station, based on the information of the ranging resource allocation, determining a cell identifier and a Frequency Partition (FP) location for uplink control channels, determining a subband index for the ranging resource allocation based on the cell identifier and a number of subbands allocated to the FP location for the uplink control channels, and transmitting a ranging signal based on the subband index for the ranging resource allocation. Thus, interference to a neighboring cell may be reduced in the ranging channel transmission.

32 Claims, 8 Drawing Sheets



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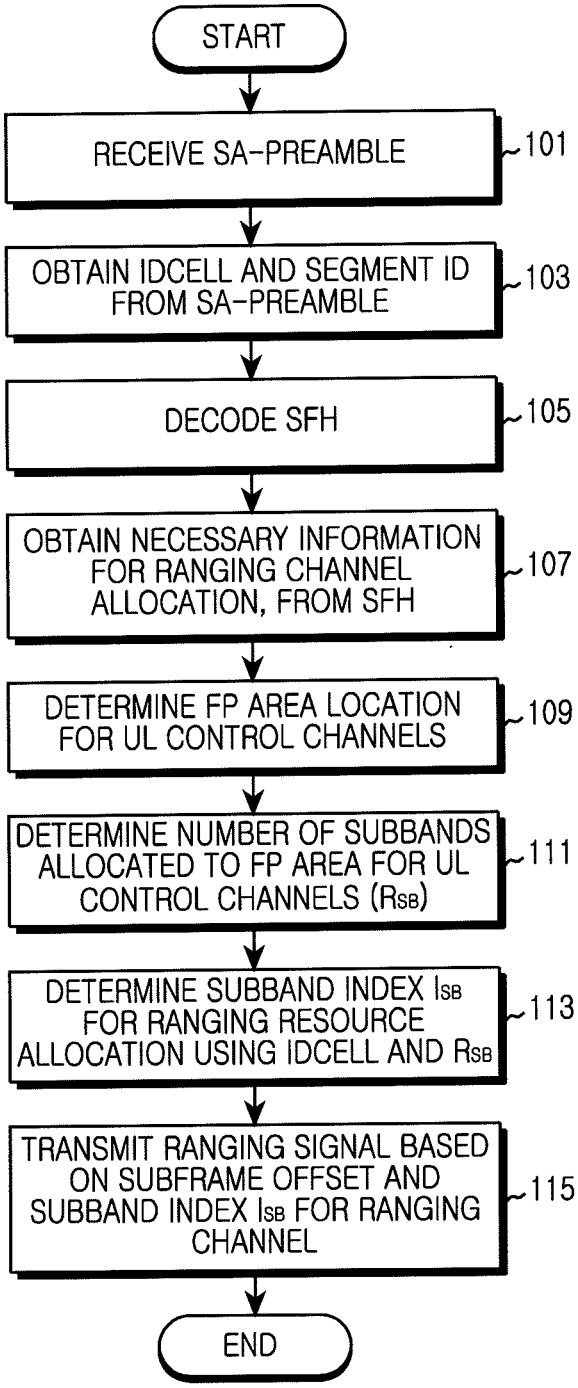

START
RECEIVE SA-PREAMBLE
101
OBTAIN IDCELL AND SEGMENT ID FROM SA-PREAMBLE
103
DECODE SFH
105
OBTAIN NECESSARY INFORMATION FOR RANGING CHANNEL ALLOCATION, FROM SFH
107
DETERMINE FP AREA LOCATION FOR UL CONTROL CHANNELS
109
DETERMINE NUMBER OF SUBBANDS ALLOCATED TO FP AREA FOR UL CONTROL CHANNELS (R_{SB})
111
DETERMINE SUBBAND INDEX I_{SB} FOR RANGING RESOURCE ALLOCATION USING IDCELL AND R_{SB}
113
TRANSMIT RANGING SIGNAL BASED ON SUBFRAME OFFSET AND SUBBAND INDEX I_{SB} FOR RANGING CHANNEL
115
END

FIG.1

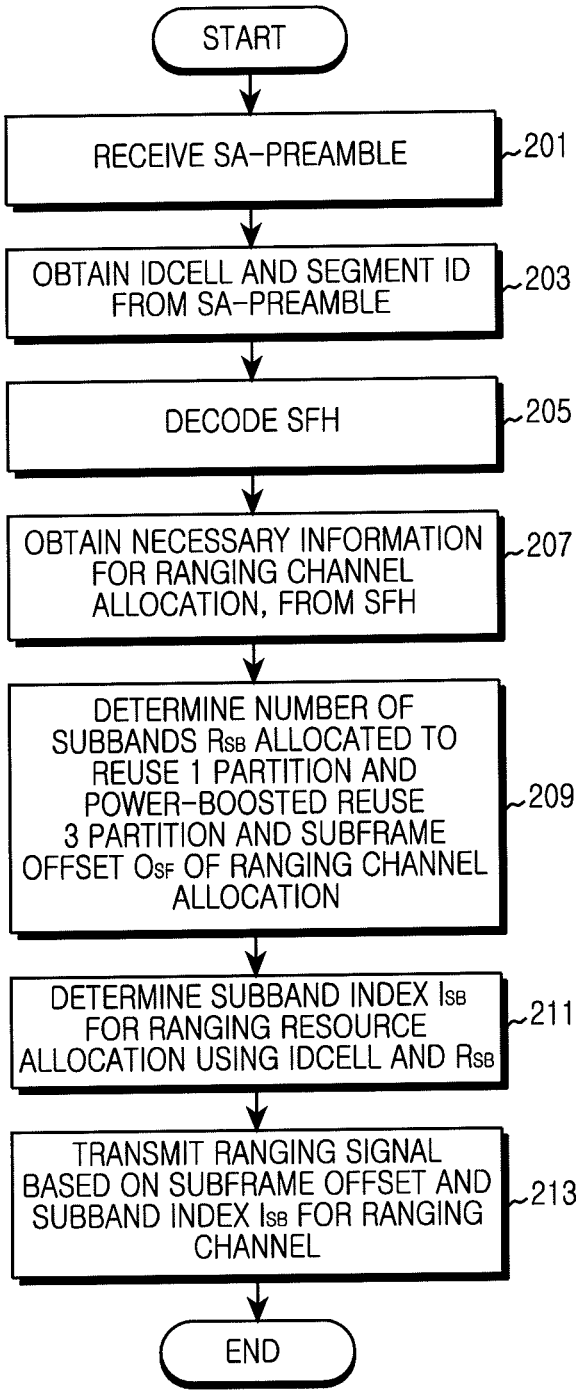

START
RECEIVE SA-PREAMBLE
201
OBTAIN IDCELL AND SEGMENT ID FROM SA-PREAMBLE
203
DECODE SFH
205
OBTAIN NECESSARY INFORMATION FOR RANGING CHANNEL ALLOCATION, FROM SFH
207
DETERMINE NUMBER OF SUBBANDS R_{SB} ALLOCATED TO REUSE 1 PARTITION AND POWER-BOOSTED REUSE 3 PARTITION AND SUBFRAME OFFSET O_{SF} OF RANGING CHANNEL ALLOCATION
209
DETERMINE SUBBAND INDEX I_{SB} FOR RANGING RESOURCE ALLOCATION USING IDCELL AND R_{SB}
211
TRANSMIT RANGING SIGNAL BASED ON SUBFRAME OFFSET AND SUBBAND INDEX I_{SB} FOR RANGING CHANNEL
213
END

FIG.2

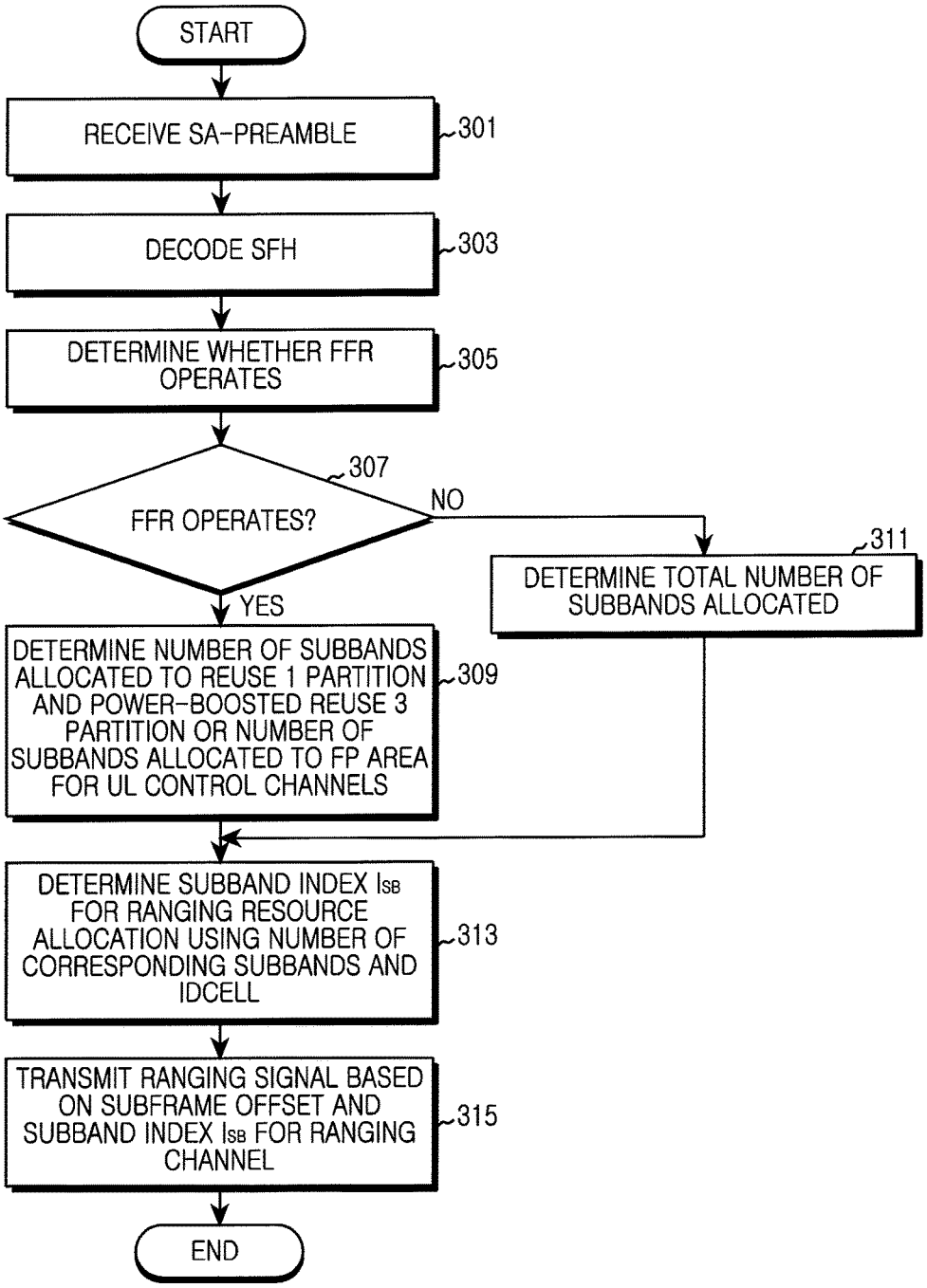

START
RECEIVE SA-PREAMBLE
301
DECODE SFH
303
DETERMINE WHETHER FFR OPERATES
305
307
FFR OPERATES?
NO
YES
311
DETERMINE TOTAL NUMBER OF SUBBANDS ALLOCATED
DETERMINE NUMBER OF SUBBANDS ALLOCATED TO REUSE 1 PARTITION AND POWER-BOOSTED REUSE 3 PARTITION OR NUMBER OF SUBBANDS ALLOCATED TO FP AREA FOR UL CONTROL CHANNELS
309
DETERMINE SUBBAND INDEX Isb FOR RANGING RESOURCE ALLOCATION USING NUMBER OF CORRESPONDING SUBBANDS AND IDCELL
313
TRANSMIT RANGING SIGNAL BASED ON SUBFRAME OFFSET AND SUBBAND INDEX Isb FOR RANGING CHANNEL
315
END

FIG.3

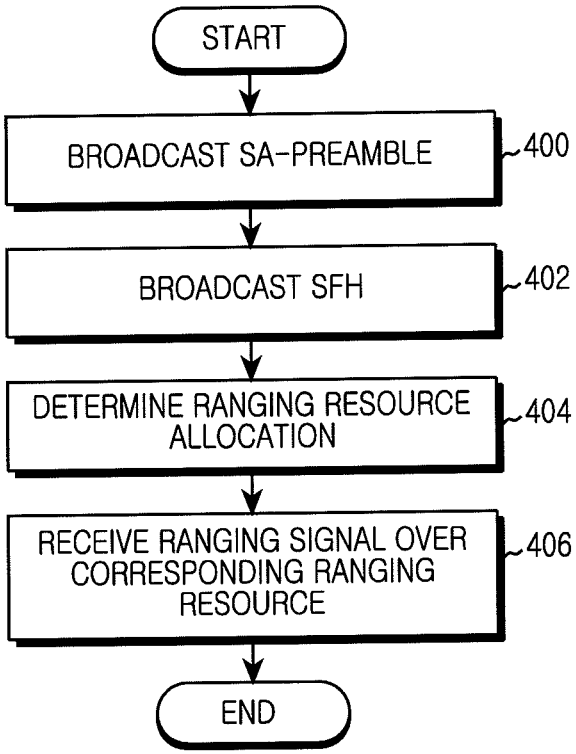
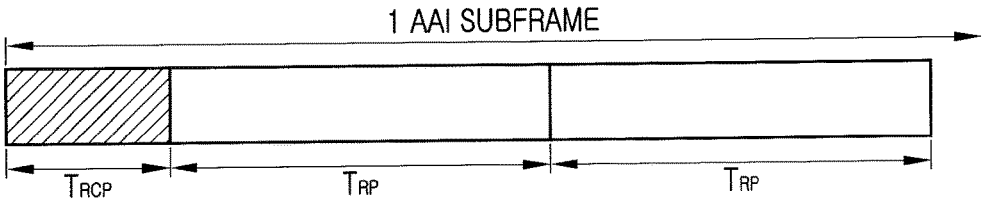
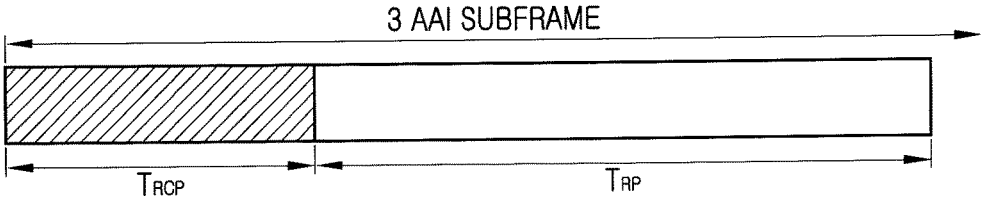

START
BROADCAST SA-PREAMBLE
400
BROADCAST SFH
402
DETERMINE RANGING RESOURCE ALLOCATION
404
RECEIVE RANGING SIGNAL OVER CORRESPONDING RANGING RESOURCE
406
END

FIG.4



FORMAT 0

FIG.5A



FORMAT 1

FIG.5B

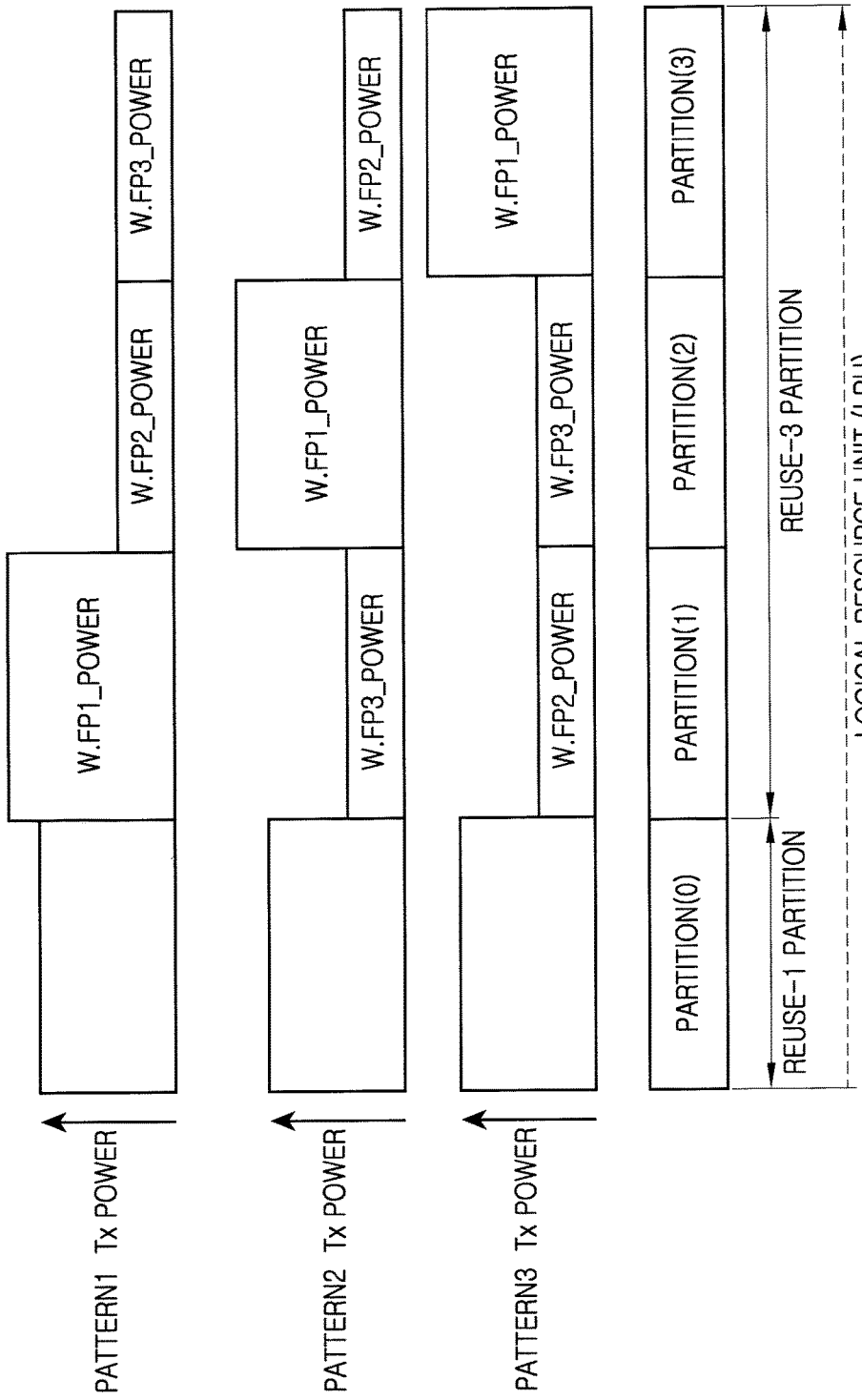

PATTERN1 Tx POWER
W.FP1_POWER
W.FP2_POWER
W.FP3_POWER
PATTERN2 Tx POWER
W.FP1_POWER
W.FP3_POWER
W.FP2_POWER
PATTERN3 Tx POWER
W.FP1_POWER
W.FP3_POWER
W.FP2_POWER
PARTITION(0)
PARTITION(1)
PARTITION(2)
PARTITION(3)
REUSE-1 PARTITION
REUSE-3 PARTITION
LOGICAL RESOURCE UNIT (LRU)

FIG.6

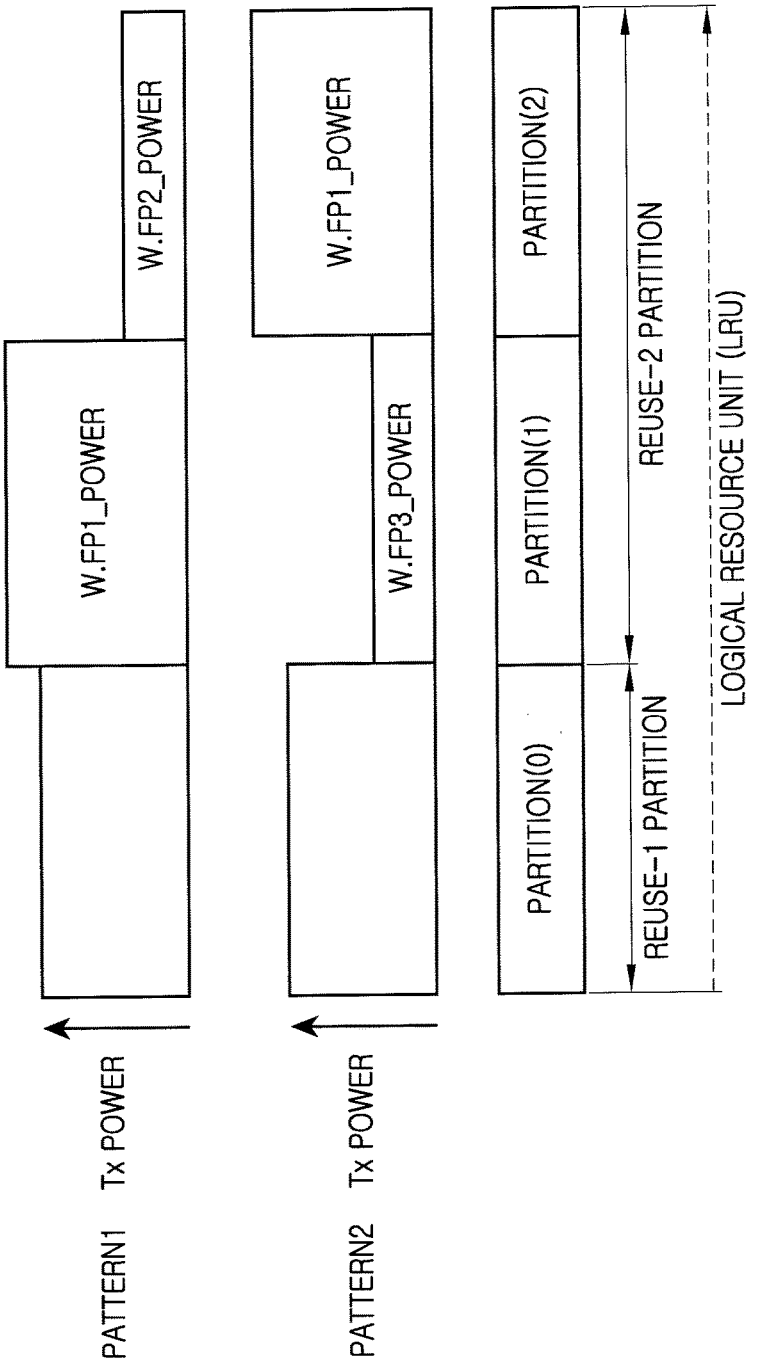

PATTERN1
Tx POWER
W.FP1_POWER
W.FP2_POWER
PATTERN2
Tx POWER
W.FP3_POWER
W.FP1_POWER
PARTITION(0)
PARTITION(1)
PARTITION(2)
REUSE-1 PARTITION
REUSE-2 PARTITION
LOGICAL RESOURCE UNIT (LRU)

FIG. 7

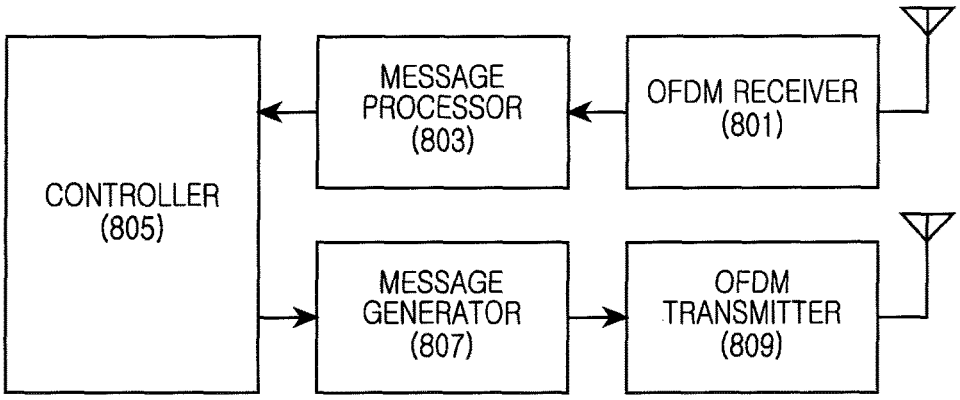

CONTROLLER
(805)
MESSAGE
PROCESSOR
(803)
OFDM RECEIVER
(801)
MESSAGE
GENERATOR
(807)
OFDM
TRANSMITTER
(809)

FIG.8

METHOD AND APPARATUS FOR TRANSMITTING RANGING SIGNAL IN WIRELESS COMMUNICATION SYSTEM

PRIORITY

This application claims the benefit under 35 U.S.C. §119 (a) of a Korean patent application filed in the Korean Intellectual Property Office on Aug. 12, 2010, and assigned Serial No. 10-2010-0077845, the entire disclosure of which is hereby incorporated by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to ranging signal transmission in a wireless communication system. More particularly, the present invention relates to a method and an apparatus for transmitting a ranging signal by considering Fractional Frequency Reuse (FFR) in a wireless communication system.

2. Description of the Related Art

In a wireless communication system, a mobile station obtains uplink timing and STation IDentification (STID) through a ranging procedure. The ranging procedure generally commences when the mobile station transmits a ranging signal. To transmit the ranging signal, it is necessary to know a location of a resource for transmitting the ranging signal.

According to Institute of Electrical and Electronics Engineers (IEEE)802.16m, the location of the resource for transmitting the ranging signal may be obtained as follows. A format of the ranging signal to transmit and a subframe location are acquired based on a SuperFrame Header (SFH), and a subband location is determined by an IDcell value of a cell carrying the current ranging signal. The location of the subband I_{SB} is determined using mod(IDcell,Y_{SB}) which is a function of a total number of subbands Y_{SB} and IDcell used in the current cell.

In a multi-carrier Orthogonal Frequency Division Multiple Access (OFDMA) system, resources are allocated based on a subchannel including subcarriers. A plurality of users divides and shares the subcarriers, thus obtaining a multi-user diversity gain in the frequency domain. Orthogonal Frequency Division Multiplexing (OFDM)/OFDMA broadband wireless communication system reuses the same frequency in every cell, applies Adaptive Modulation and Coding (AMC) according to a receive signal intensity and interference between neighboring cells, and thus maximizes throughput. However, in a system with a frequency reuse factor of 1, the interference between the neighboring cells is severe in the boundary of the cell or the sector and the yield is lowered. The system is also subject to service outage. To enhance the performance in the cell boundary with the frequency reuse factor of 1, a Fractional Frequency Reuse (FFR) scheme under consideration divides the whole frequency band into a plurality of Frequency Partitions (FPs), adequately deploys the FP areas, limits the power level of some FP areas in each cell, and thus alleviates the same channel interference between the neighboring cells. When a serving cell prefers and uses some FP areas, other neighboring cells control their power level to reduce the interference level below a certain level with respect to the FP areas preferred by the serving cell.

As stated above, the mobile station in the IEEE 802.16m system determines the subband location I_{SB} of the ranging channel based on the function mod(IDcell, Y_{SB}) of the total number of subbands Y_{SB} and IDcell used in the current cell.

However, the resource location determination for transmitting the ranging signal does not take account of the FFR. In the FFR, the power level of some FP areas of the neighboring cell is limited, whereas the subband of the ranging channel may be selected in the whole frequency band. As a result, the mobile station in the corresponding cell boundary, as transmitting the ranging signal, may cause interference in the neighboring cell.

What is needed is a method and an apparatus for reducing the interference to the neighboring cell when the ranging signal is transmitted in the wireless communication system which supports the FFR.

SUMMARY OF THE INVENTION

Aspects of the present invention are to address at least the above-mentioned problems and/or disadvantages and to provide at least the advantages described below. Accordingly, an aspect of the present invention is to provide a method and an apparatus for transmitting a ranging signal in a wireless communication system supporting Fractional Frequency Reuse (FFR).

Another aspect of the present invention is to provide a method and an apparatus for reducing interference to a neighboring cell when a ranging signal is transmitted in a wireless communication system which supports FFR.

According to an aspect of the present invention, a method of a mobile station for transmitting a ranging signal in a wireless communication system which supports FFR is provided. The method includes receiving information of ranging resource allocation, from a base station, based on the information of the ranging resource allocation, determining a cell identifier and a Frequency Partition (FP) location for uplink control channels, determining a subband index for the ranging resource allocation based on the cell identifier and a number of subbands allocated to the FP location for the uplink control channels, and transmitting a ranging signal based on the subband index for the ranging resource allocation.

According to another aspect of the present invention, a method of a base station for transmitting a ranging signal in a wireless communication system which supports FFR is provided. The method includes broadcasting information of ranging resource allocation, based the information of the ranging resource allocation, determining a cell identifier and a FP location for uplink control channels, determining a subband index for the ranging resource allocation based on the cell identifier and a number of subbands allocated to the FP location for the uplink control channels, and receiving a ranging signal from a mobile station based on the subband index for the ranging resource allocation.

According to another aspect of the present invention, a method of a mobile station for transmitting a ranging signal in a wireless communication system is provided. The method includes determining whether FFR operates, when the FFR operates, determining a cell identifier and a FP location for uplink control channels based on the information of the ranging resource allocation, determining a subband index for ranging resource allocation based on the cell identifier and a number of subbands allocated to the FP location for the uplink control channels, and transmitting a ranging signal based on the subband index for the ranging resource allocation.

According to another aspect of the present invention, an apparatus of a mobile station for transmitting a ranging signal in a wireless communication system which supports FFR is provided. The apparatus includes a receiver for

receiving information of ranging resource allocation, from a base station, a controller for determining a cell identifier and a FP location for uplink control channels based on the information of the ranging resource allocation, and for determining a subband index for the ranging resource allocation based on the cell identifier and a number of subbands allocated to the FP location for the uplink control channels, and a transmitter for transmitting a ranging signal based on the subband index for the ranging resource allocation.

According to another aspect of the present invention, an apparatus of a base station for transmitting a ranging signal in a wireless communication system which supports FFR is provided. The apparatus includes a transmitter for broadcasting information of ranging resource allocation, a controller for determining a cell identifier and a FP location for uplink control channels based on the information of the ranging resource allocation, and for determining a subband index for the ranging resource allocation based on the cell identifier and a number of subbands allocated to the FP location for the uplink control channels, and a receiver for receiving a ranging signal from a mobile station based on the subband index for the ranging resource allocation.

According to another aspect of the present invention, an apparatus of a mobile station for transmitting a ranging signal in a wireless communication system is provided. The apparatus includes a controller for determining whether FFR operates, for, when the FFR operates, determining a cell identifier and a FP location for uplink control channels based on the information of the ranging resource allocation, and for determining a subband index for ranging resource allocation based on the cell identifier and a number of subbands allocated to the FP location for the uplink control channels, and a transmitter for transmitting a ranging signal based on the subband index for the ranging resource allocation.

Other aspects, advantages, and salient features of the invention will become apparent to those skilled in the art from the following detailed description, which, taken in conjunction with the annexed drawings, discloses exemplary embodiments of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other aspects, features, and advantages of certain exemplary embodiments of the present invention will be more apparent from the following description taken in conjunction with the accompanying drawings, in which:

FIG. **1** is a flowchart of operations of a mobile station for transmitting a ranging signal in a wireless communication system according to an exemplary embodiment of the present invention;

FIG. **2** is a flowchart of operations of a mobile station for transmitting a ranging signal in a wireless communication system according to an exemplary embodiment of the present invention;

FIG. **3** is a flowchart of operations of a mobile station for transmitting a ranging signal in a wireless communication system according to an exemplary embodiment of the present invention;

FIG. **4** is a flowchart of operations of a base station for transmitting a ranging signal in a wireless communication system according to an exemplary embodiment of the present invention;

FIGS. **5**A and **5**B are a diagram of non-synchronized ranging channel allocation in one or more subframes according to an exemplary embodiment of the present invention;

FIG. **6** is a diagram of Fractional Frequency Reuse (FFR) for a scenario with reuse **3** according to an exemplary embodiment of the present invention;

FIG. **7** is a diagram of FFR for a scenario with reuse **2** according to an exemplary embodiment of the present invention; and

FIG. **8** is a block diagram of an apparatus for transmitting a ranging signal in a wireless communication system according to an exemplary embodiment of the present invention.

Throughout the drawings, like reference numerals will be understood to refer to like parts, components and structures.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

The following description with reference to the accompanying drawings is provided to assist in a comprehensive understanding of exemplary embodiments of the invention as defined by the claims and their equivalents. It includes various specific details to assist in that understanding, but these are to be regarded as merely exemplary. Accordingly, those of ordinary skill in the art will recognize that various changes and modifications of the embodiments described herein may be made without departing from the scope and spirit of the invention. In addition, descriptions of well-known functions and constructions may be omitted for clarity and conciseness.

The terms and words used in the following description and claims are not limited to the bibliographical meanings, but are merely used by the inventor to enable a clear and consistent understanding of the invention. Accordingly, it should be apparent to those skilled in the art that the following description of exemplary embodiments of the present invention is provided for illustration purposes only and not for the purpose of limiting the invention as defined by the appended claims and their equivalents.

It is to be understood that the singular forms "a," "an," and "the" include plural referents unless the context clearly dictates otherwise. Thus, for example, reference to "a component surface" includes reference to one or more of such surfaces.

By the term "substantially" it is meant that the recited characteristic, parameter, or value need not be achieved exactly, but that deviations or variations, including for example, tolerances, measurement error, measurement accuracy limitations and other factors known to those of skill in the art, may occur in amounts that do not preclude the effect the characteristic was intended to provide.

Exemplary embodiments of the present invention provide a method and an apparatus for transmitting a ranging signal in a wireless communication system. Hereinafter, an Institute of Electrical and Electronics Engineers (IEEE) 802.16m communication system is described as an example.

In the IEEE 802.16m communication system, the ranging signal is transmitted over one or three subframes in the time axis and over one subband in the frequency axis. A timing for transmitting the ranging signal is known through a SubFrame Header (SFH), and the subband for transmitting the ranging signal is obtained from IDcell. The IEEE 802.16m communication system may employ Fractional Frequency Reuse (FFR). In this case, each cell is given a Frequency Partition (FP) area to use in the corresponding cell (hereafter, referred to as a boosted frequency partition or a power-boosted reuse **3** area) among reuse **3** FP and performs scheduling to experience as little as possible interference on the FP in other neighboring cells. The frequency location (i.e., the subband index) of the current

ranging signal is determined without considering the FFR. Hence, when the FFR is applied and the location of the subband determined based on IDcell is not in the reuse **3** FP area of the corresponding cell, the ranging signal of the mobile station in the boundary of the corresponding cell may create interference in the other cell.

As stated above, when the ranging channel is allocated to the subband of the FR area, rather than to the reuse **1** area or the power-boosted reuse **3** area, considerable interference with the neighboring cell may occur. Accordingly, such allocation should be avoided. The allocation should also be fulfilled without additional signaling overhead as in the allocation method of the related art. Exemplary embodiments of the present invention provide two methods. One method calculates the subband index by adopting R_{SB} instead of the existing Y_{SB}. Y_{SB} denotes the total number of the subbands allocated to the cell and R_{SB} denotes the number of the subbands allocated to the reuse **1** or the power-boosted reuse **3** area. I_{SB}=mod(IDcell,Y_{SB}) is modified to I_{SB}=mod(IDcell, R_{SB}) where Y_{SB}=Σ(LSB-CRU, FP_i)/4 (i=0, 1, 2, 3) and RSB=(L_{SB}-CRU,FP_i+LSB-CRU, FP_k)/4, k=segment_ID+1. LSB-CRU,FP_i denotes the number of subband Contiguous Resource Units (CRUs) allocated to the FP_i area and segment_ID denotes a segment value of the corresponding cell. The location of the subband to which the ranging channel may be allocated may be restricted to the reuse **1** and the power-boosted reuse **3** area.

The other method uses frequency partition location for UpLink (UL) control channels which is a parameter of the SFH identifying locations of a current UL feedback channel and a Bandwidth Request (BR) channel. At present, this field is 1 bit. When the field value is 0b0, it signifies that the reuse **1** area includes the UL feedback channel and the BR channel. When the field value is 0b1, it signifies that the power-boosted reuse **3** area includes the UL feedback channel and the BR channel.

Exemplary embodiments of the present invention provide a method for applying this field value to the I_{SB} calculation without additional overhead increase. I_{SB}=mod(IDcell, R_{SB}) where R_{SB} denotes the number of the subbands allocated to the reuse **1** area or the power-boosted reuse **3** area determined by the field value of the frequency partition location for UL control channels of the SFH. Operations of the mobile station according to the two methods are described below with respect to FIGS. **1**, **2**, and **3**.

FIG. **1** illustrates operation of a mobile station for transmitting a ranging signal in a wireless communication system according to an exemplary embodiment of the present invention.

Referring to FIG. **1**, the mobile station receives a Secondary Advanced (SA)-preamble from a base station in step **101** and determines IDcell and segment_ID (0,1,2) based on the received SA-preamble in step **103**. IDcell, which is the cell identifier, is derived from the SA-preamble and determined based on segment_ID.

In step **105**, the mobile station decodes the SFH. The SFH carries essential system parameters and system configuration information. The SFH is positioned in the first subframe of the super frame.

In step **107**, the mobile station obtains necessary information for the ranging channel allocation from the received SFH. For example, the information may include frequency partition location for UL control channels, such as UL feedback channel and BR channel, and subframe offset O_{SF} of the ranging channel. The information includes the total number of the subbands allocated in the current cell or the number of the subbands in each FP when the FFR is applied. In the initial ranging procedure, the information includes format information (see FIG. **5**) of the ranging channel. In various implementations, the number of the subbands allocated in each FP may be changed to the number of the subband CRUs allocated in each FP (LSB-CRU,FP_i). The number of the subbands allocated in each FP is determined as LSB-CRU, FP_i/4 (i=0, 1, 2, 3). Herein, LSB-CRU,FP_i denotes the number of the subband CRUs allocated in the FP_i area. FP_0 is the FP area of the reuse **1**, and FP_1 FP_2 or FP_3 is the FP area of the power-boosted reuse **3**. The FP area of the power-boosted reuse **3** of the corresponding cell is determined as segment ID+1.

In step **109**, the mobile station determines the FP area location for the UL control channels based on the field value of the frequency partition location for UL control channels of the SFH. In step **111**, the mobile station determines the number of the subbands allocated to the FP area for the UL control channels. For example, when the 1-bit field value of the frequency partition location for UL control channels is 0b0, the UL control channels such as UL feedback channel and BR channel are allocated to the reuse **1** area. When the field value is 0b1, the UL feedback channel and BR channel are allocated to the power-boosted reuse **3** area.

In step **113**, the mobile station determines the subband index I_{SB} (0, . . . , R_{SB} −1) for the ranging resource allocation using IDcell derived from the SA-preamble and the number of the subbands allocated to the FP area for the UL control channels. The subband index I_{SB} for the ranging resource allocation is defined based on Equation 1 or Equation 2. Equation 1 is used for the ranging channel for non-synchronized mobile stations, and Equation 2 is used for the ranging channel for synchronized mobile stations.

$$I_{SB}=\mathrm{mod}(\mathrm{IDcell},R_{SB}) \quad (1)$$

mod denotes a modulo operation, IDcell denotes the cell identifier derived from the SA-preamble, and R_{SB} denotes the number of the subbands allocated to the FP area for the UL control channels.

$$I_{SB}=\mathrm{mod}(\mathrm{IDcell}+1,R_{SB}) \quad (2)$$

In step **115**, the mobile station transmits the ranging signal using the subband value I_{SB} used for the ranging channel transmission and the subframe value O_{SF}, used for the ranging channel transmission.

In FIG. **1**, the subband I_{SB} used for the ranging channel transmission is determined using the value of the frequency partition location for UL control channels of the SFH. In various implementations, the corresponding FP area may be indicated by adding a separate indication field. The subband I_{SB} is determined based on the total number of the subbands in the indicated FP area.

FIG. **2** illustrates operation of a mobile station for transmitting a ranging signal in a wireless communication system according to an exemplary embodiment of the present invention.

Referring to FIG. **2**, the mobile station receives the SA-preamble from the base station in step **201** and determines IDcell and segment_ID (0,1,2) based on the received SA-preamble in step **203**. IDcell, which is the cell identifier, is derived from the SA-preamble and determined based on segment_ID.

In step **205**, the mobile station decodes the SFH. The SFH carries the essential system parameters and the system configuration information. The SFH is positioned in the first subframe of the super frame.

In step **207**, the mobile station obtains the necessary information for the ranging channel allocation from the

received SFH. For example, the information may include the total number of the subbands in the reuse **1** FP area and the power-boosted reuse **3** FP area. The information also includes the subframe offset O_{SF} of the ranging channel. The information includes the total number of the subbands allocated in the current cell or the number of the subbands in each FP when the FFR is used. In the initial ranging procedure, the information includes the format information (see FIG. **5**) of the ranging channel. The ranging channel format is classified into a non-synchronized ranging channel and a synchronized ranging channel. FIG. **5** depicts the non-synchronized ranging channel format.

In various implementations, the number of the subbands allocated in each FP may be replaced by the number of the subband CRUs allocated in each FP (LSB-CRU, FPi). The number of the subbands allocated in each FP is determined as LSB-CRU,FPi/4 (i=0, 1, 2, 3). LSB-CRU,FPi denotes the number of the subband CRUs allocated in the FPi area. FP**0** is the FP area of the reuse **1**, and FP**1**, FP**2**, or FP**3** is the FP area of the power-boosted reuse **3**. The FP area of the power-boosted reuse **3** of the corresponding cell is determined as segment ID+1.

In step **209**, the mobile station determines the total number of the subbands R_{SB} in the reuse **1** FP area and the power-boosted reuse **3** FP area, and the subframe offset O_{SF} of the ranging channel allocation based on the SFH.

In step **211**, the mobile station determines the subband index I_{SB} $(0, \ldots, R_{SB}-1)$ for the ranging resource allocation using IDcell derived from the SA-preamble and the total number of the subbands R_{SB} of the reuse **1** FP area and the power-boosted reuse **3** FP area. The subband index I_{SB} for the ranging resource allocation is defined based on Equation 3 or Equation 4. Equation 3 is used for the ranging channel for the non-synchronized mobile stations, and Equation 4 is used for the ranging channel for the synchronized mobile stations.

$$I_{SB}=\mathrm{mod}(\mathrm{IDcell},R_{SB}) \tag{3}$$

mod denotes the modulo operation, IDcell denotes the cell identifier derived from the SA-preamble, and R_{SB} denotes the number of the subbands allocated to the reuse **1** FP area and the power-boosted reuse **3** FP area.

$$I_{SB}=\mathrm{mod}(\mathrm{IDcell}+1,R_{SB}) \tag{4}$$

In step **213**, the mobile station transmits the ranging signal using the subband value I_{SB} used for the ranging channel transmission and the subframe value O_{SF}, used for the ranging channel transmission.

While most of the operations of FIG. **1** and FIG. **2** are substantially the same, a difference lies in that the mobile station determines which FP includes the subbands of the ranging channel through the frequency partition location for UL control channels based on the SFH and calculates I_{SB} solely using the number of the subbands allocated to the corresponding FP. When the FFR is operated through the two methods, the neighboring cell interference is not caused by the location of the subbands carrying the ranging channel.

FIG. **3** is a flowchart of operations of a mobile station for transmitting a ranging signal in a wireless communication system according to an exemplary embodiment of the present invention.

Referring to FIG. **3**, the mobile station receives the SA-preamble from the base station and determines IDcell and segment_ID (0,1,2) based on the SA-preamble in step **301**. IDcell, which is the cell identifier, is derived from the SA-preamble and determined based on segment_ID. IDcell matches the SA-preamble.

In step **303**, the mobile station decodes the SFH. The SFH carries the essential system parameters and the system configuration information. The SFH is positioned in the first subframe of the super frame.

In step **305**, the mobile station determines based on the received SFH whether the FFR is operated. When the FFR is operated in step **307**, the mobile station confirms, based on the SFH, the total number of the subbands in the reuse **1** FP area and the power-boosted reuse **3** FP area, or the total number of the subbands in the FP area (either the reuse **1** FP area or the power-boosted reuse **3** FP area) allocated the UL control channels in step **309**. In contrast, when the FFR is not operated in step **307**, the mobile station determines the total number of the subbands in the whole FP area in step **311**.

In step **313**, the mobile station determines the subband index I_{SB} for the ranging resource allocation using the total number of the subbands R_{SB} in the reuse **1** FP area and the power-boosted reuse **3** FP area, the total number of the subbands R_{SB} in the FP area allocated the UL control channels, or the total number of the subbands in the whole FP area, and IDcell derived from the SA-preamble.

In step **315**, the mobile station transmits the ranging signal using the subband value I_{SB} used for the ranging channel transmission and the subframe value O_{SF} used for the ranging channel transmission.

FIG. **4** illustrates operation of a base station for transmitting a ranging signal in a wireless communication system according to an exemplary embodiment of the present invention.

Referring to FIG. **4**, the base station broadcasts the SA-preamble in step **400** and broadcasts the SFH in step **402**. The SA-preamble is determined by IDcell and segment_ID (0,1,2). The SFH carries the essential system parameters and the system configuration information. For example, the SFH includes the information necessary for the ranging channel allocation, e.g., the frequency partition location for UL control channels such as UL feedback channel and BR channel, the subframe offset O_{SF} of the ranging channel, the total number of the subbands allocated to the current cell or the number of the subbands of each FP when the FFR is applied, and the format information of the ranging channel.

In step **404**, the base station determines the ranging resource allocation location by taking account of the FFR. The subframe information O_{SF} of the ranging channel is carried by the SFH from the base station to the mobile station. The base station does not directly transmit the subband information of the ranging channel to the mobile station. Since the subbands of the ranging channel are determined based on the total number of the subbands R_{SB} in the reuse **1** FP area and the power-boosted reuse **3** FP area, the total number of the subbands R_{SB} in the FP area allocated the UL control channels, or the total number of the subbands in the whole FP area, and IDcell derived from the SA-preamble, the base station and the mobile station may implicitly determine the subbands of the ranging channel.

In step **406**, the base station receives the ranging signal from corresponding mobile stations at the confirmed ranging resource allocation location. Mobile stations in the cell transmit the ranging signal in competition with other mobile stations.

FIGS. **5**A and **5**B illustrate non-synchronized ranging channel allocation in one or more subframes according to an exemplary embodiment of the present invention.

Referring to FIGS. **5**A and **5**B, the non-synchronized ranging channel is used for the initial network entry. The

physical non-synchronized ranging channel includes a ranging preamble or a ranging code. T_{RP} is determined according to a subcarrier spacing, and T_{RCP} is a ranging cyclic prefix.

The physical non-synchronized ranging channel occupies the bandwidth corresponding to one subband.

The physical non-synchronized ranging channel is allocated to one or three subframes. Format **0** is used when the physical non-synchronized ranging channel is allocated to one subframe, and Format **1** is used when the physical non-synchronized ranging channel is allocated to three subframes.

FIG. **6** illustrates a concept of FFR for a scenario with reuse **3** according to an exemplary embodiment of the present invention.

Referring to FIG. **6**, a system bandwidth is divided into four FPs including FP**0** through FP**3**, FP**0** is used as the reuse **1** partition, and FP**1**, FP**2**, and FP**3** are used as the reuse **3** partitions.

In pattern**1**, the power level of the FP**1** is higher than that of the FP**2** and the FP**3**. In pattern**2**, the power level of the FP**2** is higher than that of the FP**1** and the FP**3**. In pattern**3**, the power level of the FP**3** is higher than that of the FP**1** and the FP**2**.

Since each cell utilizes the reuse **3** partitions of the different pattern, each cell may restrict the interference with the neighboring cell during the corresponding FP. For example, a first cell may use the reuse **3** partitions of the pattern**1**, a second cell may use the reuse **3** partitions of the pattern**2**, and a third cell may use the reuse **3** partitions of the pattern**3**. The first cell has priority in the FP**1** area and a higher power level than the FP**2** and the FP**3**. In contrast, as the second cell and the third cell have a low power level in the FP**1** area, the FP**1** area of the first cell maintains a permissible interference level. Likewise, the second cell has priority in the FP**2** area and a higher power level than the FP**1** and the FP**3**. As the first cell and the third cell have a low power level in the FP**2** area, the FP**2** area of the second cell maintains a permissible interference level. The second cell has priority in the FP**2** area and a higher power level than the FP**1** and the FP**3**. The third cell has priority in the FP**3** area and a higher power level than the FP**1** and the FP**2**. As the first cell and the second cell have a low power level in the FP**3** area, the FP**3** area of the third cell maintains a permissible interference level. Hereafter, the FP**1** area of the first cell, the FP**2** area of the second cell, and the FP**3** area of the third cell are referred to as a boosted frequency partition or a power-boosted reuse **3** area.

FIG. **7** depicts FFR for a scenario with reuse **2** according to an exemplary embodiment of the present invention.

Referring to FIG. **7**, the system bandwidth is divided into three FPs including FP**0**, FP**1**, and FP**2**. FP**0** is used as the reuse **1** partition, and FP**1** and FP**2** are used as the reuse **3** partitions.

In pattern**1**, the power level of the FP**1** is higher than that of the FP**2**. In pattern**2**, the power level of the FP**2** is higher than that of the FP**1** among the reuse **3** partitions. In pattern**1**, the boosted frequency partition is the FP**1** area. In pattern**2**, the boosted frequency partition is the FP**2** area.

FIG. **8** is a block diagram of an apparatus for transmitting a ranging signal in a wireless communication system according to an exemplary embodiment of the present invention. The apparatus may be the base station or the mobile station.

Referring to FIG. **8**, the apparatus includes an OFDM receiver **801**, a message processor **803**, a controller **805**, a message generator **807**, and an OFDM transmitter **809**. The apparatus may include additional units not shown here for clarity. Similarly, two or more of the above units may be integrated into a single component. While various units shown in FIG. **8** may be implemented as hardware, the units may also be implemented as a combination of hardware and software. It would also be apparent to a person of ordinary skill that some units shown in FIG. **8** would need to be implemented at least partially as a hardware component in order to carry out the functions of those units.

The OFDM receiver **801** converts a Radio Frequency (RF) signal received via an antenna into a baseband analog signal, and converts the analog signal into sample data. The OFDM receiver **801** converts the sample data into frequency-domain data through Fast Fourier Transform (FFT), and selects and outputs data of subcarriers to actually receive from the frequency-domain data. The OFDM receiver **801** demodulates and decodes the data at a predefined modulation level (Modulation and Coding Scheme (MCS) level) and outputs the demodulated and decoded data to the message processor **803**.

The message processor **803** decomposes a control message output from the OFDM receiver **801** and provides results to the controller **805**. For example, the message processor **803** provides the controller **805** with the necessary information for the ranging channel allocation contained in the SFH, for example, the frequency partition location for UL control channels such as UL feedback channel and BR channel, the subframe offset O_{SF} of the ranging channel, the total number of the subbands allocated to the current cell or the number of the subbands in each FP when the FFR is applied, and the format information of the ranging channel.

The controller **805** processes the information output from the message processor **803**, generates information to transmit, and outputs the generated information to the message generator **807**. In addition, the controller **805** controls the ranging procedure by determining the subbands and the subframes of the ranging channel based on the necessary information for the ranging channel allocation.

As for the operations of the mobile station for transmitting the ranging signal, the controller **805** receives the SA-preamble and the SFH from the OFDM receiver **801** and determines IDcell and segment_ID (0,1,2) based on the received SA-preamble. The controller **805** obtains the essential system parameters and the system configuration information from the SFH. The SFH includes the frequency partition location for UL control channels such as UL feedback channel and BR channel, the subframe offset O_{SF} of the ranging channel, the total number of the subbands allocated in the current cell or the number of the subbands in each FP when the FFR is applied, and the format information (see FIG. **5**) of the ranging channel.

The controller **805** locates the FP area for the UL control channels based on the field value of the frequency partition location for UL control channels of the SFH, and determines the number of the subbands R_{SB} allocated to the FP area for the UL control channels. For example, when the 1-bit field value of the frequency partition location for UL control channels is 0b0, the UL control channels such as UL feedback channel and BR channel are allocated to the reuse **1** area. When the field value is 0b1, the UL feedback channel and the BR channel are allocated to the power-boosted reuse **3** area.

The controller **805** determines the subband index I_{SB} $(0, \ldots, R_{SB}-1)$ for the ranging resource allocation using IDcell derived from the SA-preamble and the number of the subbands R_{SB} allocated to the FP area for the UL control channels. Alternatively, the controller **805** determines the subband index for the ranging resource allocation using the

total number of the subbands in the reuse **1** FP area and the power-boosted reuse **3** FP area.

For the operations of the mobile station for transmitting the ranging signal, the controller **805** may determines whether the FFR is operated using the SFH. When the FFR is operated, the controller **805** determines the total number of the subbands in the reuse **1** FP area and the power-boosted reuse **3** FP area or the total number of the subbands in the FP area allocated the UL control channels (the reuse **1** FP area or the power-boosted reuse **3** FP area). When the FFR is not operated, the controller **805** determines the total number of the subbands in the whole FP area.

The controller **805** determines the subband index I_{SB} for the ranging resource allocation using the total number of the subbands R_{SB} in the reuse **1** FP area and the power-boosted reuse **3** FP area of the SFH, the total number of the subbands R_{SB} in the FP area allocated the UL control channels, or the total number of the subbands in the whole FP area, and IDcell derived from and the SA-preamble.

The message generator **807** generates a message with the information fed from the controller **805** and outputs the generated message to the OFDM transmitter **809** of the physical layer. For example, the message generator **809** generates the SFH including the necessary information for the ranging channel allocation, for example, the frequency partition location for UL control channels such as UL feedback channel and BR channel, the subframe offset O_{SF} of the ranging channel, the total number of the subbands allocated to the current cell or the number of the subbands in each FP when the FFR is applied, and the format information of the ranging channel. The message generator **807** receives the ranging code from the controller **805** and generates a ranging message.

The OFDM transmitter **809** encodes and modulates the data output from the message generator **807** at the predefined modulation level (MCS level). The OFDM transmitter **809** outputs sample data (OFDM symbols) by applying Inverse FFT (IFFT) to the modulated symbols. The OFDM transmitter **809** converts the sample data into an analog signal, converts the analog signal into an RF signal, and transmits the RF signal over an antenna.

For example, the OFDM transmitter **809** transmits the ranging signal based on the subbands I_{SB} and the subframe information O_{SF} of the ranging channel output from the controller **805**.

As constructed above, the controller **805**, which is a protocol controller, controls the message processor **803** and the message generator **807**. The controller **805** may function as the message processor **803** and the message generator **807**. They are separately illustrated to distinguish various exemplary functions of the present invention, not to limit the scope of the invention. In exemplary implementations, the controller **805** may process all or part of the functions of the message processor **803** and the message generator **807**.

The controller **805** receives necessary information for the protocol processing from the corresponding component of the physical layer, or issues a control signal to the corresponding component of the physical layer. For example, the controller **805** may issue the control signal for controlling the subcarrier allocation scheme (or the subchannel allocation scheme) of the OFDM transmitter **809**, or receive the receive signal intensity information (e.g., SA-preamble, SINR, RSSI, and the like) from the physical layer.

As set forth above, by limiting to select the subbands of the ranging channel in the reuse **1** area and the power-boosted reuse **3** area, the interference to the neighboring cell may be reduced in the ranging channel transmission.

While the invention has been shown and described with reference to certain exemplary embodiments thereof, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the spirit and scope of the invention as defined by the appended claims and their equivalents.

What is claimed is:

1. A method of operating a mobile station in a wireless communication system, the method comprising:

identifying, by at least one processor in the mobile station, a frequency partition among a plurality of frequency partitions;

determining, by the at least one processor, a subband among a plurality of subbands included in the frequency partition based on a cell identifier and a number of subbands allocated for the frequency partition; and

transmitting, by a transmitter in the mobile station, a ranging signal on the determined subband,

wherein the number of the subbands allocated for the frequency partition is determined based on a number of subband contiguous resource units (CRUs) allocated to an FPi location corresponding to a reuse 1 partition or a power-boosted reuse 3 partition,

wherein an index of the subband is determined with a modulo operation, and

wherein the number of subband CRUs is a multiple of the subbands allocated for the frequency partition.

2. The method of claim **1**, wherein the subband is determined by the following equation:

$$I_{SB}=\mathrm{mod}(\mathrm{IDcell}, R_{SB})$$

wherein I_{SB} denotes the index of the subband, mod denotes a modulo operation, IDcell denotes the cell identifier, and R_{SB} denotes the number of the subbands allocated for the frequency partition.

3. The method of claim **2**, wherein R_{SB} is determined by the following equation:

$$R_{SB}=L_{SB\text{-}CRU,\,FP_i}/4$$

wherein $L_{SB\text{-}CRU,FP_i}$ denotes the number of subband contiguous resource units (CRUs) allocated to the FP_i location.

4. The method of claim **1**, further comprising:

based on information of the ranging resource allocation received from a base station, obtaining, by the at least one processor, a transmission point of the ranging signal.

5. The method of claim **1**, wherein the cell identifier is derived from a preamble received from a base station.

6. The method of claim **1**, further comprising:

determining, by the at least one processor, whether fractional frequency reuse (FFR) operates.

7. The method of claim **6**, further comprising:

when the FFR is not supported, determining, by the at least one processor, a subband based on a cell identifier and a total number of subbands.

8. The method of claim **1**, further comprising:

receiving, by a receiver in the mobile station, information of ranging resource allocation, from a base station,

wherein the identifying of the frequency partition among the plurality of frequency partitions comprises identifying the frequency partition among the plurality of frequency partitions based on the information of ranging resource allocation.

9. The method of claim 8, wherein the information of ranging resource allocation comprises a superframe header (SFH) indicating the frequency partition among the plurality of frequency partitions.

10. A method of operating a base station in a wireless communication system, the method comprising:

identifying, by at least one processor in the base station, a frequency partition among a plurality of frequency partitions;

determining, by the at least one processor, a subband among a plurality of subbands included in the frequency partition based on a cell identifier and a number of subbands allocated for the frequency partition; and

receiving, by a receiver in the base station, a ranging signal transmitted from a mobile station on the determined subband,

wherein the number of the subbands allocated for the frequency partition is determined based on a number of subband contiguous resource units (CRUs) allocated to an FPi location corresponding to a reuse 1 partition or a power-boosted reuse 3 partition,

wherein an index of the subband is determined with a modulo operation, and

wherein the number of subband CRUs is a multiple of the subbands allocated for the frequency partition.

11. The method of claim 10, wherein the subband is determined by the following equation:

$$I_{SB}=\mathrm{mod}(\mathrm{IDcell},R_{SB})$$

wherein I_{SB} denotes the index of the subband, mod denotes a modulo operation, IDcell denotes the cell identifier, and R_{SB} denotes the number of the subbands allocated for the frequency partition.

12. The method of claim 11, wherein R_{SB} is determined by the following equation:

$$R_{SB}=L_{SB\text{-}CRU,\ FP_i}/4$$

wherein $L_{SB\text{-}CRU,\ FP_i}$ denotes the number of subband contiguous resource units (CRUs) allocated to the FP_i location.

13. The method of claim 10, further comprising:

based on information of the ranging resource allocation received from a base station, obtaining, by the at least one processor, a transmission point of the ranging signal.

14. The method of claim 10, wherein the cell identifier is derived from a preamble received from a base station.

15. The method of claim 10, further comprising:

broadcasting, by a transmitter in the base station, information of ranging resource allocation,

wherein the identifying of the frequency partition among the plurality of frequency partitions comprises identifying the frequency partition among the plurality of frequency partitions based on the information of ranging resource allocation.

16. The method of claim 15, wherein the information of ranging resource allocation comprises a superframe header (SFH) indicating the frequency partition among the plurality of frequency partitions.

17. An apparatus of a mobile station in a wireless communication system, the apparatus comprising:

a memory including one or more programs configured to be executed by at least one processor;

the at least one processor being configured to:

identify a frequency partition among a plurality of frequency partitions, and

determine a subband among a plurality of subbands included in the frequency partition based on a cell identifier and a number of subbands allocated for the frequency partition; and

a transmitter configured to transmit a ranging signal on the determined subband,

wherein the number of the subbands allocated for the frequency partition is determined based on a number of subband contiguous resource units (CRUs) allocated to an FPi location corresponding to a reuse 1 partition or a power-boosted reuse 3 partition,

wherein an index of the subband is determined with a modulo operation, and

wherein the number of subband CRUs is a multiple of the subbands allocated for the frequency partition.

18. The apparatus of claim 17, wherein the subband is determined by the following equation:

$$I_{SB}=\mathrm{mod}(\mathrm{Idcell},R_{SB})$$

wherein I_{SB} denotes the index of the subband, mod denotes a modulo operation, IDcell denotes the cell identifier, and R_{SB} denotes the number of the subbands allocated for the frequency partition.

19. The apparatus of claim 18, wherein R_{SB} is determined by the following equation:

$$R_{SB}=L_{SB\text{-}CRU,\ FP_i}/4$$

wherein $L_{SB\text{-}CRU,\ FP_i}$, denotes the number of subband contiguous resource units (CRUs) allocated to the FP_i, location.

20. The apparatus of claim 17, wherein the at least one processor obtains a transmission point of the ranging signal based on information of the ranging resource allocation received from a base station.

21. The apparatus of claim 17, wherein the cell identifier is derived from a preamble received from a base station.

22. The apparatus of claim 17, wherein the at least one processor is further configured to determine whether fractional frequency reuse (FFR) operates.

23. The apparatus of claim 22, wherein, when the FFR is not supported, the at least one processor determines a subband based on a cell identifier and a total number of subbands.

24. The apparatus of claim 17, further comprising:

a receiver configured to receive information of ranging resource allocation, from a base station,

wherein the at least one processor is configured to identify the frequency partition among the plurality of frequency partitions based on the information of ranging resource allocation.

25. The apparatus of claim 24, wherein the information of ranging resource allocation comprises a superframe header (SFH) indicating the frequency partition among the plurality of frequency partitions.

26. An apparatus of a base station in a wireless communication system, the apparatus comprising:

a memory including one or more programs configured to be executed by at least one processor;

the at least one processor being configured to:

identify a frequency partition among a plurality of frequency partitions, and

determine a subband among a plurality of subbands included in the frequency partition based on a cell identifier and a number of subbands allocated for the frequency partition; and

a receiver configured to receive a ranging signal transmitted from a mobile station on the determined subband,

wherein the number of the subbands allocated for the frequency partition is determined based on a number of subband contiguous resource units (CRUs) allocated to an FPi location corresponding to a reuse **1** partition or a power-boosted reuse **3** partition,

wherein an index of the subband is determined with a modulo operation, and

wherein the number of subband CRUs is a multiple of the subbands allocated for the frequency partition.

27. The apparatus of claim **26**, wherein the subband is determined by the following equation:

$$I_{SB}=\mathrm{mod}(\mathrm{IDcell},R_{SB})$$

wherein I_{SB} denotes the index of the subband, mod denotes a modulo operation, IDcell denotes the cell identifier, and R_{SB} denotes the number of the subbands allocated for the frequency partition.

28. The apparatus of claim **27**, wherein R_{SB} is determined by the following equation:

$$R_{SB}=L_{SB\text{-}CRU,\ FP_i}/4$$

wherein $L_{SB\text{-}CRU,\ FP_i}$ denotes the number of subband contiguous resource units (CRUs) allocated to the FP_ilocation.

29. The apparatus of claim **26**, wherein the at least one processor obtains a transmission point of the ranging signal based on information of the ranging resource allocation.

30. The apparatus of claim **26**, wherein the cell identifier is derived from a preamble.

31. The apparatus of claim **26**, further comprising:

a transmitter configured to broadcast information of ranging resource allocation,

wherein the at least one processor is configured to identify the frequency partition among the plurality of frequency partitions based on the information of ranging resource allocation.

32. The apparatus of claim **31**, wherein the information of ranging resource allocation comprises a superframe header (SFH) indicating the frequency partition among the plurality of frequency partitions.

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