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Choi et al.

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(54) **METHOD AND APPARATUS FOR TRANSMITTING AND RECEIVING DATA IN A COMMUNICATION SYSTEM ACCORDING TO A LOCATION OF A MOBILE STATION**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 1164 days.

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(22) Filed: **Apr. 4, 2008**

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(30) **Foreign Application Priority Data**

Apr. 5, 2007 (KR) 10-2007-0033913

(51) **Int. Cl.**
H04B 7/212 (2006.01)

(52) **U.S. Cl.** **370/321**; 370/478; 455/7

(58) **Field of Classification Search** ..... None
See application file for complete search history.

(56) **References Cited**

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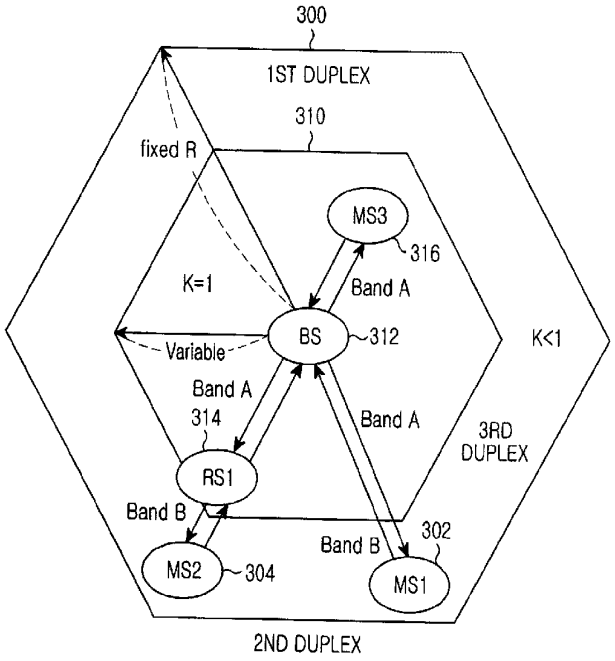
(57) **ABSTRACT**

A method and apparatus for transmitting and receiving data in a Base Station (BS) of a communication system are provided. A controller determines a location of a Mobile Station (MS), and determines a transmission/reception scheme for data transmission and reception to/from the MS according to the location of the MS. A transceiver transmits and receives data to/from the MS using the determined transmission/reception scheme. Preferably, the MS is located in any one of a cell's inner region and a cell's outer region, the cell's inner region has a radius which varies according to interference between adjacent cells, and the cell's outer region is a region defined by excepting the cell's inner region from the entire cell region.

14 Claims, 21 Drawing Sheets



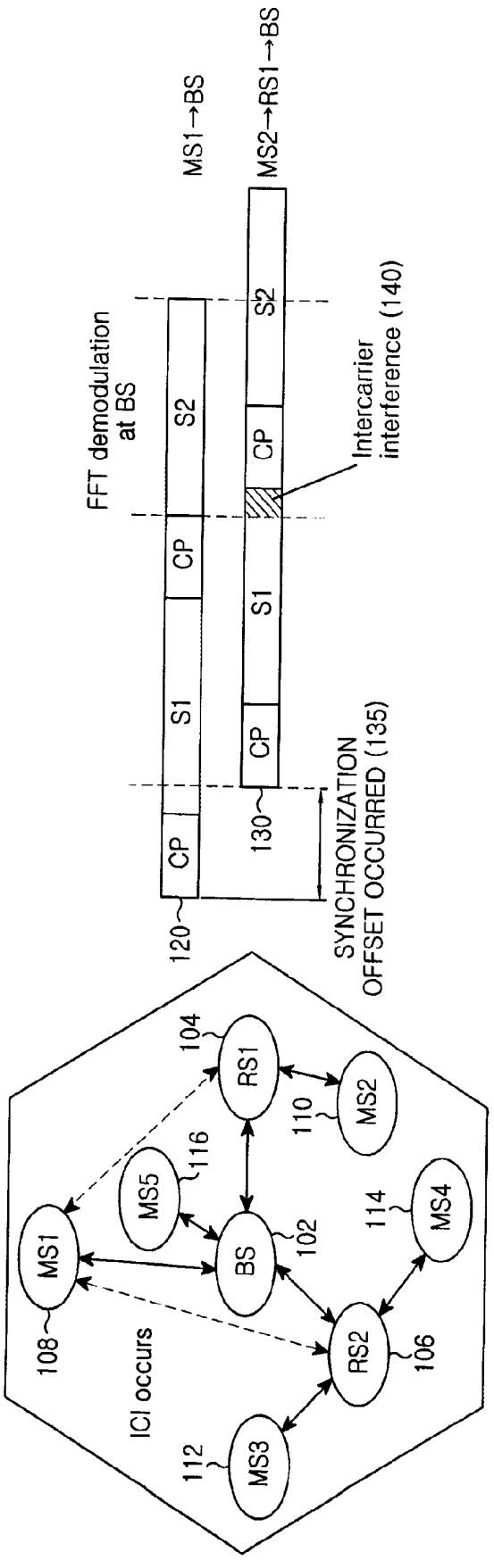


FIG. 1
(CONVENTIONAL ART)

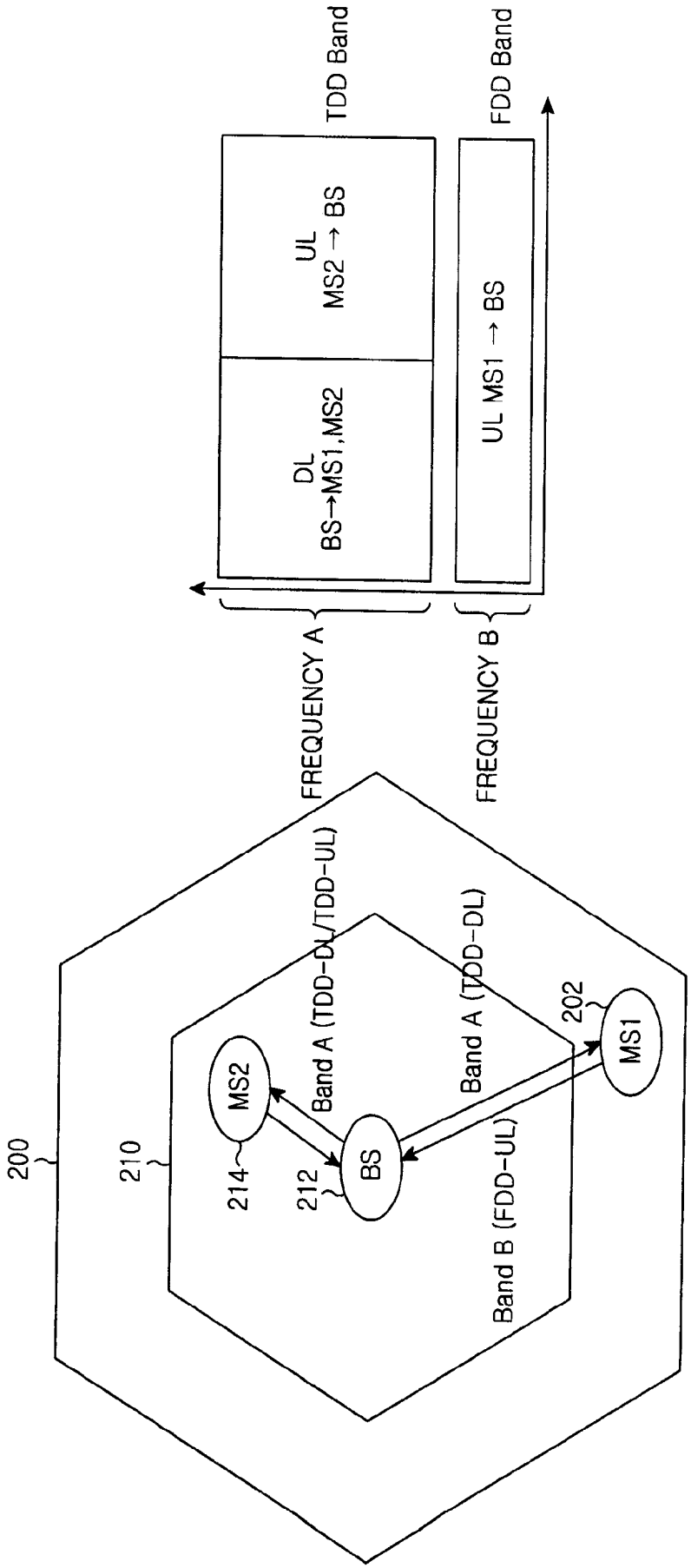

TDD Band
FDD Band
UL
MS2 → BS
DL
BS→MS1,MS2
UL MS1 → BS
FREQUENCY A
FREQUENCY B
200
210
214
212
MS2
BS
MS1
202
Band A (TDD-DL/TDD-UL)
Band A (TDD-DL)
Band B (FDD-UL)

FIG.2

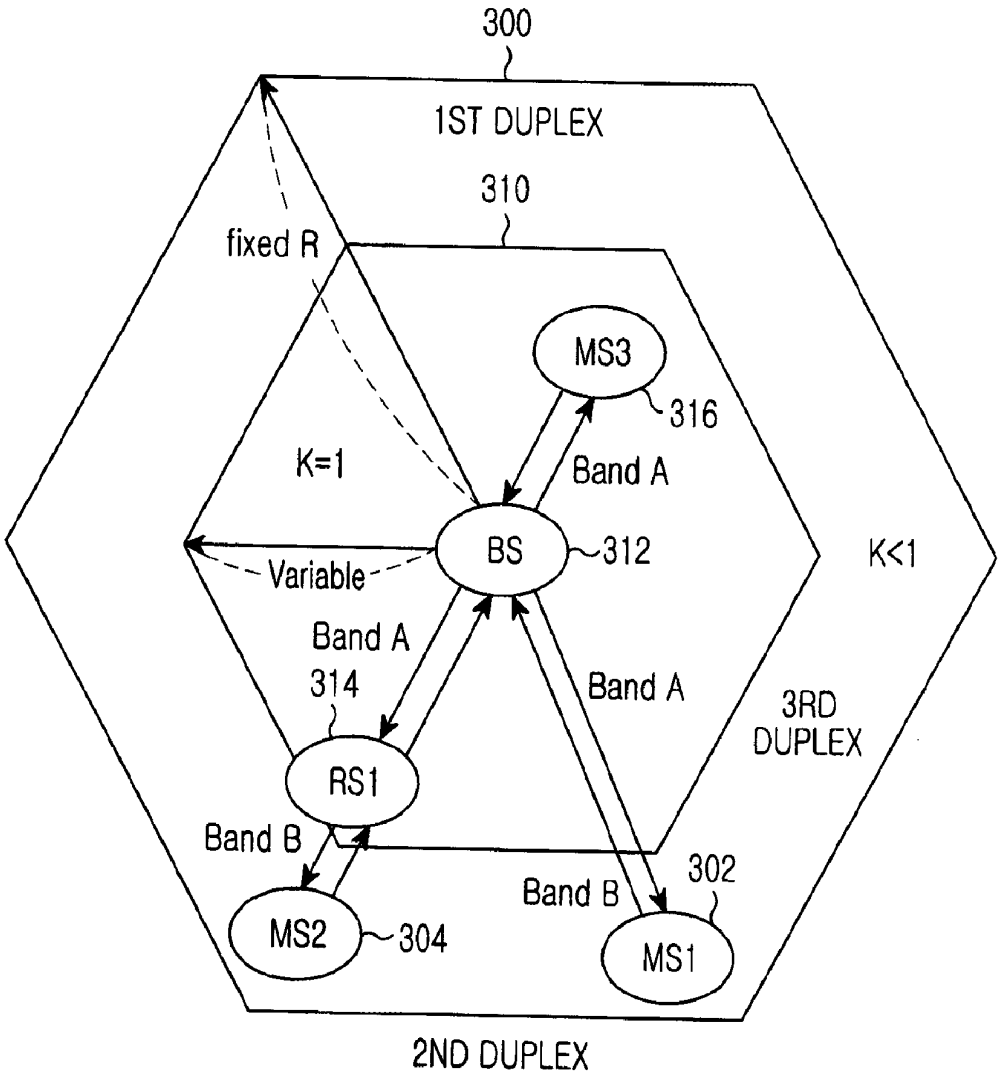

300
1ST DUPLEX
310
fixed R
MS3
316
K=1
Band A
BS
312
K<1
Variable
Band A
314
Band A
3RD
DUPLEX
RS1
Band B
Band B
302
MS2
304
MS1
2ND DUPLEX

FIG.3

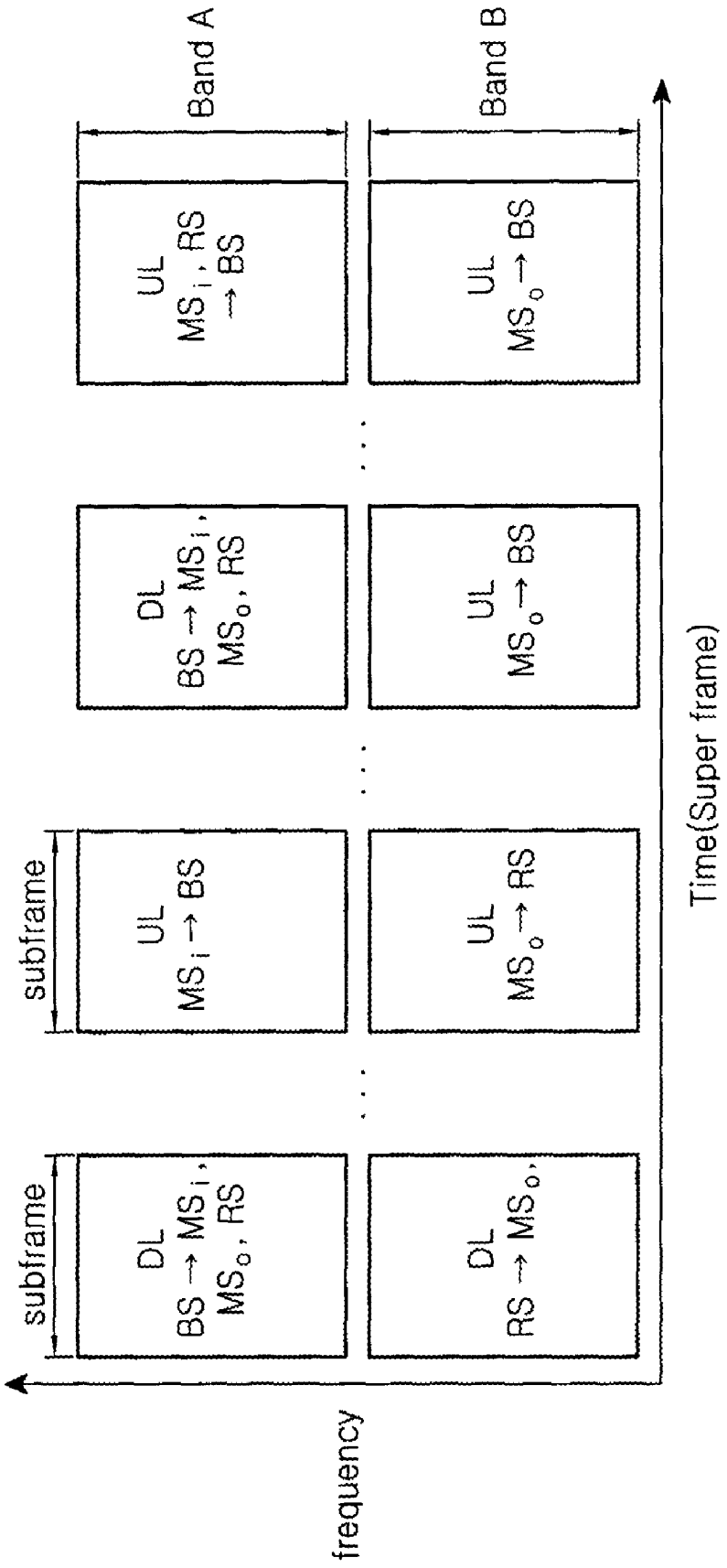

Band A
Band B
UL
MS$_i$, RS
→ BS
UL
MS$_o$ → BS
DL
BS → MS$_i$,
MS$_o$, RS
UL
MS$_o$ → BS
subframe
UL
MS$_i$ → BS
UL
MS$_o$ → RS
subframe
DL
BS → MS$_i$,
MS$_o$, RS
DL
RS → MS$_o$,
Time(Super frame)
frequency

FIG. 4

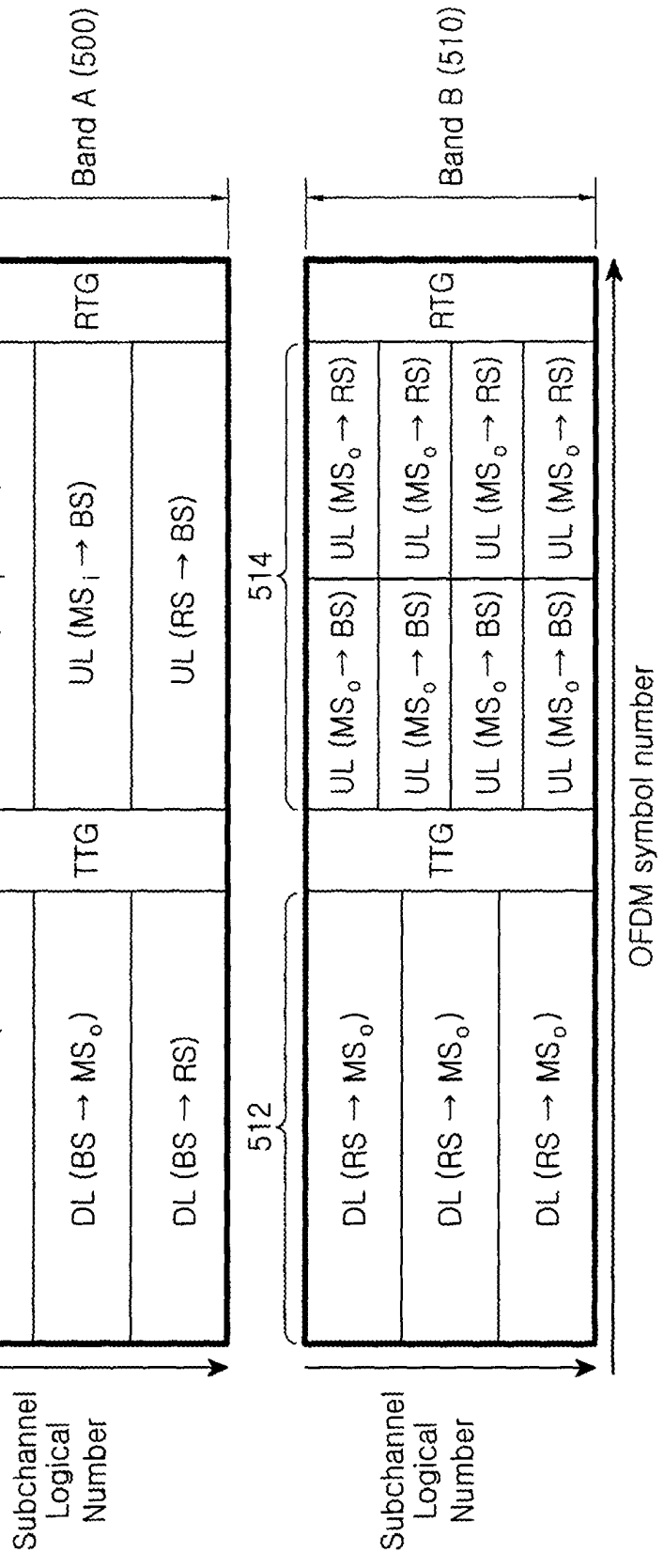

Band A (500)
Band B (510)
502
504
512
514
DL (BS → MS i)
DL (BS → MS o)
DL (BS → RS)
TTG
UL (MS i → BS)
UL (MS i → BS)
UL (RS → BS)
RTG
DL (RS → MS o)
DL (RS → MS o)
DL (RS → MS o)
TTG
UL (MS o → BS)
UL (MS o → BS)
UL (MS o → BS)
UL (MS o → BS)
UL (MS o → RS)
UL (MS o → RS)
UL (MS o → RS)
UL (MS o → RS)
RTG
Subchannel Logical Number
Subchannel Logical Number
OFDM symbol number

FIG.5

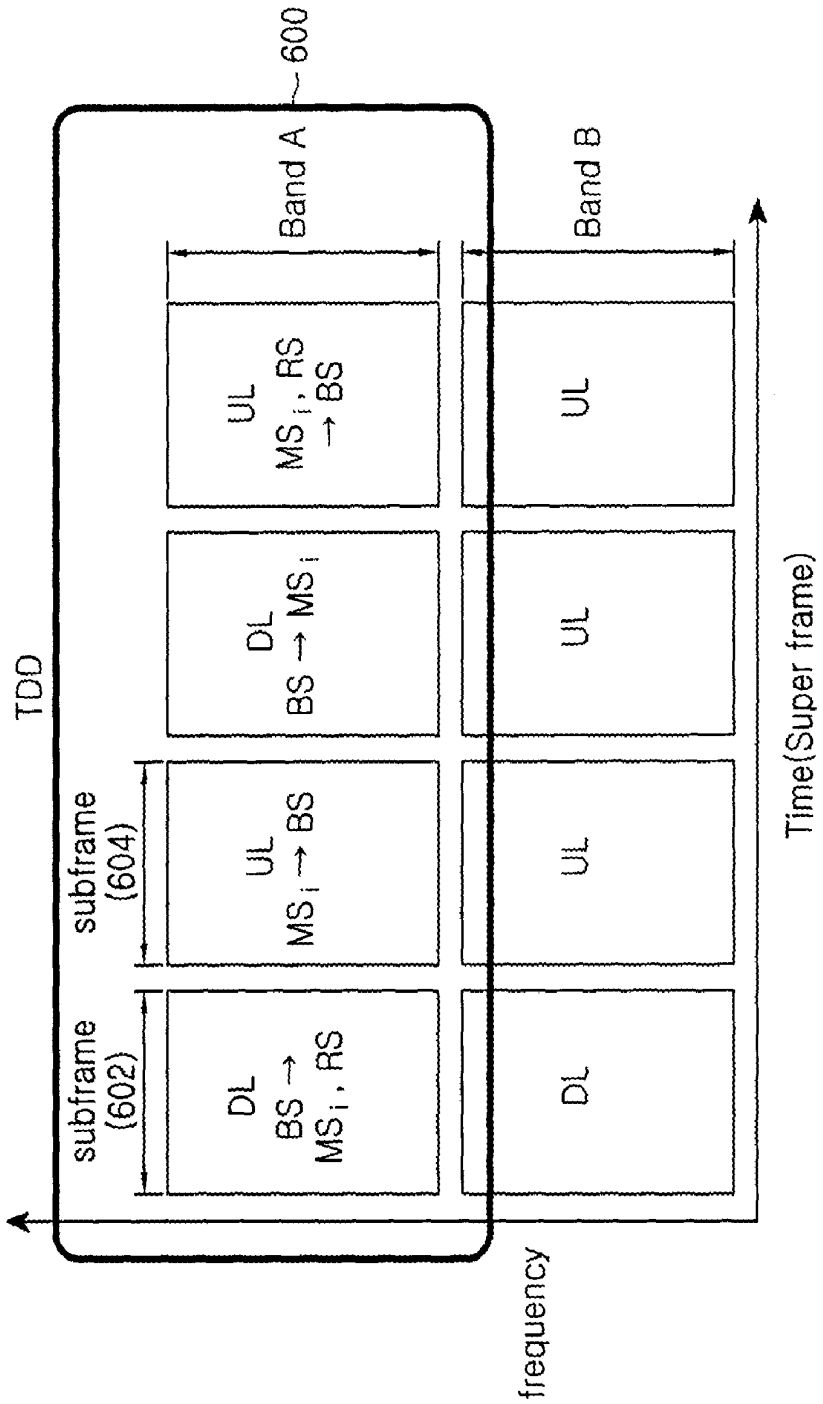

600
TDD
Band A
Band B
subframe (602)
subframe (604)
DL BS → MS$_i$, RS
UL MS$_i$ → BS
DL BS → MS$_i$
UL MS$_i$, RS → BS
DL
UL
UL
UL
frequency
Time(Super frame)

FIG.6

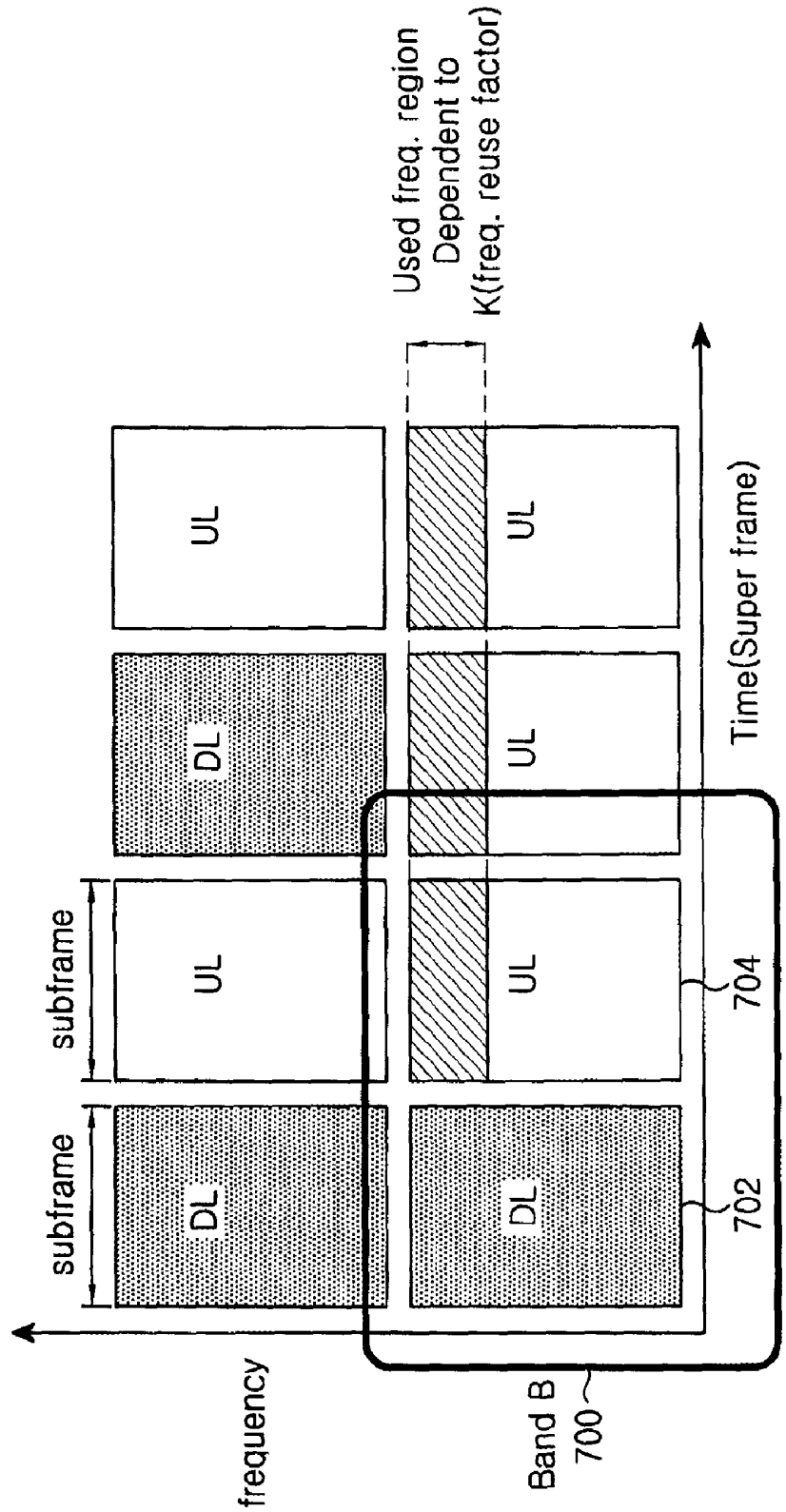

Used freq. region
Dependent to
K(freq. reuse factor)
UL
DL
UL
UL
UL
UL
DL
DL
subframe
subframe
Time(Super frame)
frequency
Band B
700
702
704

FIG. 7

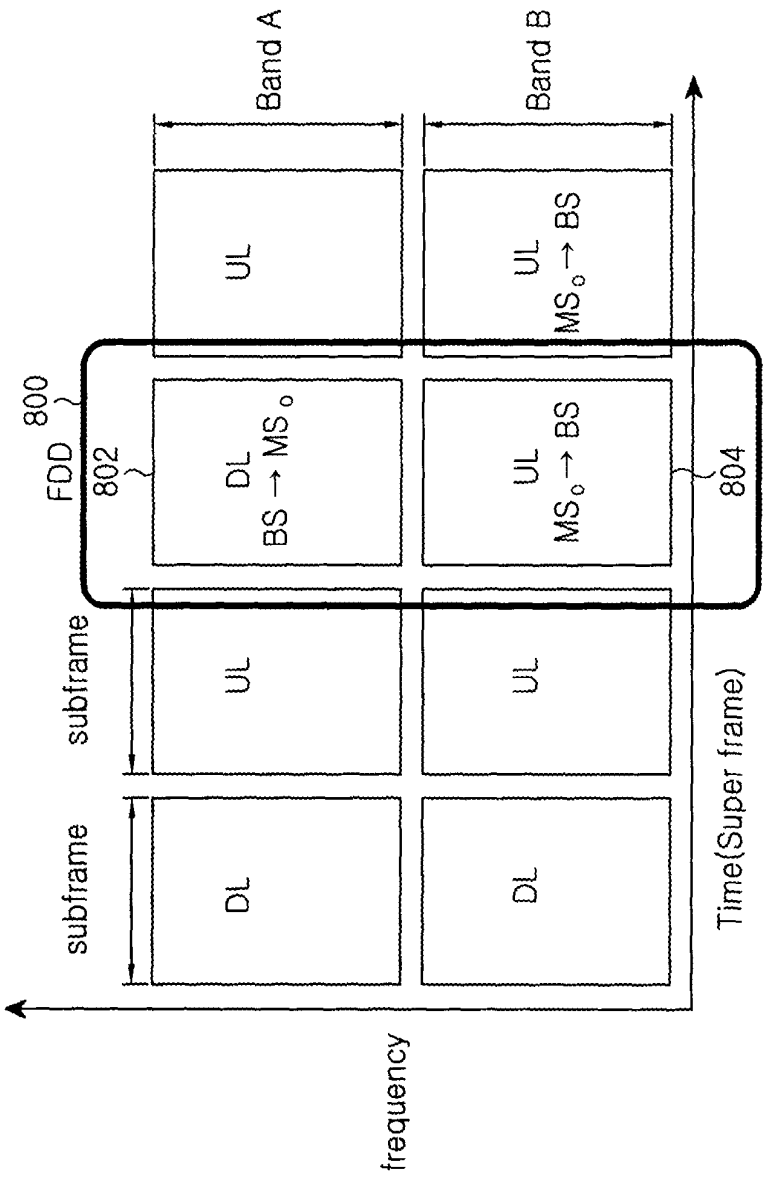

Band A
Band B
UL
UL
MS₀ → BS
800
FDD
802
DL
BS → MS₀
UL
MS₀ → BS
804
subframe
UL
UL
subframe
DL
DL
Time(Super frame)
frequency

FIG.8

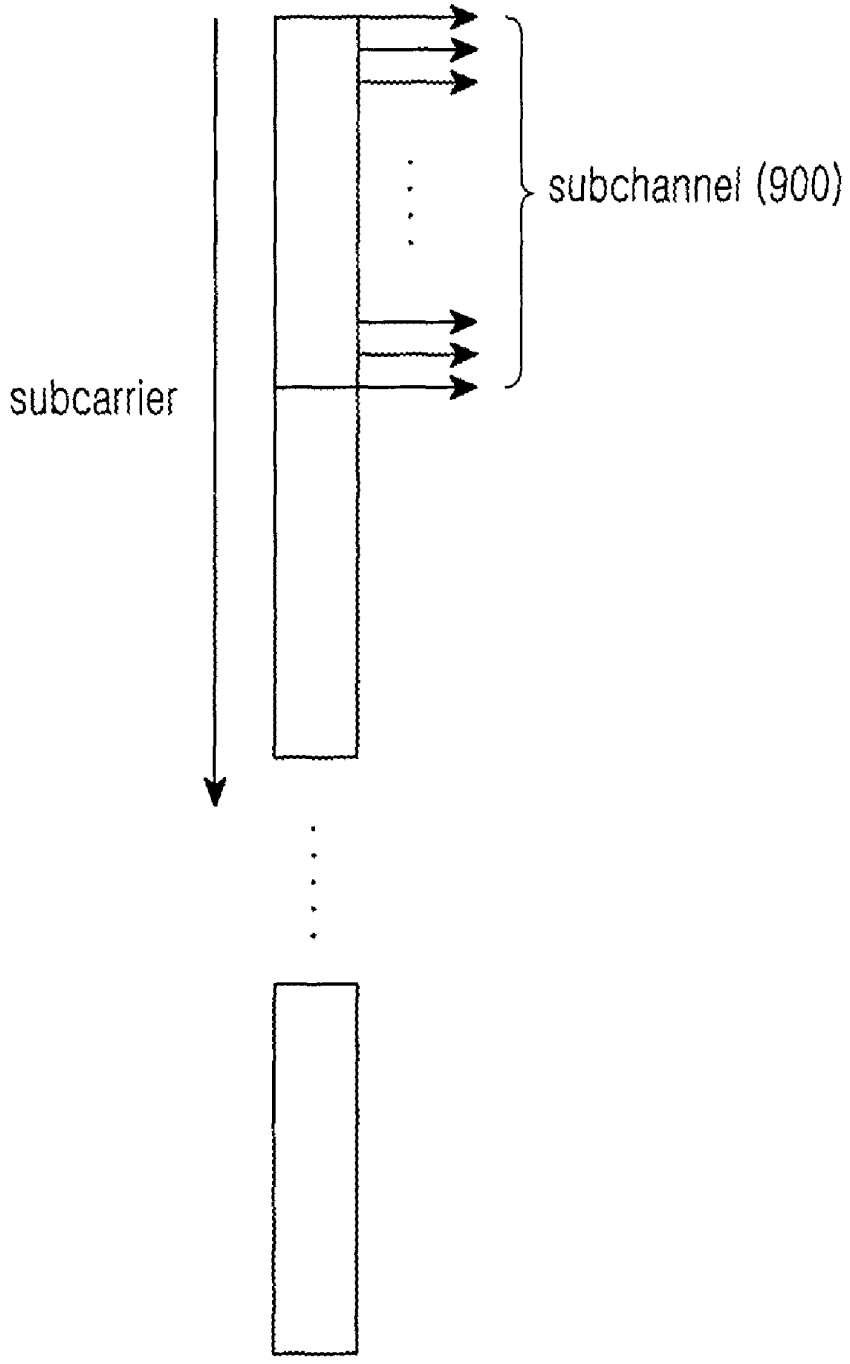


FIG.9A

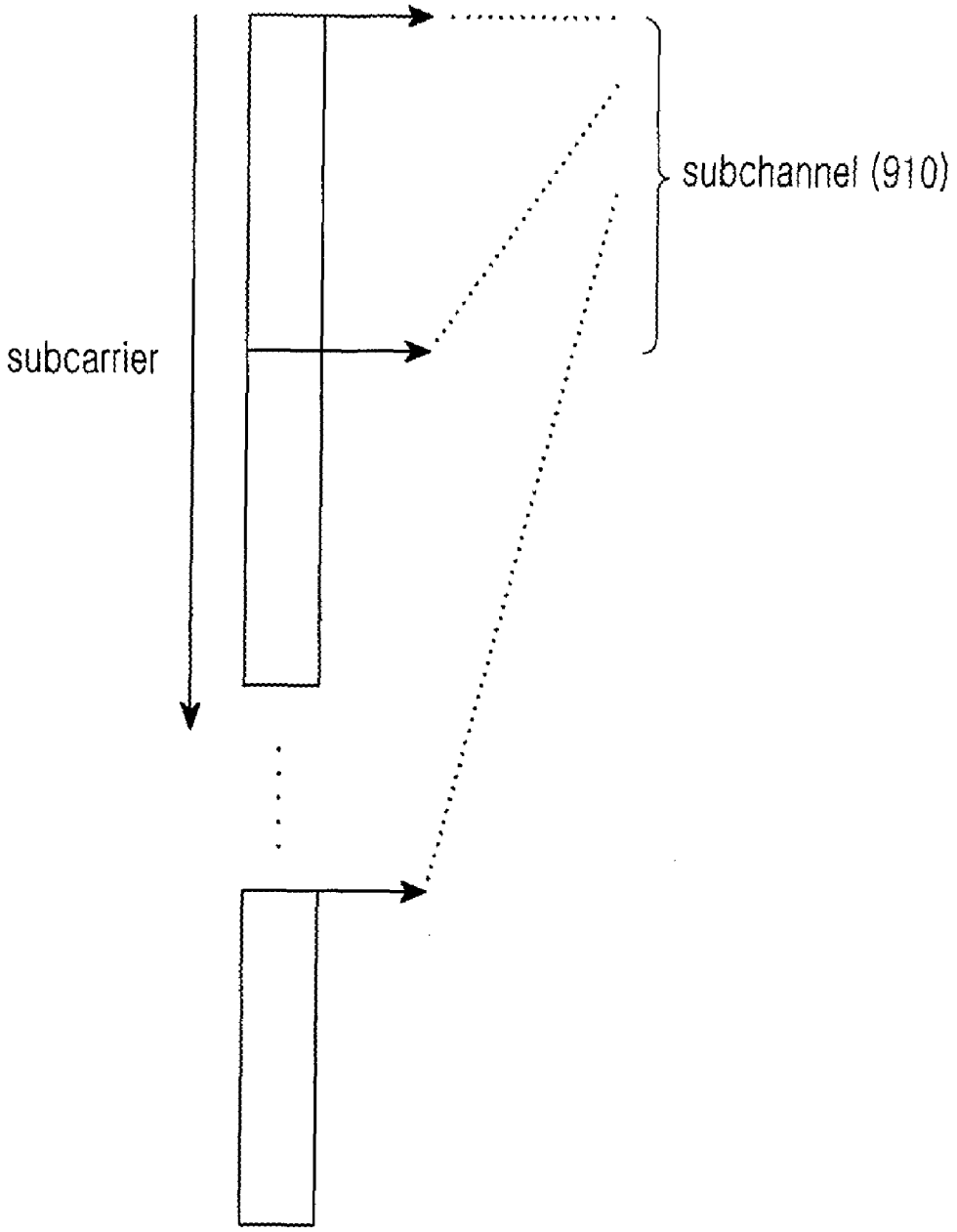


FIG.9B

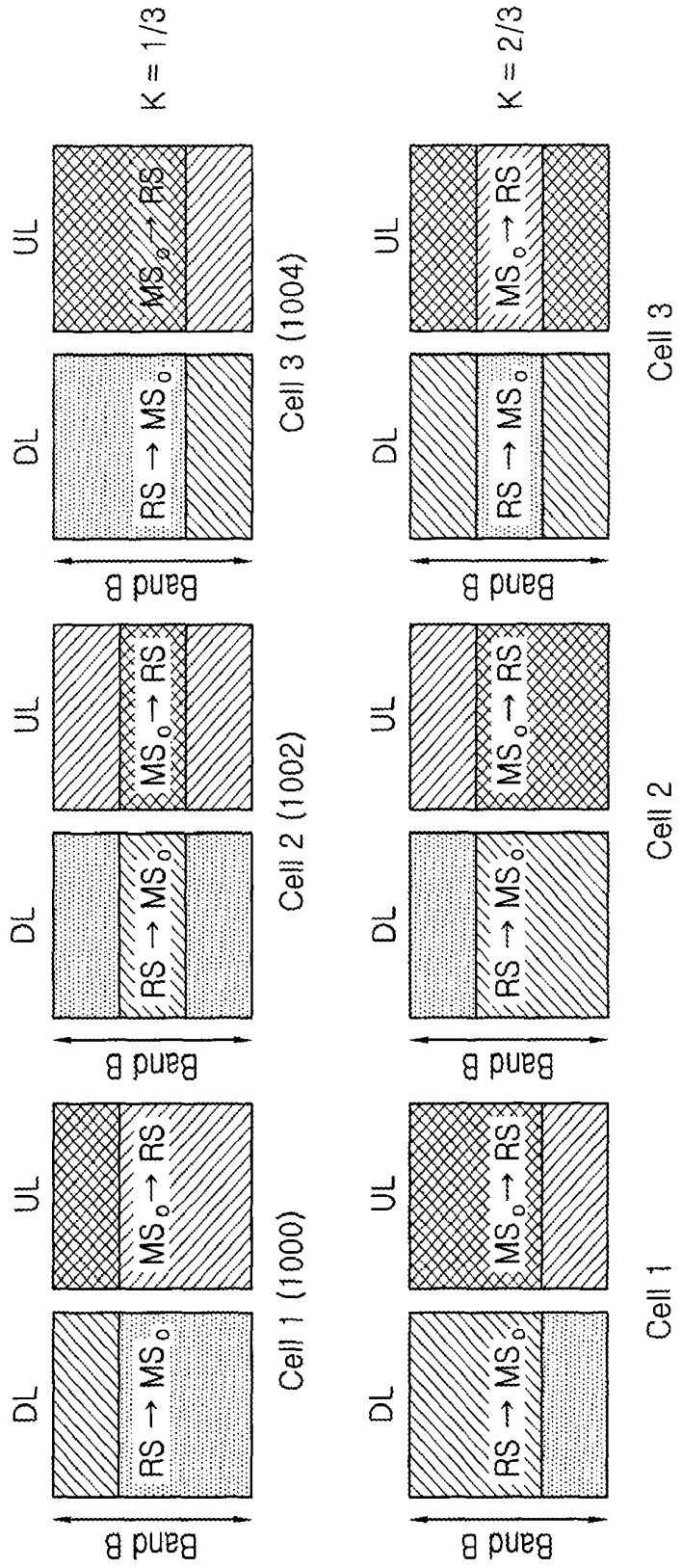

K = 1/3
K = 2/3
Cell 1 (1000)
Cell 2 (1002)
Cell 3 (1004)
Cell 1
Cell 2
Cell 3
DL
UL
Band B
RS → MS o
MS o → RS
: Used freq. region

FIG. 10

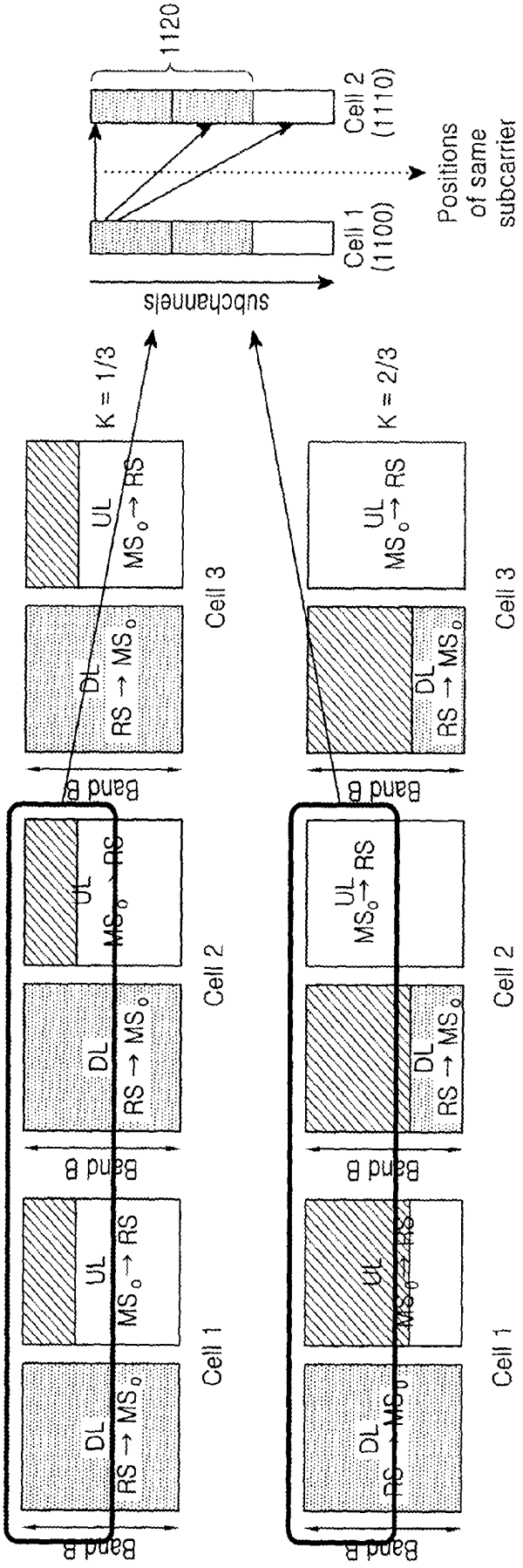

1120
Cell 2 (1110)
Cell 1 (1100)
Positions of same subcarrier
subchannels
K = 1/3
K = 2/3
UL
DL
RS → MS$_o$
MS$_o$ → RS
Band B
Cell 1
Cell 2
Cell 3

FIG. 11

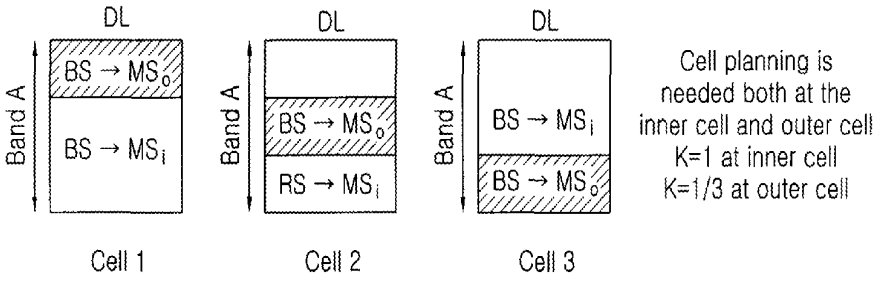


FIG.12A

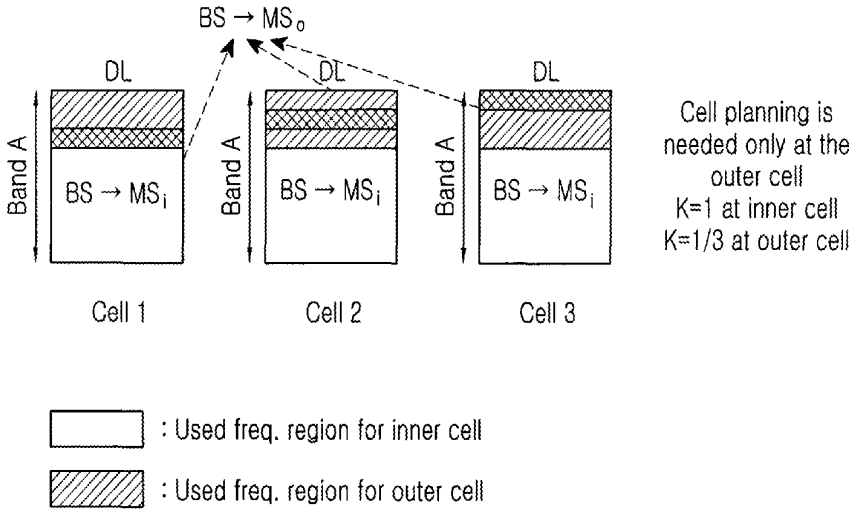


FIG.12B

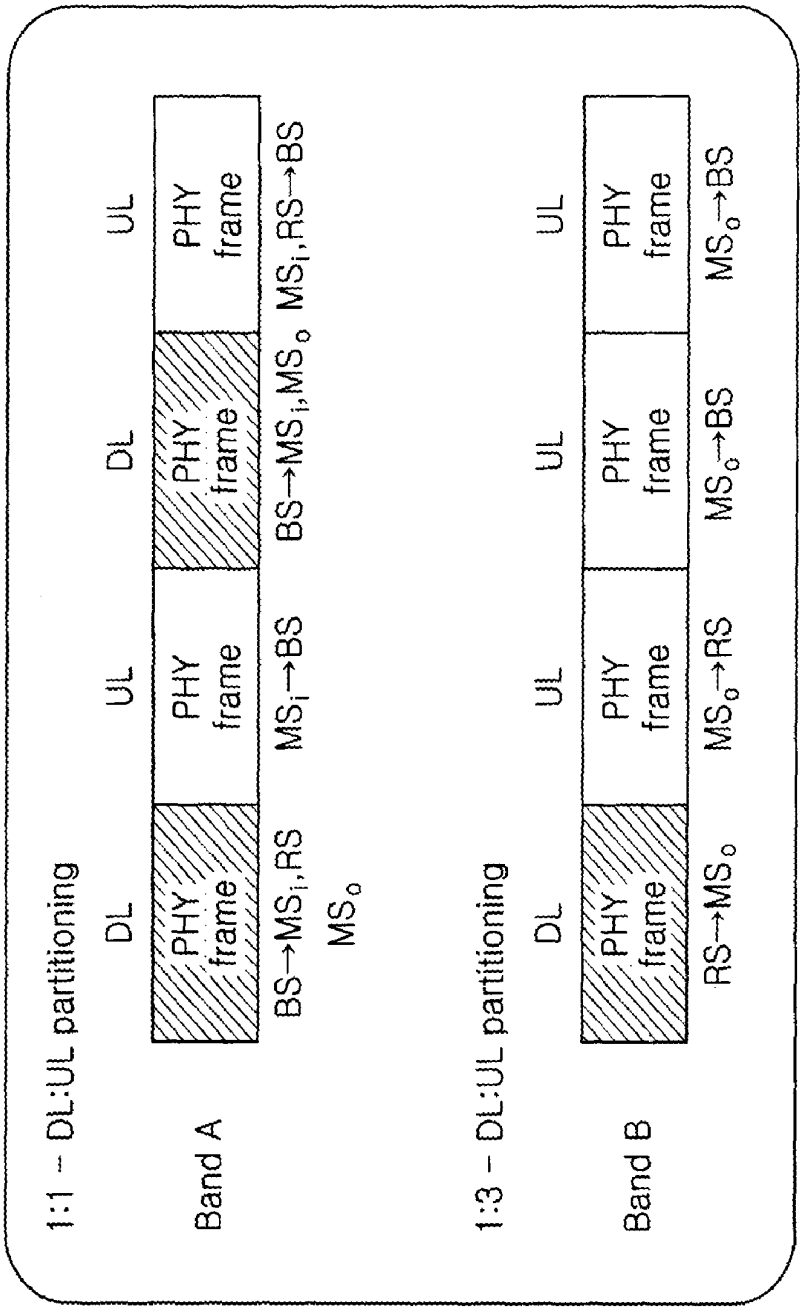

1:1 – DL:UL partitioning
DL
UL
DL
UL
Band A
PHY frame
PHY frame
PHY frame
PHY frame
BS→MSi,RS
MSo
MSi→BS
BS→MSi,MSo
MSi,RS→BS
1:3 – DL:UL partitioning
DL
UL
UL
UL
Band B
PHY frame
PHY frame
PHY frame
PHY frame
RS→MSo
MSo→RS
MSo→BS
MSo→BS

FIG.13A

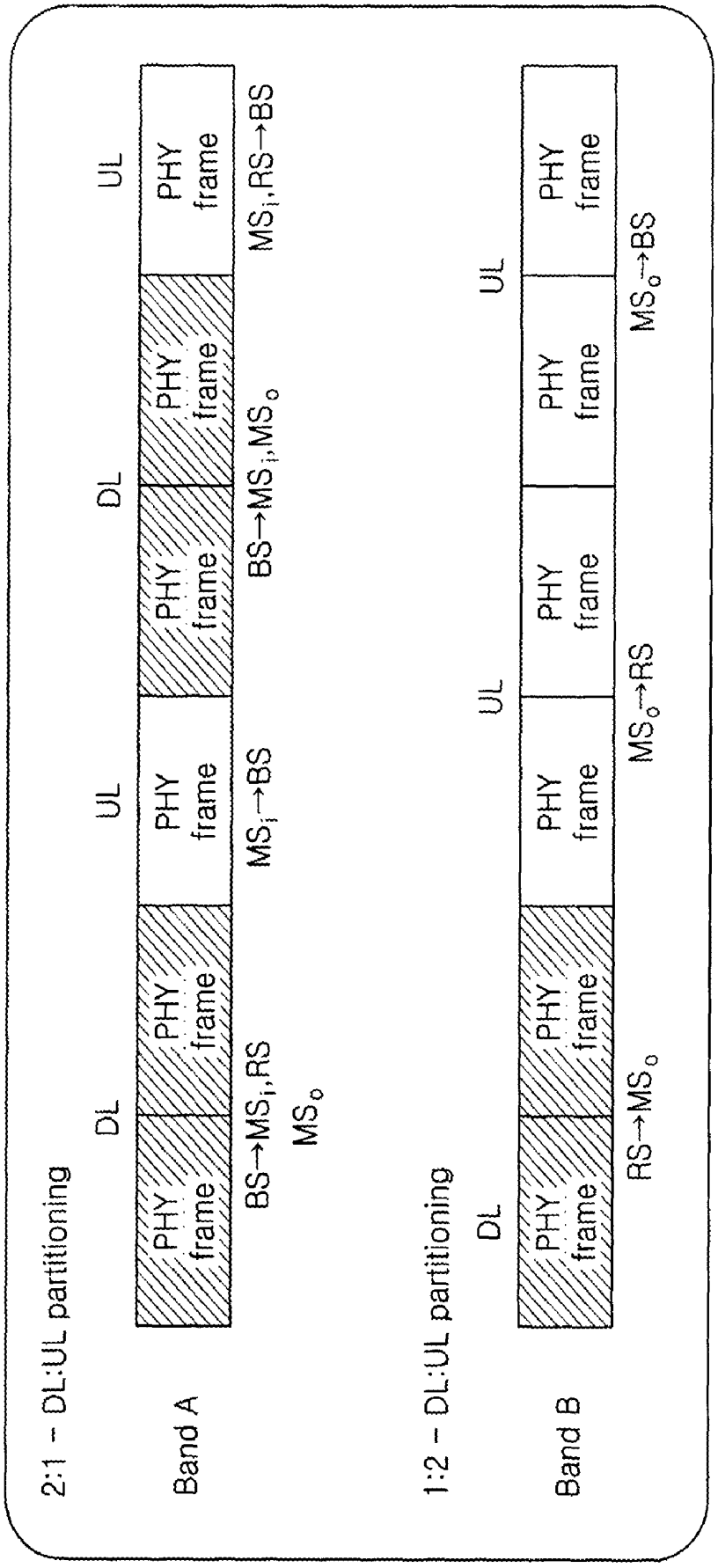

2:1 – DL:UL partitioning
Band A
DL
UL
DL
UL
PHY frame
PHY frame
PHY frame
PHY frame
BS→MS$_i$,RS
MS$_o$
MS$_i$→BS
BS→MS$_i$,MS$_o$
MS$_i$,RS→BS
1:2 – DL:UL partitioning
Band B
DL
UL
UL
PHY frame
PHY frame
PHY frame
PHY frame
RS→MS$_o$
MS$_o$→RS
MS$_o$→BS

FIG. 13B

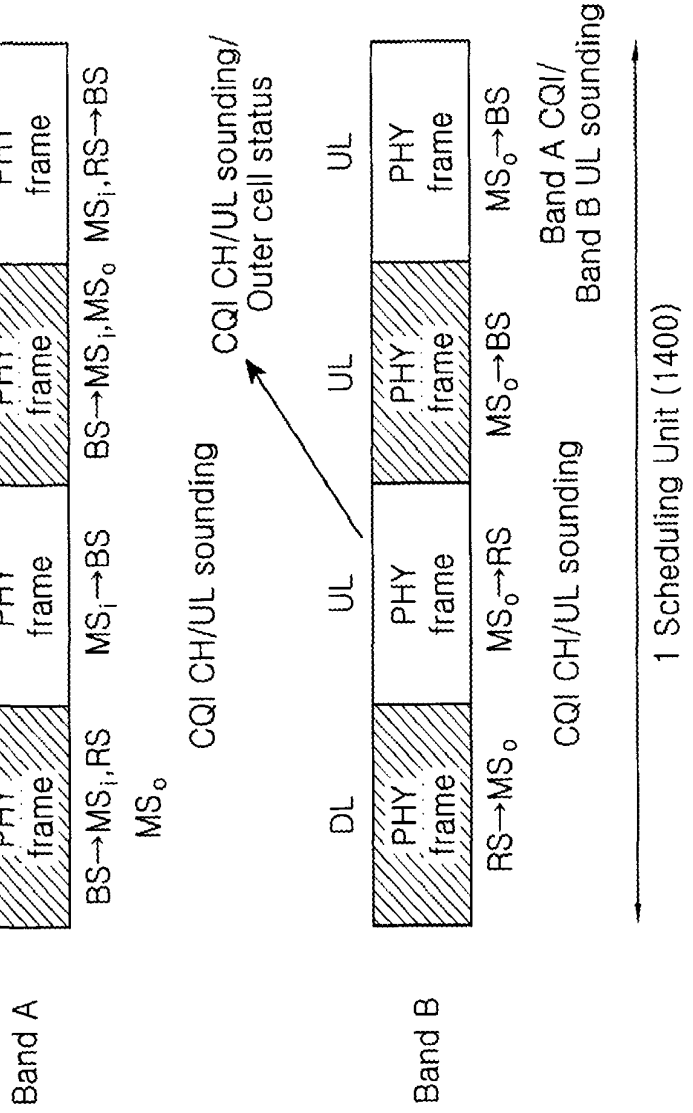

Band A
DL
UL
DL
UL
PHY frame
PHY frame
PHY frame
PHY frame
BS→MS$_i$,RS
MS$_i$→BS
BS→MS$_i$,MS$_o$
MS$_i$,RS→BS
MS$_o$
CQI CH/UL sounding
CQI CH/UL sounding/
Outer cell status
Band B
DL
UL
UL
UL
PHY frame
PHY frame
PHY frame
PHY frame
RS→MS$_o$
MS$_o$→RS
MS$_o$→BS
MS$_o$→BS
CQI CH/UL sounding
Band A CQI/
Band B UL sounding
1 Scheduling Unit (1400)

FIG. 14

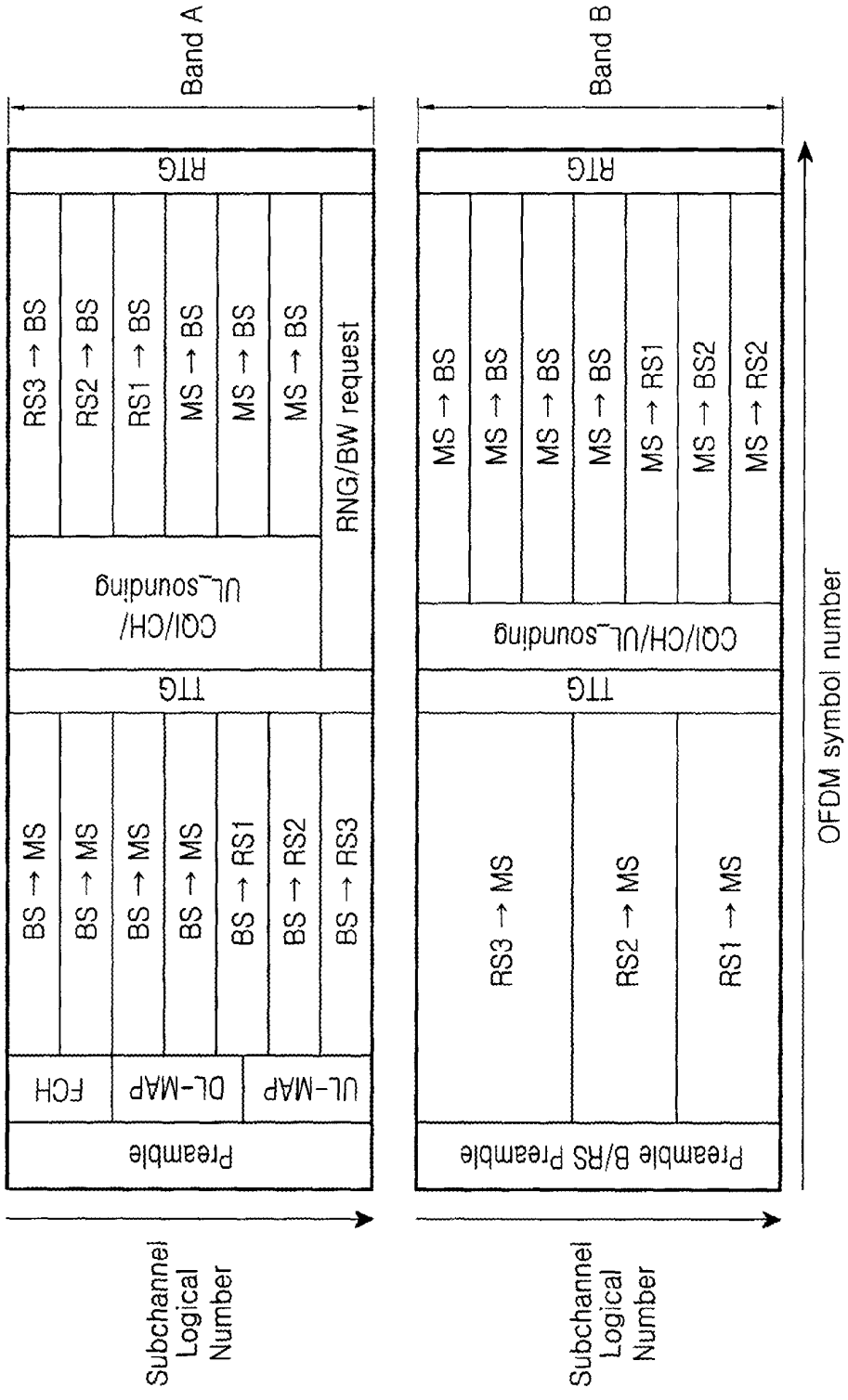
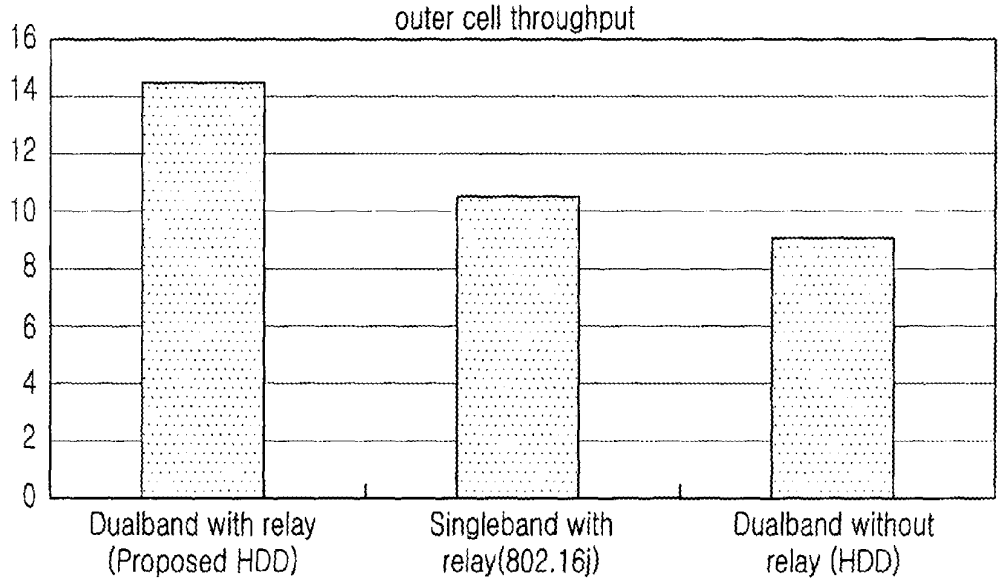

Band A
Band B
RTG
RS3 → BS
RS2 → BS
RS1 → BS
MS → BS
MS → BS
MS → BS
RNG/BW request
CQI/CH/UL_sounding
TTG
BS → MS
BS → MS
BS → MS
BS → MS
BS → RS1
BS → RS2
BS → RS3
FCH
DL-MAP
UL-MAP
Preamble
MS → BS
MS → BS
MS → BS
MS → BS
MS → RS1
MS → BS2
MS → RS2
CQI/CH/UL_sounding
RS3 → MS
RS2 → MS
RS1 → MS
Preamble B/RS Preamble
Subchannel Logical Number
Subchannel Logical Number
OFDM symbol number

FIG. 15


outer cell throughput
16
14
12
10
8
6
4
2
0
Dualband with relay (Proposed HDD)
Singleband with relay(802.16j)
Dualband without relay (HDD)

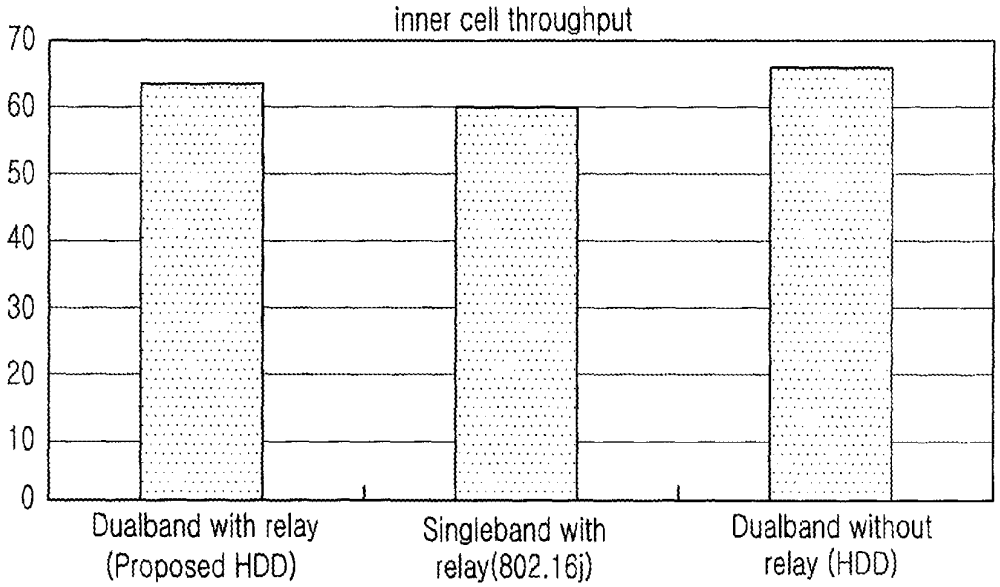

inner cell throughput
70
60
50
40
30
20
10
0
Dualband with relay (Proposed HDD)
Singleband with relay(802.16j)
Dualband without relay (HDD)

FIG.16

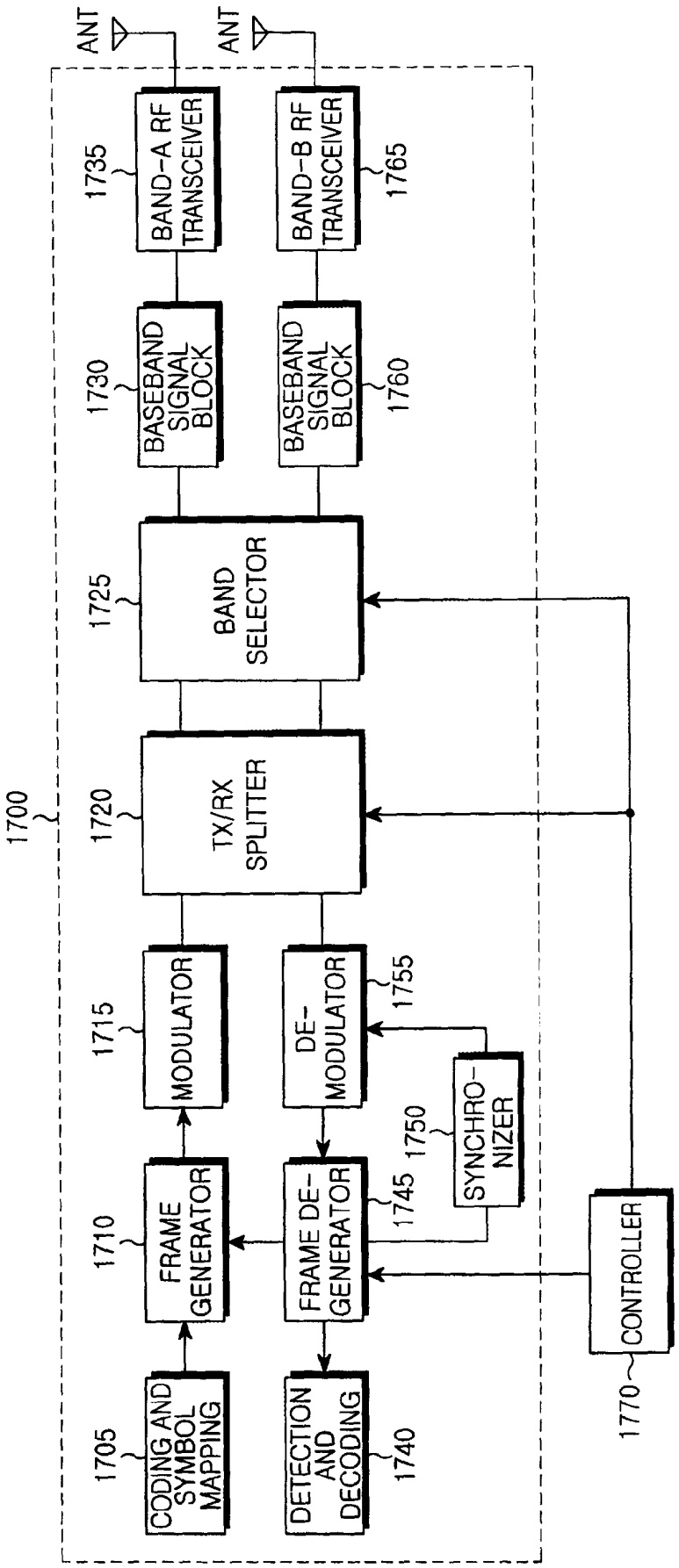

ANT
ANT
1735
BAND-A RF TRANSCEIVER
1765
BAND-B RF TRANSCEIVER
1730
BASEBAND SIGNAL BLOCK
1760
BASEBAND SIGNAL BLOCK
1725
BAND SELECTOR
1700
1720
TX/RX SPLITTER
1715
MODULATOR
DE-MODULATOR
1755
1750
SYNCHRO-NIZER
1710
FRAME GENERATOR
FRAME DE-GENERATOR
1745
CONTROLLER
1770
1705
CODING AND SYMBOL MAPPING
DETECTION AND DECODING
1740

FIG. 17

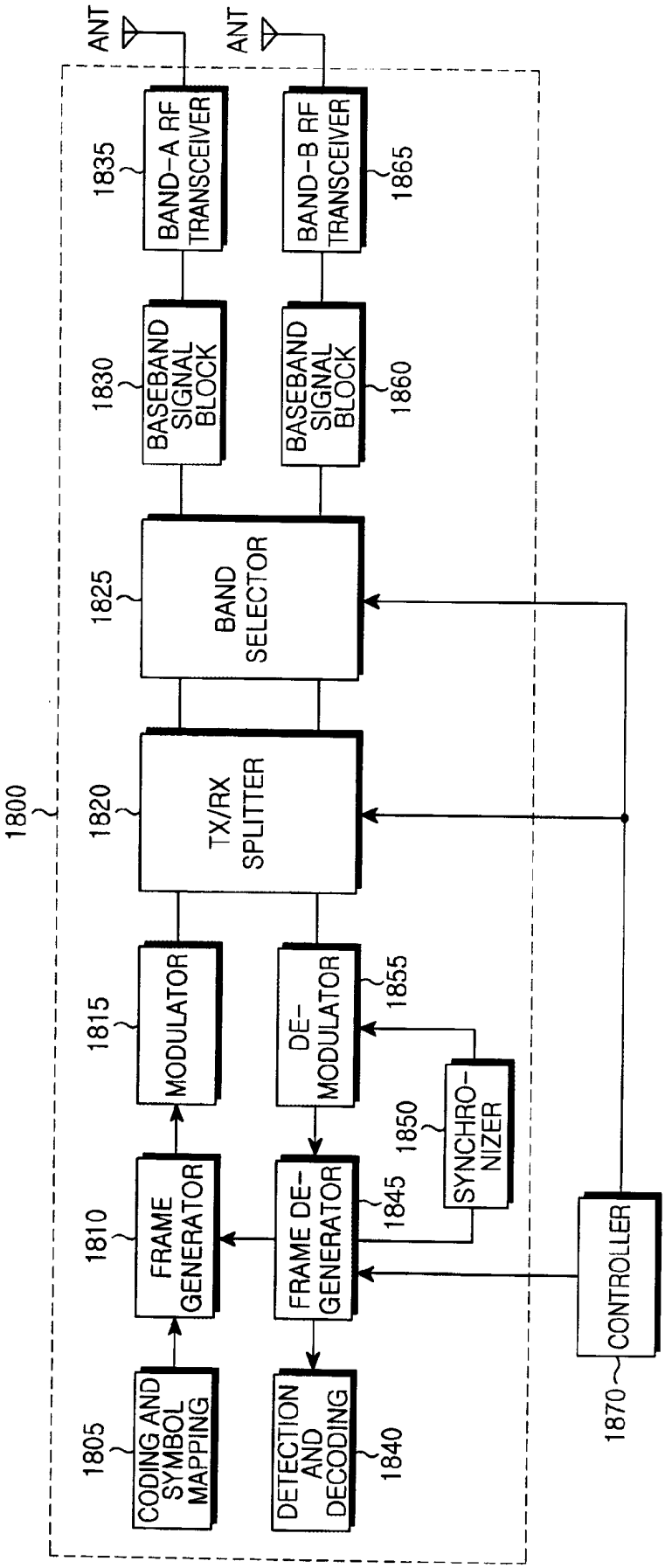

ANT
ANT
1835
BAND-A RF TRANSCEIVER
1865
BAND-B RF TRANSCEIVER
1830
BASEBAND SIGNAL BLOCK
1860
BASEBAND SIGNAL BLOCK
1825
BAND SELECTOR
1800
1820
TX/RX SPLITTER
1815
MODULATOR
DE-MODULATOR
1855
1850
SYNCHRO-NIZER
1810
FRAME GENERATOR
FRAME DE-GENERATOR
1845
CONTROLLER
1870
1805
CODING AND SYMBOL MAPPING
DETECTION AND DECODING
1840

FIG. 18

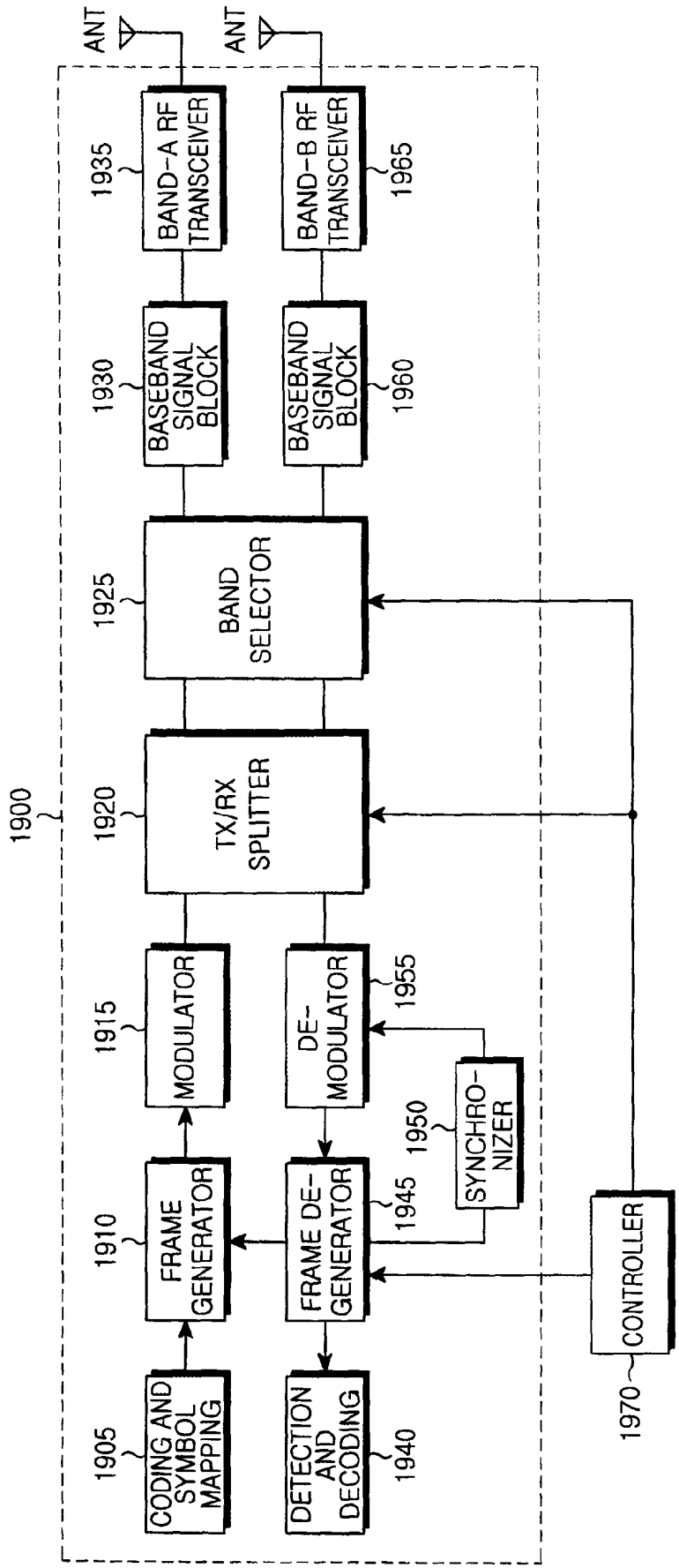

1900
ANT
ANT
1935
BAND-A RF TRANSCEIVER
1965
BAND-B RF TRANSCEIVER
1930
BASEBAND SIGNAL BLOCK
1960
BASEBAND SIGNAL BLOCK
1925
BAND SELECTOR
1920
TX/RX SPLITTER
1915
MODULATOR
1955
DE-MODULATOR
1950
SYNCHRO-NIZER
1910
FRAME GENERATOR
1945
FRAME DE-GENERATOR
1905
CODING AND SYMBOL MAPPING
1940
DETECTION AND DECODING
1970
CONTROLLER

FIG. 19

METHOD AND APPARATUS FOR TRANSMITTING AND RECEIVING DATA IN A COMMUNICATION SYSTEM ACCORDING TO A LOCATION OF A MOBILE STATION

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 Apr. 5, 2007 and assigned Serial No. 2007-33913, the entire disclosure of which is hereby incorporated by reference.

JOINT RESEARCH AGREEMENT

The presently claimed invention was made by or on behalf of the below listed parties to a joint research agreement. The joint research agreement was in effect on or before the date the claimed invention was made and the claimed invention was made as a result of activities undertaken within the scope of the joint research agreement. The parties to the joint research agreement are Samsung Electronics Co. Ltd. and Industry-Academic Cooperation Foundation, Yonsei University.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates generally to a method and apparatus for transmitting and receiving data in a communication system. More particularly, the present invention relates to a method and apparatus for transmitting and receiving data using Relay Stations (RSs) in a Hybrid Division Duplex (HDD)-based communication system.

2. Description of the Related Art

FIG. **1** is a diagram illustrating data transmission and reception using RSs according to the conventional art.

Referring to FIG. **1**, in an arbitrary cell **100**, a Base Station (BS) **102** communicates with any of Mobile Station **1** (MS**1**) **108**, MS**2** **110**, MS**3** **112**, MS**4** **114** and MS**5** **116** directly or via one of an RS**1** **104** and an RS**2** **106**. The BS **102** and the RSs **104** and **106** use different subchannels.

The MS**1** **108** located in a boundary of the cell **100** and the MS**5** **116** located inside the cell **100** both communicate directly with the BS **102**. That is, because the BS **102** is located a shorter distance from each of them as compared to the distance to either of RS**1** **104** or RS**2** **106**, the MS**1** **108** and the MS**5** **117** communicate in synchronization with the BS **102** directly, without using an RS. In comparison, because of its distance from the BS **102** compared with its distance to an RS, the MS**2** **110** communicates with the BS **102** via its nearest RS**1** **104**. Similarly, the MS**3** **112** and the MS**4** **114** also communicate with BS **102** via their nearest RS**2** **106**.

Because of the different paths by which the MSs connect to the BS, the MSs have different synchronizations and an offset between the different synchronizations may occur. For example, a synchronization offset **135** occurs between first data **120** that the BS **102** has directly received from the MS**1** **108** and second data **130** that the BS **102** has received from the MS**2** **110** via the RS**1** **104**. That is, in a period where the BS **102** performs Fast Fourier Transform (FFT) demodulation on the received first and second data **120** and **130**, Cyclic Prefix (CP)-length phase shift occurs at arrival times of the data **120** and **130**, causing Inter-Carrier Interference (ICI) **140**.

In the foregoing conventional communication system, since the devices, such as BS and/or RS, to which an MS is connected, have different synchronizations, ICI interference may occur during received data demodulation at the BS, causing a decrease in the system performance.

SUMMARY OF THE INVENTION

An aspect of the present invention is 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 apparatus for minimizing ICI interference by adaptively applying an HDD scheme according to the location of a Mobile Station (MS).

Another aspect of the present invention is to use different frequency reuse factors in a cell's inner region and a cell's outer region, and provide an adaptive HDD method between a Base Station (BS) and a Relay Station (RS) according to the location of an MS.

According to one aspect of the present invention, a method for transmitting and receiving data by a Base Station (BS) in a communication system is provided. The method includes determining a location of a Mobile Station (MS), determining a transmission/reception scheme for data transmission and reception to/from the MS according to the location of the MS and transmitting and receiving data to/from the MS using the determined transmission/reception scheme. In one implementation, the MS is located in any one of a cell's inner region and a cell's outer region, the cell's inner region having a radius which is flexible according to interference between adjacent cells, and the cell's outer region being a region defined by excepting the cell's inner region from the entire cell region.

According to another aspect of the present invention, an apparatus for transmitting and receiving data in a Base Station (BS) of a communication system is provided. The apparatus includes a controller for determining a location of a Mobile Station (MS) and for determining a transmission/reception scheme for data transmission and reception to/from the MS according to the location of the MS and a transceiver for transmitting and receiving data to/from the MS using the determined transmission/reception scheme. In one implementation, the MS is located in any one of a cell's inner region and a cell's outer region, the cell's inner region having a radius which is flexible according to interference between adjacent cells, and the cell's outer region being a region defined by excepting the cell's inner region from the entire cell region.

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 become more apparent from the following detailed description taken in conjunction with the accompanying drawings in which:

FIG. **1** is a diagram illustrating data transmission and reception using RSs according to the conventional art;

FIG. **2** is a diagram illustrating an HDD-based communication system according to an exemplary embodiment of the present invention;

FIG. **3** is a diagram illustrating a relay system based on an HDD scheme according to an exemplary embodiment of the present invention;

FIG. **4** is a diagram illustrating a frame structure according to an exemplary embodiment of the present invention;

FIG. **5** is a diagram illustrating a frame structure to which a TDD-based double band-type HDD scheme is applied according to an exemplary embodiment of the present invention;

FIG. **6** is a diagram illustrating a frame structure to which a first duplex scheme is applied according to an exemplary embodiment of the present invention;

FIG. **7** is a diagram illustrating a frame structure to which a second duplex scheme is applied according to an exemplary embodiment of the present invention;

FIG. **8** is a diagram illustrating a frame structure to which a third duplex scheme is applied according to an exemplary embodiment of the present invention;

FIGS. **9**A and **9**B are diagrams illustrating patterns of subchannels according to exemplary embodiments of the present invention;

FIG. **10** is a diagram illustrating an example of a method for generating a subchannel of each cell according to an exemplary embodiment of the present invention;

FIG. **11** is a diagram illustrating another example of a method for generating a subchannel of each cell according to an exemplary embodiment of the present invention;

FIGS. **12**A and **12**B are diagrams illustrating a method for performing cell planning of an MS located in a cell's outer region according to an exemplary embodiment of the present invention;

FIGS. **13**A and **13**B are diagrams illustrating examples of UL/DL resources allocated symmetrically or asymmetrically according to exemplary embodiments of the present invention;

FIG. **14** is a diagram illustrating an example of generating a superframe composed of multiple subframes, which is a scheduling unit, according to an exemplary embodiment of the present invention;

FIG. **15** is a diagram schematically illustrating a frame structure according to an exemplary embodiment of the present invention;

FIG. **16** is a graph illustrating performance of an exemplary embodiment of the present invention;

FIG. **17** is a diagram illustrating a structure of an MS according to an exemplary embodiment of the present invention;

FIG. **18** is a diagram illustrating a structure of an RS according to an exemplary embodiment of the present invention; and

FIG. **19** is a diagram illustrating a structure of a BS according to an exemplary embodiment of the present invention.

Throughout the drawings, it should be noted that like reference numbers are used to depict the same or similar elements, features 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 can be made without departing from the scope and spirit of the invention. Also, descriptions of well-known functions and constructions are omitted for clarity and conciseness. Terms used herein are defined based on functions in the present invention and may vary according to users, operators' intention or usual practices. Therefore, the definition of the terms should be made based on contents throughout the specification.

A Hybrid Division Duplex (HDD) scheme uses both a Time Division Duplex (TDD) scheme suitable for a micro cell, and a Frequency Division Duplex (FDD) scheme suitable for a fast MS and a macro cell. That is, the HDD scheme is suitable for a system having an asymmetric ratio and a high data rate.

FIG. **2** is a diagram illustrating a HDD-based communication system according to an exemplary embodiment of the present invention.

Referring to FIG. **2**, a cell is divided into an inner region **210**, which is a shorter distance from a BS **212** and an outer region **200**, which is a longer distance from the BS **212**. With application of the FDD scheme, the BS **212** separates a frequency band with which it communicates with an MS**2** **214** located in the inner region **210** from a frequency band with which it communicates with an MS**1** **202** located in the outer region **200**.

That is, by applying the TDD scheme to a single frequency band A, the MS**2** **214** located in the inner region **210** communicates with the BS **212** using an Up Link (UL) interval and a Down Link (DL) interval on a separate basis. The MS**1** **202** located in the outer region **200** uses a frequency band B to which the FDD scheme is applied, in the UL interval, and uses the frequency band A to which the TDD scheme is applied, in the DL interval.

As described above, the HDD scheme can have the merits of both the TDD scheme and the FDD scheme. In addition, the HDD scheme can overcome inter-Cross Time Slot (CTS) interference which may occur due to the UL/DL asymmetry between cells by means of the TDD scheme. However, in the UL interval where the frequency band B is used, there is interference from an adjacent cell.

With use of two different frequency bands, exemplary embodiments of the present invention use different duplex schemes, i.e., TDD scheme and FDD scheme, for communication between each pair of a Base Station (BS), a Relay Station (RS) and a Mobile Station (MS). Each duplex scheme efficiently controls interference between adjacent cells using different frequency reuse factors, and separates ICI which may occur due to a signal generated in an outer region, from that of an inner region, by separating transmission/reception bands between the inner region and the outer region. In addition, exemplary embodiments of the present invention can efficiently manage the interference between adjacent cells by allocating different frequency reuse factors in the cell's outer region and the cell's inner region on a fixed or adaptive basis.

FIG. **3** is a diagram illustrating a relay system based on an HDD scheme according to an exemplary embodiment of the present invention.

Referring to FIG. **3**, a cell is divided into an inner region **310**, which is a shorter distance from a BS **312** and an outer region **300**, which is a longer distance from the BS **312**. In an exemplary implementation as illustrated, the cell is assumed to use two different frequency bands (e.g. a frequency band A and a frequency band B) and to have one RS **314** for communication between the BS **312** and an MS**1** **302** and an MS**2** **304** located in the outer region **300**. Of course, it is to be understood that this is by way of example only, and the number of RSs as well as the number of frequency bands is subject to change.

For communication with the BS **312**, an MS**3** **316** located in the inner region **310** and the RS **314** use a first duplex

method of transmitting/receiving data by applying a TDD method to a frequency band A.

The MS1 **302** and the MS2 **304** in the outer region **300** either communicate with the BS **312** via the RS **314** or directly communicate with the BS **312**. For communication between the MS2 **304** in the outer region **300** and the RS **314**, a second duplex method of transmitting/receiving data is used by applying the TDD method to a frequency band B.

For direct communication between the BS **312** and the MS1 **302** located in the outer region **300**, a third duplex method of transmitting/receiving data is used by applying an FDD scheme that uses the frequency band B in a UL interval, and uses the frequency band A in a DL interval.

The first through the third duplex schemes use different UL/DL frequency reuse factors between adjacent cells. That is, the duplex schemes use a frequency reuse factor K=1 in the inner region **310**, and use a frequency reuse factor K<1 in the outer region **300**.

A radius r of the inner region **310** may vary according to a frequency reuse factor and an interference level between adjacent cells. In this case, the interference level between adjacent cells can be determined by measuring signal strength of an unused frequency band according to a frequency reuse factor allocated to each cell. The inner region **310** and the outer region **300** of the cell are separated according to the radius r of the inner region **310**, and the RS **314** can be located in the cell's inner region **310**, or can variably change in the cell's outer region **300** according to the distribution of MSs and the distribution of shadow areas. A radius R of the outer region **300** is fixed.

FIG. **4** is a diagram illustrating a frame structure according to an exemplary embodiment of the present invention.

Referring to FIG. **4**, one subframe is allocated to each of UL and DL intervals, and a group of the subframes constitutes one superframe-type frame structure.

FIG. **5** is a diagram illustrating a frame structure to which a TDD-based double band-type HDD scheme is applied according to an exemplary embodiment of the present invention.

Referring to FIG. **5**, for a frequency band A **500**, a TDD scheme is applied in the first duplex scheme and an FDD scheme applied in the third duplex scheme. That is, in a DL interval **502** of the frequency band A **500**, a DL subframe for each of an MS MS_i located in a cell's inner region, an MS MS_o located in a cell's outer region, and an RS is allocated from a BS. In a UL interval **504** spaced apart from the DL interval **502** by a Transmit/Receive Transition Gap (TTG), a UL subframe for the BS is allocated from each of an MS MS_i located in the cell's inner region and the RS. Thereafter, a DL interval spaced apart from the UL interval by a Receive/Transmit Transition Gap (RTG) follows the UL interval.

For a frequency band B **510**, a TDD scheme is applied in the second duplex scheme, and the FDD scheme is applied in the third duplex scheme. That is, in a DL interval **512**, a subframe between the RS and the MS_o is allocated. In a UL interval **514** spaced apart from the DL interval **512** by TTG, a UL subframe for each of the BS and the RS is allocated from the MS_o. Thereafter, a DL interval spaced apart from the UL interval by RTG follows the UL interval.

With reference to FIGS. **6** to **8**, a detailed description will now be made of a frame structure to which the first through third duplex schemes are applied according to an exemplary embodiment of the present invention.

FIG. **6** is a diagram illustrating a frame structure to which a first duplex scheme is applied according to an exemplary embodiment of the present invention.

Referring to FIG. **6**, in a frequency band A **600**, subframes of UL and DL intervals are alternately allocated, by applying the TDD scheme according to the first duplex scheme. Here, a frequency reuse factor of the DL interval between an MS_i and a BS is 1.

A first subframe **602** is a subframe of the DL interval, with which the BS transmits data to an MS_i or an RS. A second subframe **604** is a subframe of the UL interval, with which the BS receives data from the MS_i. Thereafter, a third subframe is a subframe of the DL interval, with which the MS_i receives data from the BS, and a fourth subframe is a subframe of the UL interval, with which the MS_i or the RS transmits data to the BS.

FIG. **7** is a diagram illustrating a frame structure to which a second duplex scheme is applied according to an exemplary embodiment of the present invention.

Referring to FIG. **7**, a first subframe **702** of a frequency band B **700** is a subframe of a DL interval, with which an RS transmits data to an MS_o. A second subframe **704** is a subframe of a UL interval, with which the MS_o transmits data to the RS, or the MS_o directly transmits data to the BS. A frequency reuse factor of the UL and DL intervals for the frequency band B, to which the FDD scheme is applied, is adjusted according to an interference level between adjacent cells. Here, signal strength of the frequency band currently used in the cell is determined and the determined signal strength is used as a criterion for determining the interference level between adjacent cells.

FIG. **8** is a diagram illustrating a frame structure to which a third duplex scheme is applied according to an exemplary embodiment of the present invention.

Referring to FIG. **8**, an FDD scheme is applied for subframes **802** and **804** in the same time interval **800** according to the third duplex scheme. That is, a subframe **802** of the frequency band A is a subframe of a DL interval, with which a BS directly transmits data to an MS_o. A subframe **804** of the frequency band B in the same time interval **800** is a UL subframe with which the MS_o transmits data to the BS.

Exemplary embodiments of the present invention use different types of subchannels according to whether a location the corresponding MS belongs to a cell's outer region or a cell's inner region.

FIGS. **9**A and **9**B are diagrams illustrating patterns of subchannels according to exemplary embodiments of the present invention.

Referring to FIG. **9**A, an MS located in a cell's inner region uses a subchannel **900** composed of subcarriers which are adjacent along the frequency domain.

Referring to FIG. **9**B, an MS located in a cell's outer region uses a subchannel **910** composed of subcarriers which are distributed at regular intervals along the frequency domain.

FIG. **10** is a diagram illustrating a method for generating a subchannel of each cell according to an exemplary embodiment of the present invention. A description thereof will be made herein for a frequency reuse factor of 1/3 and a frequency reuse factor of 2/3, by way of example. It is to be understood that these frequency reuse factors are merely exemplary and other reuse factors may be used in their place.

Referring to FIG. **10**, if it is assumed that perfect cell planning is possible, a subchannel of each cell is composed of the same subcarriers. That is, subcarriers of a subchannel in a cell#**1 1000**, subcarriers of a subchannel in a cell#**2 1002**, and subcarriers of a subchannel in a cell#**3 1004** are equal to one another.

FIG. **11** is a diagram illustrating another example of a method for generating a subchannel of each cell according to an exemplary embodiment of the present invention.

Referring to FIG. **11**, there is a case where it is difficult to separate a subchannel used in each cell. Therefore, only some of subcarriers constituting a subchannel of each cell are equal to corresponding ones of subcarriers constituting a subchannel of an adjacent cell. It is assumed herein that the frequency reuse factor is ⅓. That is, subchannels of a cell#**1 1100** and a cell#**2 1110** each are composed of 3 subcarriers, and the cells are equal in 2 of the 3 subcarriers.

When MSs are allocated for each subframe, an MS that will communicate with an RS is allocated taking into account a Signal-to-Noise Ratio (SNR) between the BS and the MS in a frequency band A, an SNR between the BS and the MS in a frequency band B and an SNR between the RS and the MS in the frequency band B. In addition, subchannels, transmission power and transmission methods are determined for communication between the BS and the RS and communication between the RS and the MS.

Among MSs located in the outer region of the cell, an MS having a greater difference between an SNR between the corresponding MS and the BS and an SNR between the corresponding MS and the RS is first allocated to the corresponding RS.

When the third duplex scheme is used, signal strength of a frequency band currently unused in the cell is measured and the measured signal strength is used as a criterion for determining an interference level between adjacent cells. An adaptive frequency reuse factor is provided that can increase or decrease a frequency reuse factor of the DL interval according to the interference level between adjacent cells. If the DL interval to which the third duplex scheme is applied is assumed to be allocated using the frequency band A, a frequency reuse factor is determined taking into account DL resources of the first duplex scheme. That is, when a BS directly communicates with an MS_o, since its interference to/from an adjacent cell's MS increases, it cannot use a frequency reuse factor K=1. Therefore, DL resources used for communication with the cell's outer region have different frequency reuse factors from the MSs allocated in the cell's inner region.

In this case, the DL frequency reuse factor allocated to the MS located in the cell's outer region is flexible as its cell planning is simple, and the corresponding MS is also flexibly allocated the resources which are allocated for the DL according to the first duplex scheme.

FIGS. **12**A and **12**B are diagrams illustrating a method for performing cell planning for an MS located in a cell's outer region according to an exemplary embodiment of the present invention.

Herein, the cell's outer region uses a frequency reuse factor K=⅓ and the cell's inner region uses a frequency reuse factor K=1. In the DL interval of each cell, the shaded part represents an interval allocated for the cell's outer region, and the non-shaded part represents an interval allocated for the cell's inner region.

Referring to FIG. **12**A, the cells undergo cell planning taking both the cell's inner region and the cell's outer region into consideration. In the frequency band A, cell#**1**, cell#**2** and cell#**3** allocate DL between the BS and MS_o, and DL between the BS and MS_i.

Referring to FIG. **12**B, the cells undergo cell planning taking only the cell's outer region into account. A part of the frequency band A is established as a region for the outer region and, by adjusting a frequency reuse factor in the corresponding region, a region to be used in each of cell#**1** through cell#**3** is allocated. Herein, ⅓ of the cell is established as the region for the cell's outer region, and ⅓ of the corresponding region, i.e., ⅑ of the entire cell, is allocated as a DL between the BS and MS_o.

Another exemplary embodiment of the present invention allocates DL and UL resources to a frequency band A and a frequency band B symmetrically or asymmetrically according to each duplex scheme taking into account the required amount of resources of the corresponding system.

FIGS. **13**A and **13**B are diagrams illustrating examples of UL/DL resources allocated symmetrically or asymmetrically according to exemplary embodiments of the present invention.

Referring to FIG. **13**A, in a frequency band A, resources of the DL and UL intervals are allocated symmetrically using a ratio 1:1. A first DL subframe is used for communication between the BS and MS_i, and between the RS and MS_o. Next, a first UL subframe is used for communication between the MS_i and BS. A second DL subframe is used for communication between the BS and MS_i and between the BS and MS_o, and finally, a second UL subframe is used for communication between the MS_i and BS and between the RS and BS.

In a frequency band B, resources of the DL and UL intervals are allocated asymmetrically using a 1:3 ratio. A first DL subframe is used for communication between the RS and MS_o. Next, a first UL subframe is used for communication between the MS_o and RS, and a second UL subframe is used for communication between the MS_o and BS. Finally, a third UL subframe is used for communication between the MS_o and BS.

Referring to FIG. **13**B, in a frequency band A, resources of DL and UL intervals are allocated asymmetrically using a **2**:**1** ratio. Consecutive first and second DL subframes are used for communication between the BS and MS_i and between the RS and MS_o, and a first UL subframe is used for communication between the MS_i and BS. Consecutive third and fourth DL subframes are used for communication between the BS and MS_i and between BS and MS_o, and finally, a second UL subframe is used for communication between the MS_i and BS and between the RS and BS.

In a frequency band B, resources of DL and UL intervals are allocated asymmetrically using a 1:2 ratio. Consecutive first and second DL subframes are used for communication between the RS and MS_o. Next, consecutive first and second UL subframes are used for communication between the MS_o and RS, and consecutive third and fourth UL subframes are used for communication between the MS_o and BS.

FIG. **14** is a diagram illustrating an example of generating a superframe composed of multiple subframes, which is a scheduling unit, according to an exemplary embodiment of the present invention.

Referring to FIG. **14**, a superframe **1400** is composed of 2 DL subframes and 2 UL subframes for each of frequency band A and a frequency band B.

First, a first DL subframe of the frequency band A is used for communication between the BS and MS_i, RS and MS_o, and a second DL subframe is used for communication between the BS and MS_i and between the BS and MS_o. A first UL subframe of the frequency band A is used for communication between the MS_i and BS, and a second UL subframe is used for communication between the MS_i and BS and between the RS and BS.

Next, a first DL subframe of the frequency band B is used for communication between RS and MS_o, and a second UL subframe is used for communication between MS_o and RS. Third and fourth UL subframes of the frequency band B are used for communication between MS_o and BS.

FIG. **15** is a diagram schematically illustrating a frame structure according to an exemplary embodiment of the present invention.

Referring to FIG. **15**, in a frame of a frequency band A, Fundamental Channel (FCH), DL_MAP and UL_MAP are located after a preamble for synchronization, and DL resources between the BS and MSs and between the BS and RSs are allocated. A Channel Quality Information (CQI)/Channel/UL_Sounding subframe is located after a TTG, UL resources between the RSs and BS and between the MSs and BS are allocated, and an RTG is located thereafter.

In a frame of a frequency band B, DL resources between the RSs to MS are allocated after a preamble. A CQI/Channel/UL_Sounding subframe is located after a TTG, UL resources between the MS and BS and between the MS and RSs are allocated, and an RTG is located thereafter. As shown in FIG. **15**, one frame constitutes a scheduling unit.

FIG. **16** is a graph illustrating performance of an exemplary embodiment of the present invention.

Referring to FIG. **16**, it can be appreciated that the dual-band HDD system using RS(s) in the cell's outer region and the cell's inner region, compared to the conventional system not using RS(s), increases in the HDD performance at the cell's outer region. It addition, it can be noted that a single-band system, when its guard interval is not long enough, may suffer inter-carrier interference, causing performance degradation.

As a result, it is shown that the dual-band HHD system using RS(s) in the cell's outer region and the cell's inner region exhibits higher performance as compared to the existing HDD system without RS and the single-band system with only RS(s).

FIG. **17** is a diagram illustrating a structure of an MS according to an exemplary embodiment of the present invention.

Referring to FIG. **17**, an MS **1700** includes a coding and symbol mapping unit **1705**, a frame generator **1710**, a modulator **1715**, a Transmission/Reception (Tx/Rx) splitter **1720**, a band selector **1725**, a baseband signal block **1730**, a frequency band-A Radio Frequency (RF) transceiver **1735**, a detection and decoding unit **1740**, a frame de-generator **1745**, a synchronizer **1750**, a demodulator **1755**, a baseband signal block **1760**, a frequency band-B RF transceiver **1765**, and a controller **1770**.

The coding and symbol mapping unit **1705** outputs desired transmission data, a control signal, and a UL sounding signal to the frame generator **1710**. Based on frame configuration information received from the controller **1770**, the frame generator **1710** generates a frame configured in the form of FIG. **15** using the received data and control signal, and outputs the generated frame to the modulator **1715**. The modulator **1715** modulates the frame, generates a transmission symbol using a pulse shaping filter, and then outputs the result to the Tx/Rx splitter **1720**.

The Tx/Rx splitter **1720** determines a transmission slot and a reception slot of each band for data exchange with an RS or a BS according to transmission/reception time information received from the controller **1770**, and outputs the result to the band selector **1725**. The band selector **1725** determines a transmission slot and a reception slot for each of transmission and reception bands for data exchange with the RS or the BS according to path information received from the controller **1770**. The first through third duplex methods are determined depending on the band and time slots determined by means of the Tx/Rx splitter **1720** and the band selector **1725**.

The band selector **1725** selects a frequency band corresponding to the determined duplex method. When the frequency band is selected, the data scheduled to use the selected frequency band is delivered to the corresponding BS or RS by way of the frequency band-A RF transceiver **1735** or the frequency band-B RF transceiver **1765** after undergoing the baseband signal block **1730** or **1760**.

The data received via the BS or the RS is delivered from the band selector **1725** to the Tx/Rx splitter **1720** by way of the frequency band-A RF transceiver **1735** or the frequency band-B RF transceiver **1765** and the baseband signal block **1730** or **1760** according to the corresponding frequency band. Thereafter, the received data is demodulated by means of the demodulator **1755**, and then separated into a control signal and data by means of the frame de-generator **1745**. The frame de-generator **1745** delivers a pilot and a preamble included in the separated control signal to the synchronizer **1750**. The synchronizer **1750** performs synchronization with the BS or the RS according to the received pilot and preamble.

The data signal and control signal output by means of the frame de-generator **1745** are decoded in the detection and decoding unit **1740**.

The controller **1770** controls the frame generator **1710** and the frame de-generator **1745** using channel state information received from the BS or the RS, and location information necessary for communication with each of the BS and the RS, and its own location information, and delivers transmission/reception time information and path information for determining an appropriate duplex method, to the Tx/Rx splitter **1720** and the band selector **1725**.

FIG. **18** is a diagram illustrating a structure of an RS according to an exemplary embodiment of the present invention.

Referring to FIG. **18**, an RS **1800** includes a coding and symbol mapping unit **1805**, a frame generator **1810**, a modulator **1815**, a Tx/Rx splitter **1820**, a band selector **1825**, a baseband signal block **1830**, a frequency band-A RF transceiver **1835**, a detection and decoding unit **1840**, a frame de-generator **1845**, a synchronizer **1850**, a demodulator **1855**, a baseband signal block **1860**, a frequency band-B RF transceiver **1865**, and a controller **1870**.

The coding and symbol mapping unit **1805** outputs desired transmission data and a control signal to the frame generator **1810**. Based on frame configuration information received from the controller **1870**, the frame generator **1810** generates a frame configured in the form of FIG. **15** using the received data and control signal, and outputs the generated frame to the modulator **1815**. The modulator **1815** modulates the frame, generates a transmission symbol using a pulse shaping filter, and then outputs the result to the Tx/Rx splitter **1820**.

The Tx/Rx splitter **1820** determines a transmission slot and a reception slot of each band for data exchange with an MS or a BS according to the transmission/reception time information received from the controller **1870**, and outputs the result to the band selector **1825**. The band selector **1825** determines a transmission slot and a reception slot for each of transmission and reception bands for data exchange with the MS or the BS according to the path information received from the controller **1870**. The first through third duplex methods are determined depending on the band and time slots determined by means of the Tx/Rx splitter **1820** and the band selector **1825**.

The data output from the band selector **1825** according to the determined frequency band is delivered to the corresponding MS or BS by way of the frequency band-A RF transceiver **1835** or the frequency band-B RF transceiver **1865** after undergoing the baseband signal block **1830** or **1860**.

The symbol received via the BS or the MS is delivered from the band selector **1825** to the Tx/Rx splitter **1820** by way of the frequency band-A RF transceiver **1835** or the frequency

band-B RF transceiver **1865** and the baseband signal block **1830** or **1860** according to the corresponding frequency band. Thereafter, the received symbol is demodulated by means of the demodulator **1855**, and then separated into a control signal and data by means of the frame de-generator **1845**. The frame de-generator **1845** delivers a pilot and a preamble in the received signal to the synchronizer **1850**. The synchronizer **1850** performs synchronization with the BS or MS according to the received pilot and preamble.

The data signal and control signal output by means of the frame de-generator **1845** are decoded in the detection and decoding unit **1840**. The controller **1870** controls the frame generator **1810** and the frame de-generator **1845** using channel state information received from the BS or the MS, location information necessary for communication with the BS or MS, and its own location information, and delivers transmission/reception time information and path information for determining a duplex method to the Tx/Rx splitter **1820** and the band selector **1825**.

FIG. **19** is a diagram illustrating a structure of a BS according to an exemplary embodiment of the present invention.

Referring to FIG. **19**, a BS **1900** includes a coding and symbol mapping unit **1905**, a frame generator **1910**, a modulator **1915**, a Tx/Rx splitter **1920**, a band selector **1925**, a baseband signal block **1930**, a frequency band-A RF transceiver **1935**, a detection and decoding unit **1940**, a frame de-generator **1945**, a synchronizer **1950**, a demodulator **1955**, a baseband signal block **1960**, a frequency band-B RF transceiver **1965**, and a controller **1970**.

The coding and symbol mapping unit **1905** outputs the desired transmission data and a control signal to the frame generator **1910**. Based on frame configuration information received from the controller **1970**, the frame generator **1910** generates a frame configured in the form of FIG. **15** using the received data and control signal, and outputs the result to the modulator **1915**. The modulator **1915** modulates the frame, generates a transmission symbol using a pulse shaping filter, and then outputs the result to the Tx/Rx splitter **1920**.

The Tx/Rx splitter **1920** determines a transmission slot and a reception slot of each band for data exchange with an MS or RS according to the transmission/reception time information received from the controller **1970**, and outputs the result to the band selector **1925**. The band selector **1925** determines a transmission slot and a reception slot for each of transmission and reception bands for data exchange with the MS or RS according to the path information received from the controller **1970**. The first through third duplex methods are determined depending on the band and time slots determined by means of the Tx/Rx splitter **1920** and the band selector **1925**.

The data output from the band selector **1925** according to the determined frequency band is delivered to the corresponding MS or RS by way of the frequency band-A RF transceiver **1935** or the frequency band-B RF transceiver **1965** after undergoing the baseband signal block **1930** or **1960**.

The symbol received via the RS or MS is delivered from the band selector **1925** to the Tx/Rx splitter **1920** via the frequency band-A RF transceiver **1935** or the frequency band-B RF transceiver **1965** and the baseband signal block **1930** or **1960** according to the corresponding frequency band. Thereafter, the received symbol is demodulated by means of the demodulator **1955**, and then separated into a control signal and data by means of the frame de-generator **1945**. The frame de-generator **1945** delivers a pilot and a preamble in the received symbol to the synchronizer **1950**. The synchronizer **1950** performs synchronization with the RS or MS according to the received pilot and preamble.

The data signal and control signal output by means of the frame de-generator **1945** are decoded in the detection and decoding unit **1940**.

The controller **1970** controls the frame generator **1910** and the frame de-generator **1945** using channel state information received from the RS or MS, location information necessary for communication with the RS and MS, and its own location information, and delivers transmission/reception time information and path information for determining a duplex method to the Tx/Rx splitter **1920** and the band selector **1925**.

As is apparent from the foregoing description, exemplary embodiments of the present invention use different frequency reuse factors in the cell's inner region and the cell's outer region, and provide an adaptive HDD method between the BS and the RS according to the location of the MS, thereby facilitating the minimization of ICI interference.

While the invention has been shown and described with reference to 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 for transmitting and receiving data by a Base Station (BS) in a communication system, the method comprising:

determining a location of a Mobile Station (MS);

determining a transmission/reception scheme for data transmission and reception to/from the MS according to the location of the MS; and

transmitting and receiving data to/from the MS using the determined transmission/reception scheme;

wherein the MS is located in at least one of a cell's inner region and a cell's outer region, and further wherein the cell's inner region has a radius that is adjusted according to an interference level between adjacent cells and the cell's outer region is defined by excepting the cell's inner region from the entire cell region,

wherein the determining of the transmission/reception scheme comprises:

when the MS is located in the cell's outer region, determining whether the MS transmits and receives a signal using a Relay Station (RS) located in the cell's inner region; and

determining the transmission/reception scheme as a time division duplex scheme when the MS transmits and receives a signal using the RS,

wherein a frequency applied to the time division duplex scheme between the MS and the RS is a second frequency, and a frequency applied to the time division duplex scheme between the BS and the RS is a first frequency which is different from the second frequency.

2. The method of claim **1**, wherein a frequency reuse factor used in the cell's inner region is 1 and a frequency reuse factor used in the cell's outer region is less than 1.

3. The method of claim **1**, wherein the determining of the transmission/reception scheme comprises:

when the MS is located in the cell's inner region, determining the transmission/reception scheme as the time division duplex scheme, and determining a frequency applied to the time division duplex scheme as the first frequency;

wherein the MS located in the cell's inner region uses physically consecutive subcarriers.

4. The method of claim 1, further comprising:

when the MS does not transmit and receive a signal using the RS, determining the transmission/reception scheme as a frequency division duplex scheme; and

determining a frequency applied to the frequency division duplex scheme as the first frequency and the second frequency;

wherein the first frequency is used for data transmission to the MS, and the second frequency is used for data reception from the MS.

5. The method of claim 4, wherein the MS, which does not transmit and receive a signal using the RS, uses physically inconsecutive subcarriers.

6. The method of claim 4, wherein a frequency reuse factor of the MS which does not transmit and receive a signal using the RS comprises a value obtained by adaptively controlling a frequency reuse factor of the cell's outer region taking into account a ratio of interference between adjacent cells to signal strength of a frequency band currently unused in the cell.

7. The method of claim 1, wherein the transmitting and receiving of data to/from the MS using the determined transmission/reception scheme further comprises:

allocating downlink resources and uplink resources for data transmission and reception to/from the MS by at least one of symmetrically and asymmetrically according to a required amount of resources of the system.

8. An apparatus for transmitting and receiving data in a Base Station (BS) of a communication system, the apparatus comprising:

a controller for determining a location of a Mobile Station (MS), and for determining a transmission/reception scheme for data transmission and reception to/from the MS according to the location of the MS; and

a transceiver for transmitting and receiving data to/from the MS using the determined transmission/reception scheme;

wherein the MS is located in at least one of a cell's inner region and a cell's outer region, and further wherein the cell's inner region has a radius that is adjusted according to an interference level between adjacent cells, and the cell's outer region is defined by excepting the cell's inner region from the entire cell region,

wherein, when the MS is located in the cell's outer region, the controller determines whether the MS transmits and receives a signal using a Relay Station (RS) located in the cell's inner region, and determines the transmission/reception scheme as a time division duplex scheme when the MS transmits and receives a signal using the RS, and

wherein a frequency applied to the time division duplex scheme between the MS and the RS is a second frequency, and a frequency applied to the time division duplex scheme between the BS and the RS is a first frequency which is different from the second frequency.

9. The apparatus of claim 8, wherein a frequency reuse factor used in the cell's inner region is 1 and a frequency reuse factor used in the cell's outer region is less than 1.

10. The apparatus of claim 8, wherein, when the MS is located in the cell's inner region, the controller determines the transmission/reception scheme as the time division duplex scheme and determines a frequency applied to the time division duplex scheme as the first frequency;

wherein the MS located in the cell's inner region uses physically consecutive subcarriers.

11. The apparatus of claim 8, wherein, when the MS does not transmit and receive a signal using the RS, the controller determines the transmission/reception scheme as a frequency division duplex scheme, and determines a frequency applied to the frequency division duplex scheme as the first frequency and the second frequency;

wherein the first frequency is used for data transmission to the MS, and the second frequency is used for data reception from the MS.

12. The apparatus of claim 11, wherein the MS, which does not transmit and receive a signal using the RS, uses physically inconsecutive subcarriers.

13. The apparatus of claim 11, wherein a frequency reuse factor of the MS which does not transmit and receive a signal using the RS comprises a value obtained by adaptively controlling a frequency reuse factor of the cell's outer region taking into account a ratio of interference between adjacent cells to signal strength of a frequency band currently unused in the cell.

14. The apparatus of claim 8, wherein the controller allocates downlink resources and uplink resources for data transmission and reception to/from the MS by at least one of symmetrically and asymmetrically according to a required amount of resources of the system.

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