US009439179B2

(12) **United States Patent**
Lu et al.

(10) **Patent No.: US 9,439,179 B2**
(45) **Date of Patent: Sep. 6, 2016**

(54) **METHOD AND APPARATUS FOR ASSIGNING RESOURCES IN A WIRELESS SYSTEM WITH MULTIPLE REGIONS**

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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 0 days.

(21) Appl. No.: **13/360,499**

(22) Filed: **Jan. 27, 2012**

(65) **Prior Publication Data**

US 2012/0120912 A1 May 17, 2012

Related U.S. Application Data

(62) Division of application No. 12/135,930, filed on Jun. 9, 2008, now Pat. No. 8,130,780.

(60) Provisional application No. 60/944,466, filed on Jun. 15, 2007.

(51) **Int. Cl.**
H04L 5/22 (2006.01)
H04W 72/04 (2009.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H04W 72/042*** (2013.01); ***H04L 5/0023*** (2013.01); ***H04L 5/0094*** (2013.01); *H04L 5/0037* (2013.01); *H04L 5/0044* (2013.01); *H04L 5/0064* (2013.01); *H04W 72/04* (2013.01)

(58) **Field of Classification Search**
CPC H04Q 7/20; H04W 72/04; H04W 72/042; H04L 5/0044
USPC 455/69, 7, 436; 370/465, 312, 328, 330, 370/447
See application file for complete search history.

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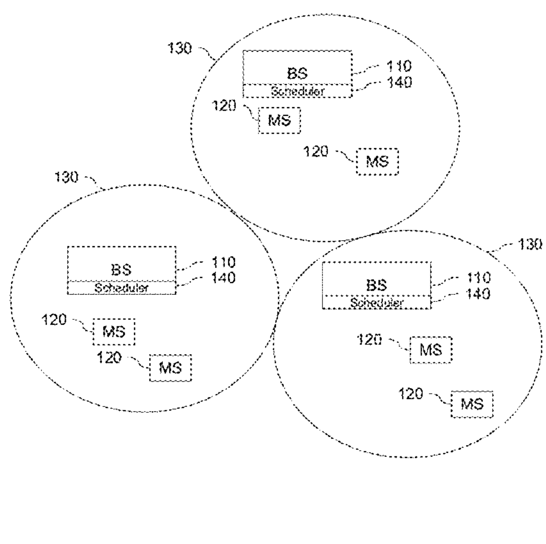
(57) **ABSTRACT**

A method and apparatus of signaling radio resource allocation in a wireless communication system includes transmitting at least one region boundary to a mobile station indicating a division of the time-frequency resources into at least two regions, determining a time-frequency resource assignment for the mobile station, transmitting an indication of the determined time-frequency resource to the mobile station in the same region as the determined time-frequency resource, and transmitting a packet to the mobile station using the physical time-frequency resources corresponding to the determined time-frequency resource.

20 Claims, 14 Drawing Sheets



(51) **Int. Cl.**

H04W 36/00	(2009.01)
H04W 4/00	(2009.01)
H04L 12/413	(2006.01)
H04L 5/00	(2006.01)

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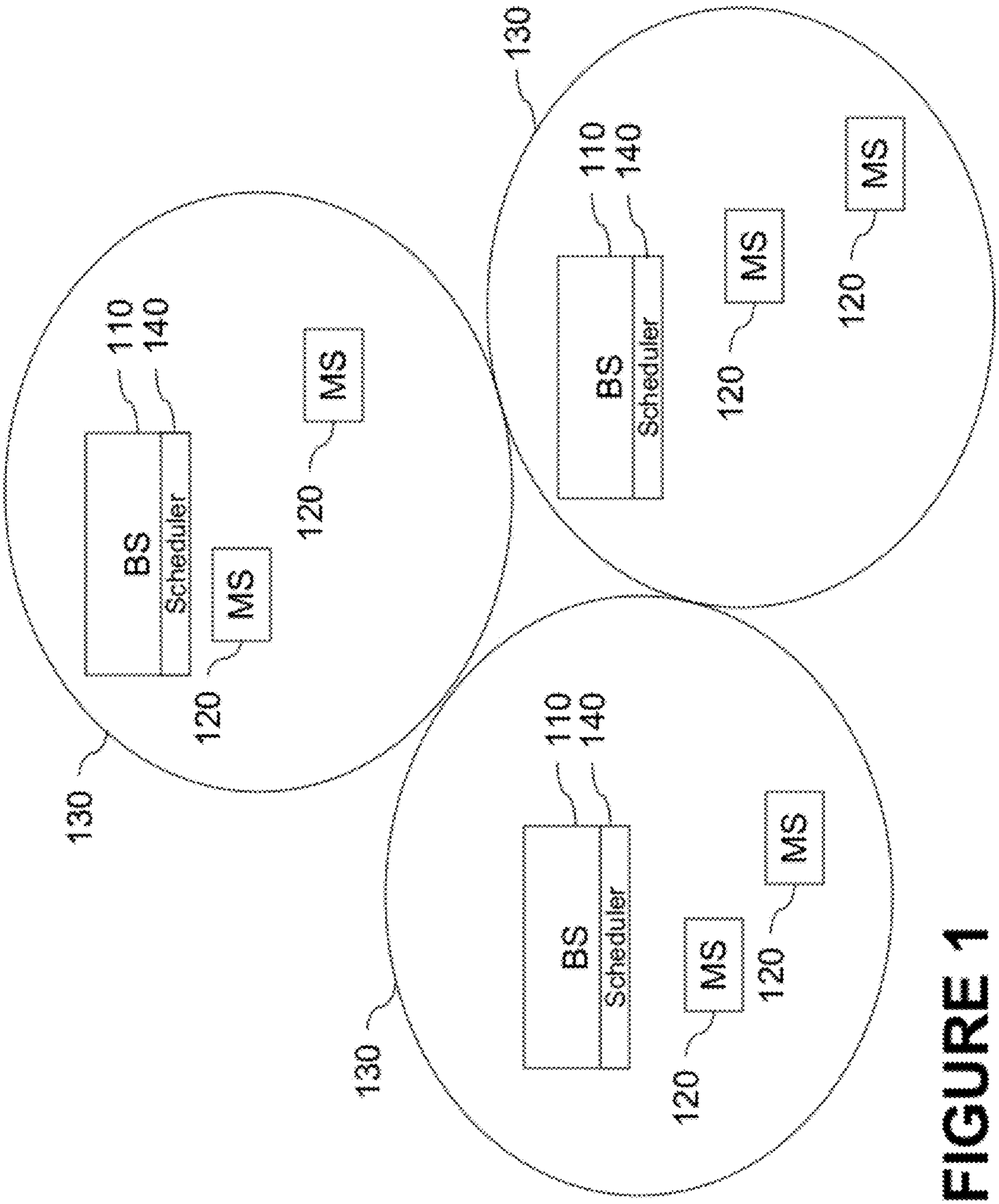
130
110
140
BS
Scheduler
MS
120
130
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140
BS
Scheduler
MS
120
130
110
140
BS
Scheduler
MS
120

FIGURE 1

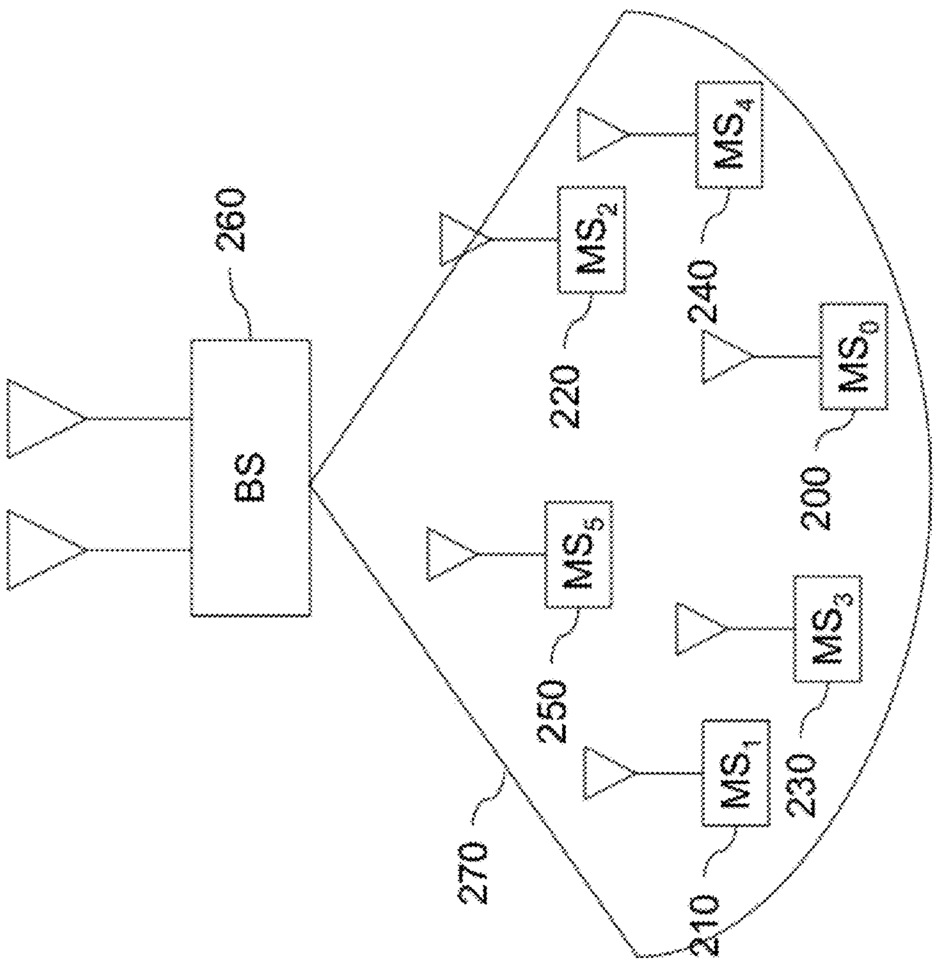
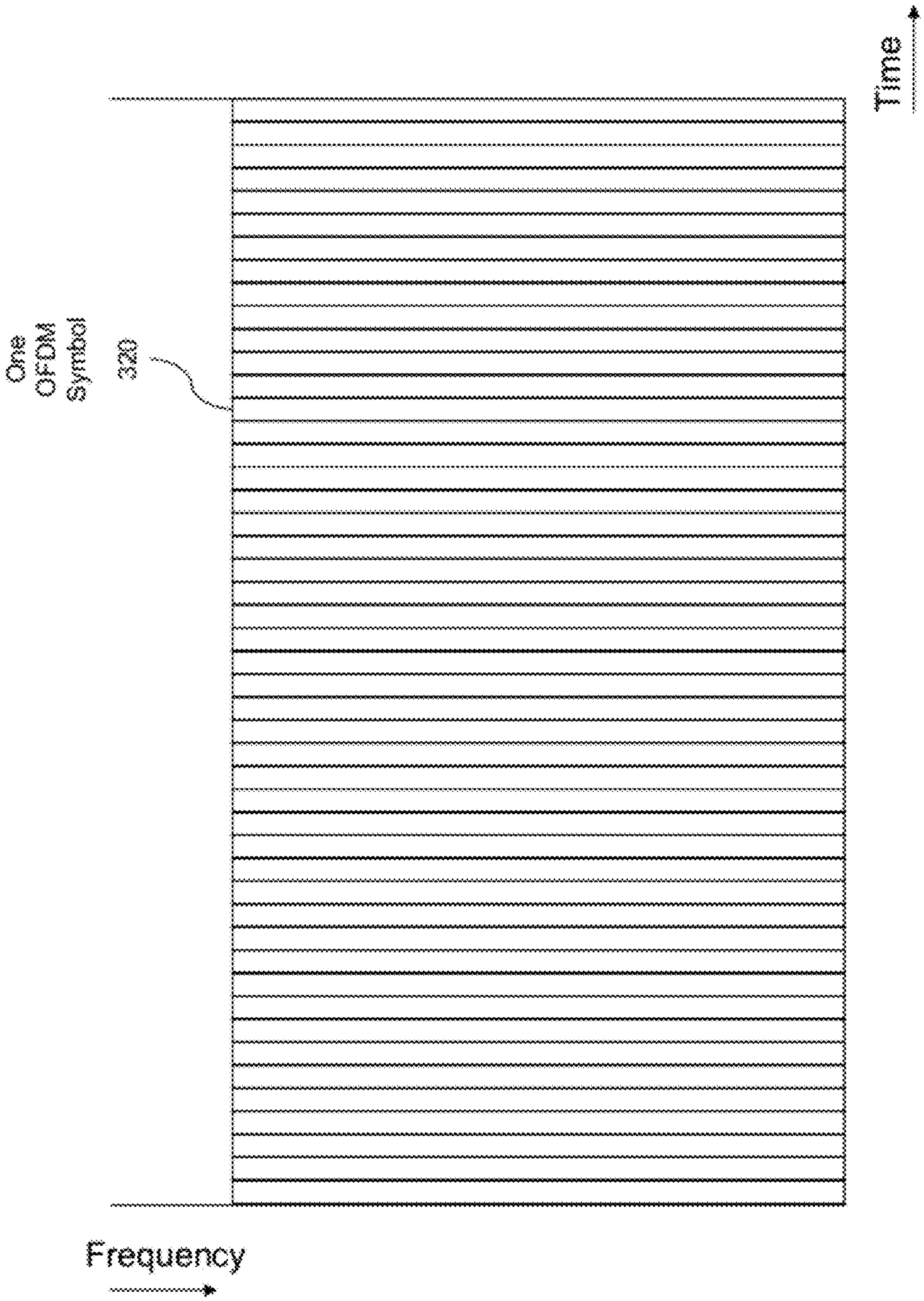


FIGURE 2



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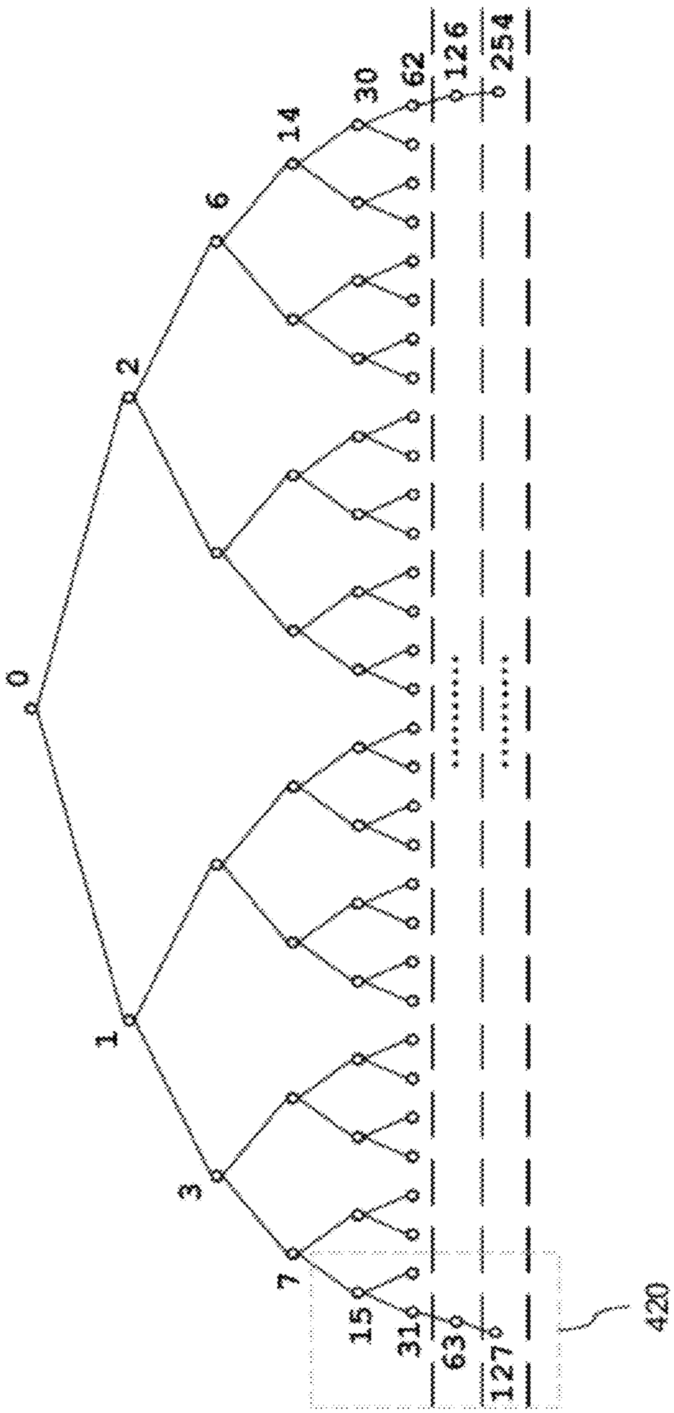


FIGURE 4

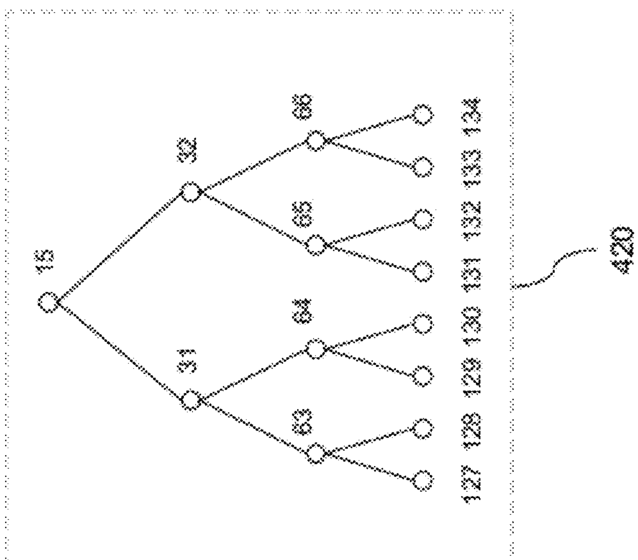


FIGURE 5

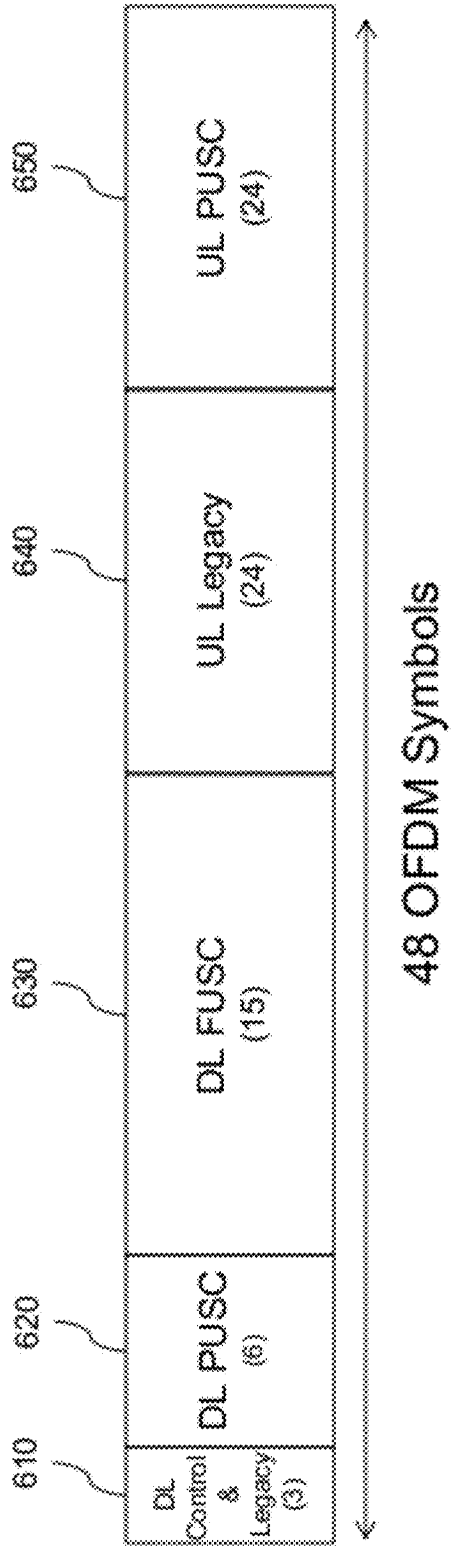
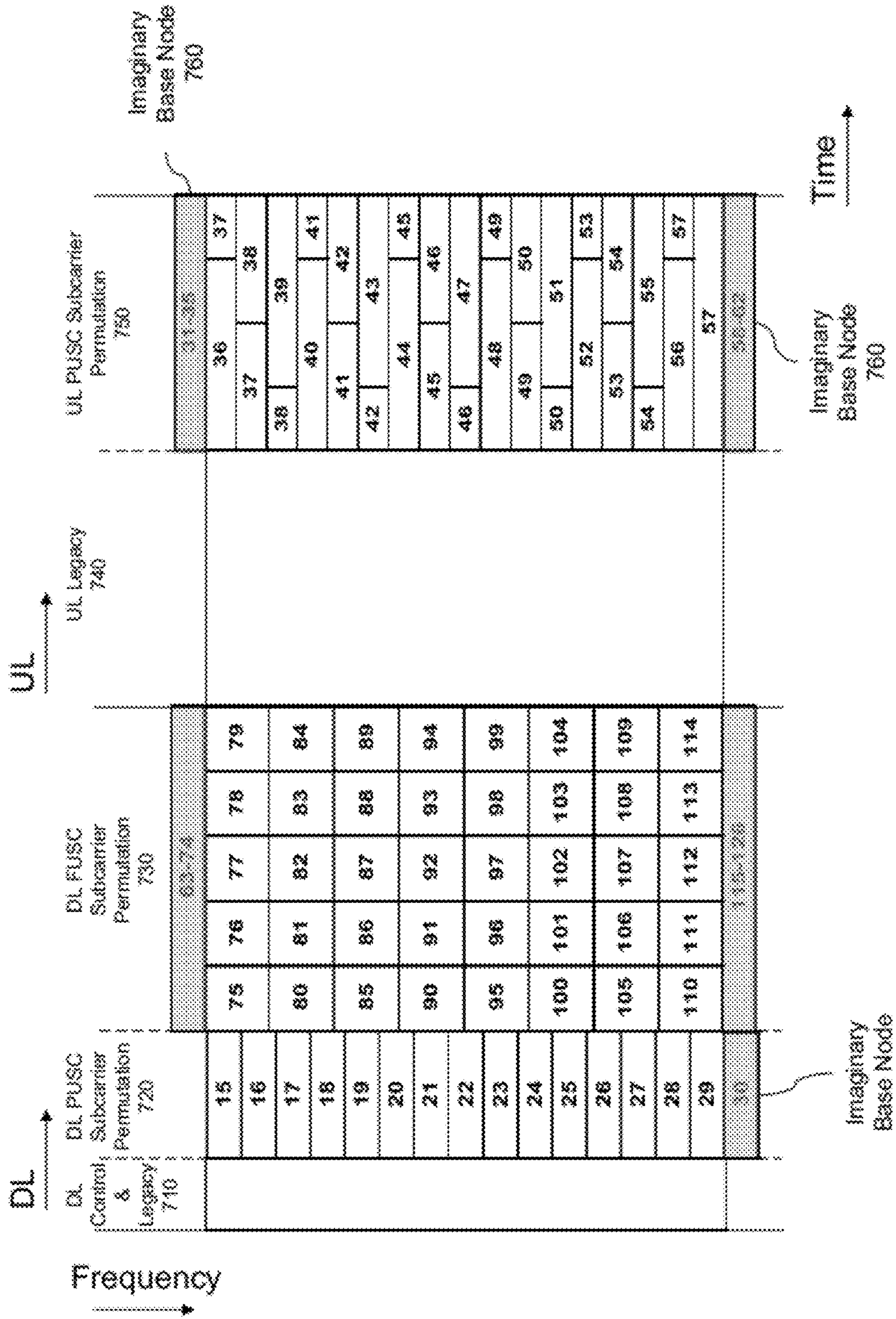

610
620
630
640
650
DL Control & Legacy (3)
DL PUSC (6)
DL FUSC (15)
UL Legacy (24)
UL PUSC (24)
48 OFDM Symbols

FIGURE 6



Frequency
Time
DL
UL
DL Control & Legacy 710
DL PUSC Subcarrier Permutation 720
DL FUSC Subcarrier Permutation 730
UL Legacy 740
UL PUSC Subcarrier Permutation 750
Imaginary Base Node 760
Imaginary Base Node 760
Imaginary Base Node 760

FIGURE 7

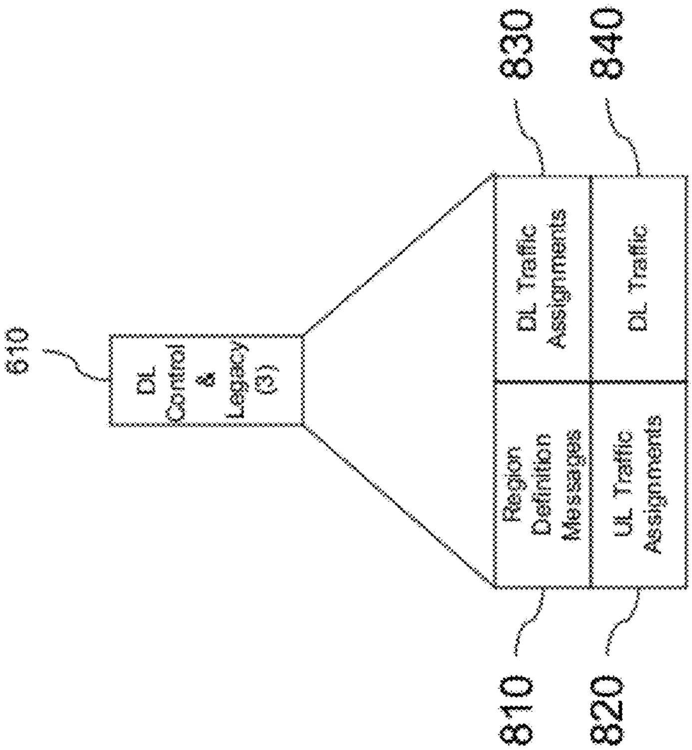

610
DL Control & Legacy (3)
Region Definition Messages
DL Traffic Assignments
UL Traffic Assignments
DL Traffic
810
820
830
840

FIGURE 8

910

Parameter Name	Number of Bits
Connection Identifier	16
Region Identifier	3
Channel Identifier	7
MIMO	4
Modulation/Coding	4

912 913 914 915 916

FIGURE 9

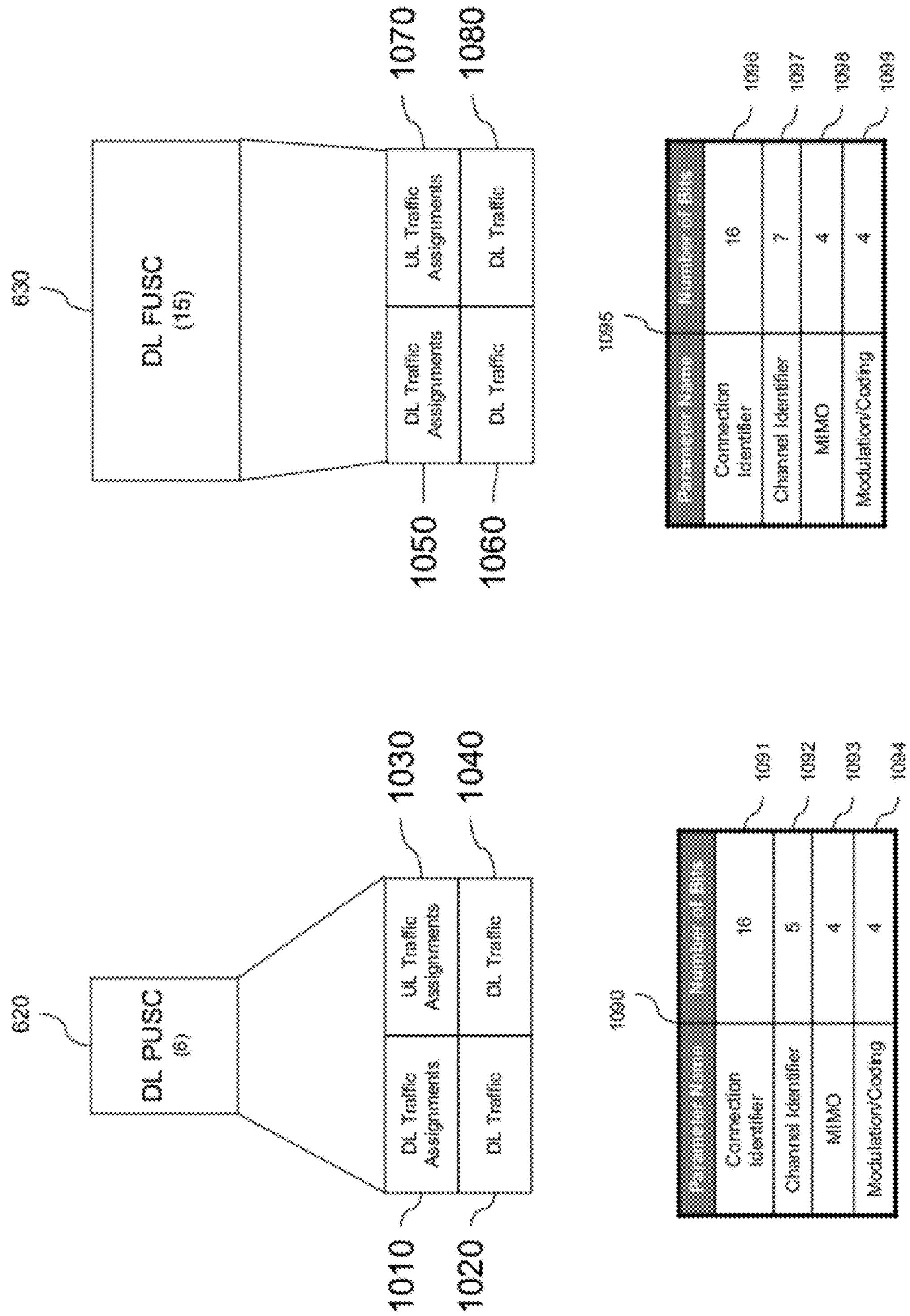

620
DL PUSC
(6)
DL Traffic Assignments
UL Traffic Assignments
DL Traffic
DL Traffic
1010
1020
1030
1040
630
DL FUSC
(15)
DL Traffic Assignments
UL Traffic Assignments
DL Traffic
DL Traffic
1050
1060
1070
1080
1090
Connection Identifier
16
Channel Identifier
5
MIMO
4
Modulation/Coding
4
1091
1092
1093
1094
1095
Connection Identifier
16
Channel Identifier
7
MIMO
4
Modulation/Coding
4
1096
1097
1098
1099

FIGURE 10

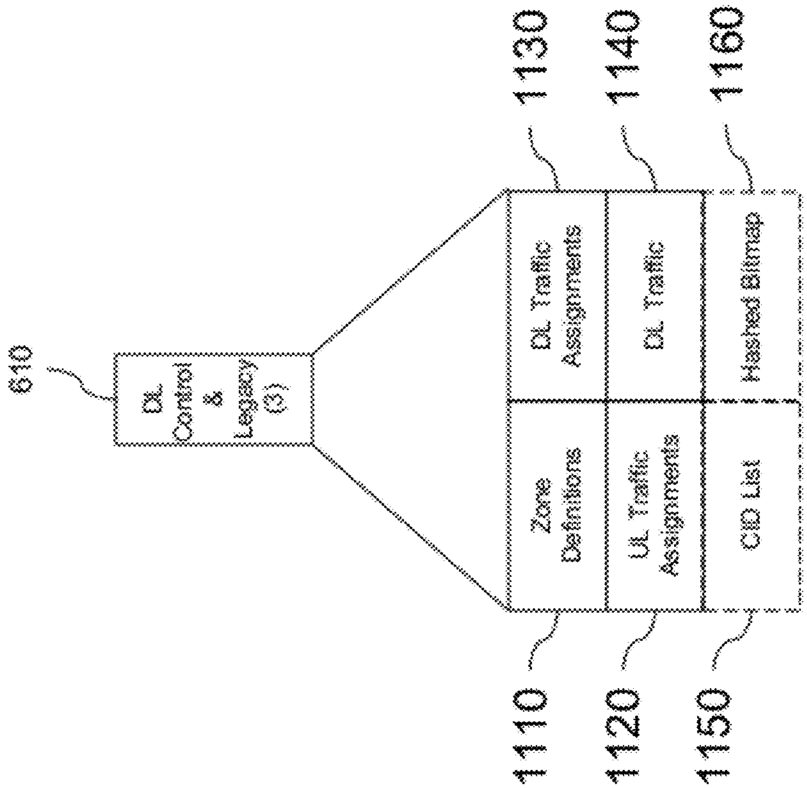

610
DL Control & Legacy (3)
Zone Definitions
DL Traffic Assignments
UL Traffic Assignments
DL Traffic
CID List
Hashed Bitmap
1110
1120
1150
1130
1140
1160

FIGURE 11

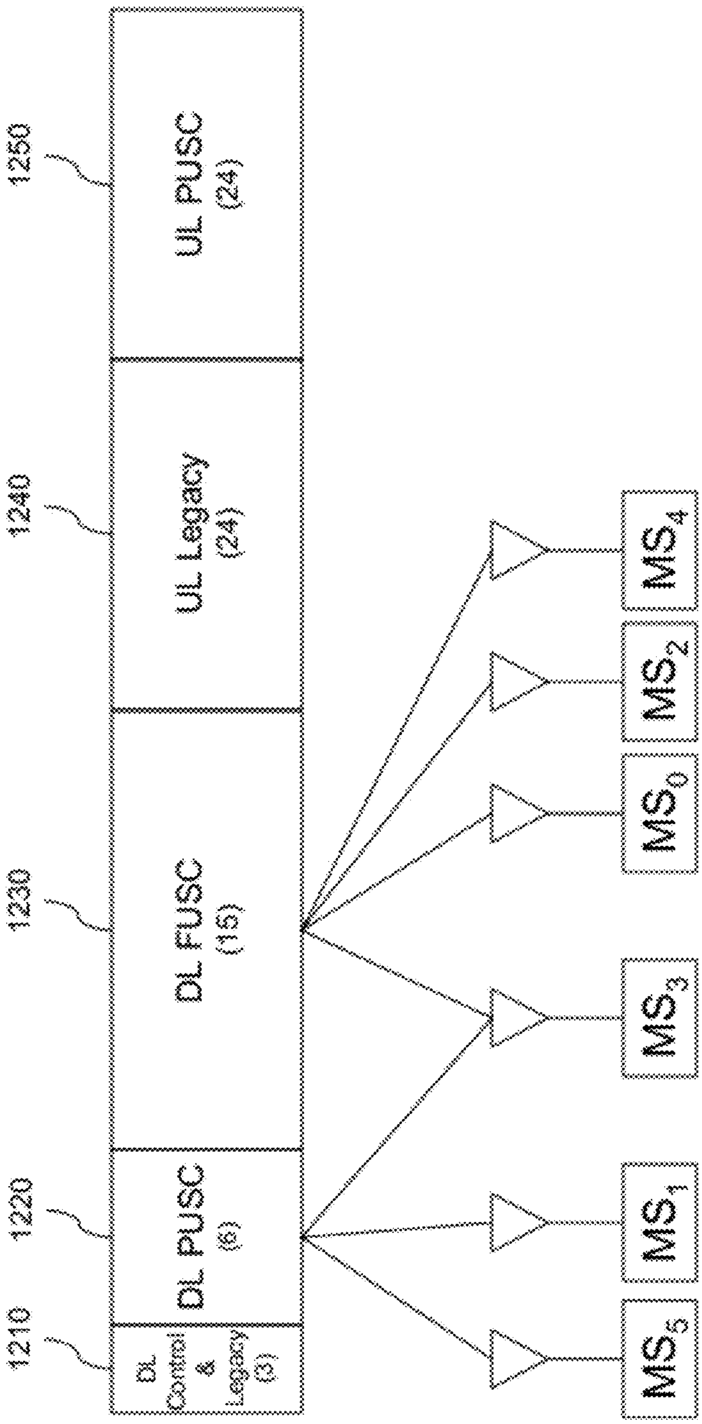
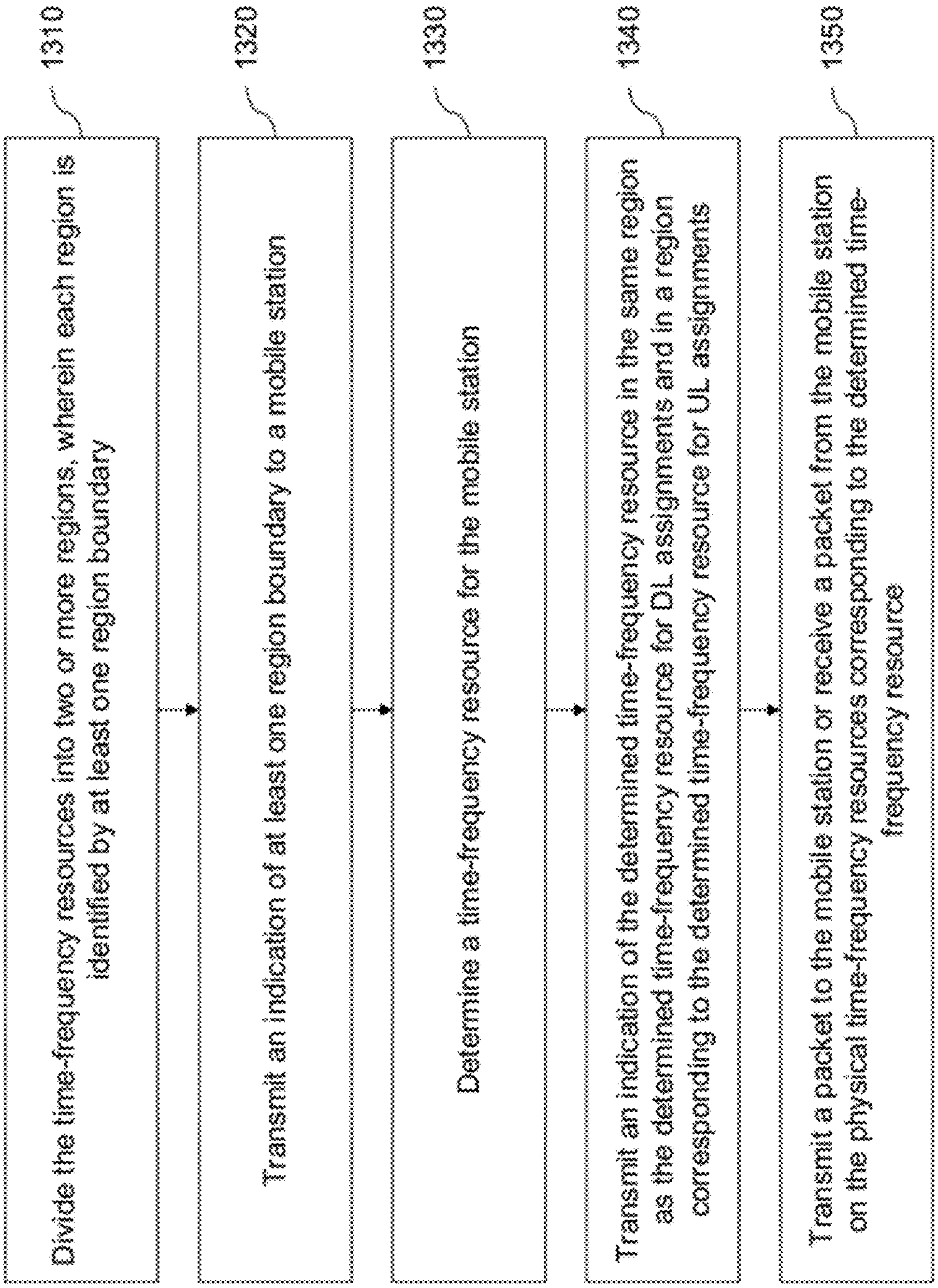

1210
DL Control & Legacy (3)
1220
DL PUSC (6)
1230
DL FUSC (15)
1240
UL Legacy (24)
1250
UL PUSC (24)
MS5
MS1
MS3
MS0
MS2
MS4

FIGURE 12



1310
Divide the time-frequency resources into two or more regions, wherein each region is identified by at least one region boundary
1320
Transmit an indication of at least one region boundary to a mobile station
1330
Determine a time-frequency resource for the mobile station
1340
Transmit an indication of the determined time-frequency resource in the same region as the determined time-frequency resource for DL assignments and in a region corresponding to the determined time-frequency resource for UL assignments
1350
Transmit a packet to the mobile station or receive a packet from the mobile station on the physical time-frequency resources corresponding to the determined time-frequency resource

FIGURE 13

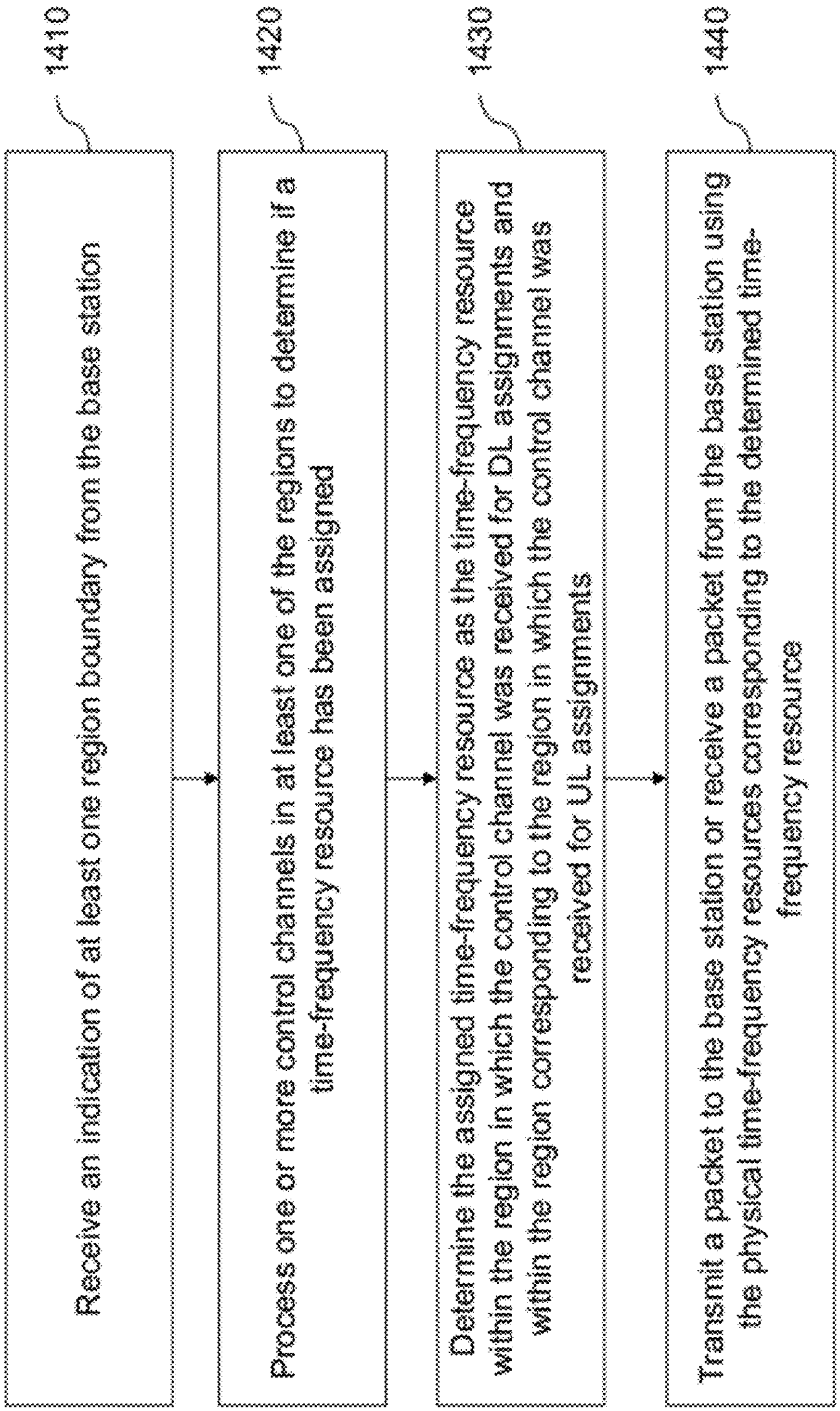

1410
Receive an indication of at least one region boundary from the base station
1420
Process one or more control channels in at least one of the regions to determine if a time-frequency resource has been assigned
1430
Determine the assigned time-frequency resource as the time-frequency resource within the region in which the control channel was received for DL assignments and within the region corresponding to the region in which the control channel was received for UL assignments
1440
Transmit a packet to the base station or receive a packet from the base station using the physical time-frequency resources corresponding to the determined time-frequency resource

FIGURE 14

METHOD AND APPARATUS FOR ASSIGNING RESOURCES IN A WIRELESS SYSTEM WITH MULTIPLE REGIONS

This application is a divisional patent application of U.S. Non-Provisional patent application Ser. No. 12/135,930 filed Jun. 9, 2008, which claims priority to U.S. Provisional Patent Application No. 60/944,466 filed Jun. 15, 2007, both of which are entitled "Method and Apparatus For Assigning Resources In A Wireless System with Multiple Regions" and are hereby incorporated herein by reference.

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is related to the following provisional U.S. patent applications, each of which is incorporated herein by reference: U.S. Provisional Patent Application No. 60/944,462 filed Jun. 15, 2007; U.S. Provisional Patent Application No. 60/944,469 filed Jun. 15, 2007; and U.S. Provisional Patent Application No. 60/944,477 filed Jun. 15, 2007. Further, this application is related to the following non-provisional patent applications, each of which is incorporated herein by reference: U.S. patent application Ser. No. 12/134,025, filed Jun. 5, 2008; U.S. patent application Ser. No. 12/135,599, filed Jun. 9, 2008; and U.S. patent application Ser. No. 12/135,916, filed Jun. 9, 2008.

FIELD OF THE INVENTION

The present invention generally relates to allocation of radio resources for transmission in a wireless communication system. Specifically, the present invention relates to a novel method of signaling the allocation of radio resources for transmission in, e.g., orthogonal frequency division multiplexing (OFDM) and orthogonal frequency division multiple access (OFDMA) communication systems and the resulting systems. Even more specifically, the present invention relates to improved efficiency in assigning time-frequency resources to one or more mobile stations.

BACKGROUND OF THE INVENTION

In an OFDMA communication system, the time-frequency resources of the system are shared among a plurality of mobile stations. Since different mobile stations have different channel conditions, quality of service (QoS) requirements, and capabilities, in some OFDMA communication systems, the time-frequency resources are divided into multiple regions to facilitate different types of transmissions. For time division duplex (TDD) systems, the time domain is divided into a downlink (DL) region and an uplink (UL) region. In some systems, the DL region and UL region are further divided into additional regions. For example, the DL may be divided into a partial usage of subcarriers (PUSC) region and a full usage of subcarriers (FUSC) region such as described by the IEEE 802.16 standard. Mobile stations assigned to the DL PUSC region experience less interference than mobile stations assigned to the DL FUSC region. Therefore, the DL PUSC region is often advantageous for mobile stations near the cell edge. The DL FUSC region utilizes the entire bandwidth in each sector, thereby maximizing the spectral efficiency. The DL FUSC region is advantageous for those mobile stations that can tolerate increased interference relative to what would be seen in the DL PUSC region and is therefore advantageous for mobile stations near the base station.

The base station assigns resources to mobile stations using an assignment message, which is transmitted as part of a control channel. The assignment message typically contains an indication of the assigned channel (channel identifier) and other parameters related to the transmission of a particular packet or series of packets. If multiple regions exist, it is known for the assignment message to explicitly indicate the region, either through additional bits in the overhead message or by embedding the region information in the channel identifier. An indication of the region, whether explicitly indicated or included as part of the channel identifier, creates additional control channel overhead. For wireless systems, it is essential that control channel overhead be carefully managed. Thus, there is a need for assigning time-frequency resources in a system with multiple regions without indicating the region.

SUMMARY OF THE INVENTION

In one aspect, the present invention provides for a method of assigning time-frequency resources in a wireless communication system. The method includes transmitting at least one region boundary to a mobile station, the at least one region boundary indicating a division of the time-frequency resources into at least two regions, and determining a time-frequency resource assignment for the mobile station. The method further includes transmitting an indication of the determined time-frequency resource assignment to the mobile station in a same region as the determined time-frequency resource, and transmitting a packet to the mobile station using the physical time-frequency resources corresponding to the determined time-frequency resource.

In another aspect, the present invention provides for a method of receiving a radio resource assignment in a wireless communication system including receiving at least one region boundary indicating a division of the radio resources into at least two regions, processing a control channel in a first one of the at least two regions, and receiving a radio resource assignment in the first one of the at least two regions. The method further includes receiving a communication packet on the physical radio corresponding to the received time-frequency resource assignment in the first one of the at least two regions.

In yet another aspect, the present invention provides for a base station. The base includes a microprocessor and a computer readable medium storing programming for execution by the processor. The programming includes instructions to define a first region and a second region of time-frequency resources, including defining a boundary between the first region and the second region of time-frequency resources direct the transmission of the definition of a first region and a second region of time-frequency resources to a mobile station during the first region of time-frequency resources. The programming includes further instructions to define a time-frequency resource assignment for the mobile station, and direct the transmission of the definition of the time-frequency resource assignment to the mobile station during the first region of time-frequency resources; and direct the transmission of a communication packet to the mobile station using the physical time-frequency resources corresponding to the determined time-frequency resources during the first region of time-frequency resources.

An advantageous feature of the present invention is that signaling overhead can be lessened by transmitting a time-frequency resource assignment and a time-resource region definition in the actual time-resource region.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** illustrates a wireless communications network;

FIG. **2** illustrates a base station and several mobile stations from a wireless communications network;

FIG. **3** illustrates an exemplary set of OFDMA time-frequency radio resources;

FIGS. **4-5** illustrate an example channel tree;

FIG. **6** illustrates the division of the time domain into downlink control and legacy, downlink PUSC, downlink FUSC, uplink legacy, and uplink PUSC regions;

FIG. **7** illustrates an exemplary base node numbering scheme for the regions defined in FIG. **6**;

FIG. **8** illustrates exemplary information transmitted in a downlink control and legacy region according to one embodiment of the present invention;

FIG. **9** is an exemplary assignment message;

FIG. **10** illustrates exemplary information transmitted in each of exemplary downlink regions according to one embodiment of the present invention;

FIG. **11** illustrates exemplary information transmitted in a downlink control and legacy region according to one embodiment of the present invention;

FIG. **12** illustrates exemplary assignment of preferred regions;

FIG. **13** is a flow chart for exemplary base station operation; and

FIG. **14** is a flow chart for exemplary mobile station operation.

DETAILED DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS

The present disclosure can be described by the embodiments given below. It is understood, however, that the embodiments below are not necessarily limitations to the present disclosure, but are used to describe a typical implementation of the invention.

The present invention provides a unique method and apparatus for assigning resources in a wireless system with multiple regions. It is understood, however, that the following disclosure provides many different embodiments, or examples, for implementing different features of the invention. Specific examples of components, signals, messages, protocols, and arrangements are described below to simplify the present disclosure. These are, of course, merely examples and are not intended to limit the invention from that described in the claims. Well known elements are presented without detailed description in order not to obscure the present invention in unnecessary detail. For the most part, details unnecessary to obtain a complete understanding of the present invention have been omitted inasmuch as such details are within the skills of persons of ordinary skill in the relevant art. Details regarding control circuitry described herein are omitted, as such control circuits are within the skills of persons of ordinary skill in the relevant art.

FIG. **1** is a wireless communications network comprising a plurality of base stations (BS) **110** providing voice and/or data wireless communication service to respective pluralities of mobile stations (MS) **120**. A BS is also sometimes referred to by other names such as access network (AN), access point (AP), Node-B, etc. Each BS has a corresponding coverage area **130**. Referring to FIG. **1**, each base station includes a scheduler **140** for allocating radio resources to the mobile stations. Exemplary wireless communication systems include, but are not limited to, Evolved Universal Terrestrial Radio Access (E-UTRA) networks, Ultra Mobile Broadband (UMB) networks, IEEE 802.16 networks, and other OFDMA based networks. In some embodiments, the network is based on a multiple access scheme other than OFDMA. For example, the network can be a frequency division multiplex access (FDMA) network wherein the time-frequency resources are divided into frequency intervals over a certain time interval, a time division multiplex access (TDMA) network wherein the time-frequency resources are divided into time intervals over a certain frequency interval, and a code division multiplex access (CDMA) network wherein the resources are divided into orthogonal or pseudo-orthogonal codes over a certain time-frequency interval.

FIG. **2** illustrates one base station and several mobile stations from the wireless communications network of FIG. **1**. As is known in the art, the coverage area, or cell, of a base station **260** can be divided into, typically, three sub-coverage areas or sectors, one of which is shown **270**. Six exemplary mobile stations **200**, **210**, **220**, **230**, **240**, **250** are in the shown coverage area. The base station typically assigns each mobile station one or more connection identifiers (CID) (or another similar identifier) to facilitate time-frequency resource assignment. The CID assignment can be transmitted from the base station to the mobile station on a control channel, can be permanently stored at the mobile station, or can be derived based on a mobile station or base station parameter.

FIG. **3** schematically illustrates an exemplary set of OFDMA time-frequency radio resources. In OFDMA systems, the time-frequency resources are divided into OFDM symbols and OFDM subcarriers for allocation to respective mobile stations by a base station scheduler. In an exemplary OFDMA system, the OFDM subcarriers are approximately 10 kHz apart and the duration of each OFDM symbol is approximately 100 μsec. FIG. **3** illustrates one 5 msec frame of an OFDMA system, such as that defined by the IEEE 802.16e standard. Referring to FIG. **3**, in this exemplary embodiment, resources in the time domain (x-axis) are divided into 48 OFDM symbols **320**. In the frequency domain (y-axis), the resources are divided into multiple subchannels (not shown), wherein the size of the subchannel depends on the subcarrier permutation scheme, as will be discussed in more detail later.

FIGS. **4-5** illustrate an exemplary channel tree, which is used to logically illustrate the division of time-frequency resources. Referring to FIG. **4**, the main parent node, labeled as node **0**, represents the entire set of time-frequency resources. In this channel tree, each node is sub-divided into two nodes. Therefore, the main parent node, node **0**, is sub-divided into parent nodes **1** and **2**. Parent nodes **1** and **2** each represent fifty percent of the entire set of time-frequency resources. The lowest level nodes (nodes **127**, **128**, **129**, . . . , **254**) are referred to as base nodes. A base node represents the smallest time-frequency resource that can be allocated to a mobile station using the channel tree. The collection of nodes under parent node **15**, enclosed by **420**, is enlarged and depicted in FIG. **5**. Referring to FIG. **5**, parent node **15** is divided into parent nodes **31** and **32**. Parent node **31** is divided into parent nodes **63** and **64**, and parent node **32** is divided into parent nodes **65** and **66**. Parent node **63** is divided into base nodes **127** and **128**, parent node **64** is divided into base nodes **129** and **130**, parent node **65** is divided into base nodes **131** and **132**, and parent node **66** is divided into base nodes **133** and **134**.

Each channel tree node corresponds to a physical portion of the time-frequency resources. For example, consider an OFDMA system containing 384 useful subcarriers, indexed **0** to **383**. In one exemplary channel tree configuration, node **0** corresponds to subcarriers **0** through **383**, node **1** corresponds to subcarriers **0** through **191**, and node **2** corresponds to subcarrier **192** through **384**. In another exemplary channel tree configuration, node **0** corresponds to subcarriers **0** through **383**, node **1** corresponds to subcarriers **0**, **2**, **4**, . . . , **382**, and node **2** corresponds to subcarrier **1**, **3**, **5**, . . . , **383**. The mapping of logical channel tree nodes to physical time-frequency resources may change with time and may be different in different sectors. Any mapping of logical channel tree nodes to physical time-frequency resources is possible, as long as the mapping scheme is known at the base station and the mobile station. The mapping scheme can be stored at a base station and a mobile station, transmitted to a mobile station from a base station, determined at a mobile station based on a parameter received from a base station, combinations of the above, and the like.

FIG. **6** illustrates the division of the time domain into three downlink regions **610**, **620**, and **630** and two uplink regions **640**, **650**. Referring to FIG. **3**, note that there are 48 OFDM symbols in each 5 msec frame. First DL region **610** is denoted the DL control and legacy region and preferably has a duration of 3 OFDM symbols. Second DL region **620** is denoted the DL PUSC region and preferably has a duration of 6 OFDM symbols. Third DL region **630** is denoted the DL FUSC region and preferably has a duration of 15 OFDM symbols. First UL region **640** is denoted the UL legacy region and has a duration of 24 OFDM symbols in the illustrated example. Second UL region **650** is denoted the UL PUSC region and has a duration of 24 OFDM symbols in the illustrated example. Note that the guard interval between the DL and UL regions is ignored for illustration, although those skilled in the art will recognize the need and typical configuration of a guard region in the frame. Referring to FIG. **6**, the three DL regions contain 24 OFDM symbols collectively, and the two UL regions contain 24 OFDM symbols collectively. As will be discussed in more detail later, preferred embodiments of the invention provide a new control mechanism. Some mobile stations, denoted new mobile stations, in the system will be able to interpret this new control mechanism while other mobile stations, denoted legacy mobile stations, in the system will not be able to interpret this new control mechanism. In FIG. **6**, the legacy mobile stations will be served in DL legacy region **610** and UL legacy region **650**, as is known in the art.

Within each region, subcarrier permutations are defined by the base station. DL PUSC, DL FUSC, and UL PUSC are exemplary subcarrier permutations schemes defined in the IEEE 802.16 standard. Other permutation schemes are also defined in the IEEE 802.16 standard; DL PUSC, DL FUSC, and UL PUSC are merely used to illustrate the invention. Any subcarrier permutation scheme could be used in each region. For exemplary DL PUSC region **620**, there are preferably 360 data subcarriers divided into 15 subchannels, wherein each subchannel has 24 subcarriers. For DL PUSC region **620**, the base station preferably assigns an even number of OFDM symbols for each subchannel. For exemplary DL FUSC region **630**, there are preferably 384 data subcarriers divided into 8 subchannels, wherein each subchannel has 48 subcarriers. For exemplary UL PUSC region **650**, there are preferably 408 subcarriers (data plus pilot) divided into 17 subchannels, wherein each subchannel has 24 subcarriers (16 data plus 8 pilot). For UL PUSC, the number of OFDM symbols for each subchannel is preferably a multiple of 3.

Once regions are defined, the base station transmits assignment messages to mobile stations to indicate particular time-frequency resource assignments. There are several ways for allocating radio resources. FIG. **7** provides an exemplary technique for allocating radio resources, wherein the time-frequency resources are divided into base nodes and a channel tree structure, such as the channel tree structure of FIGS. **4**-**5**, is used to indicate time-frequency resource assignments. Referring to FIG. **7**, unique channel trees are preferably used in each region. DL PUSC region **720** has base nodes numbered **15**-**30**, DL FUSC region **730** has base nodes **63**-**126**, and UL PUSC region **750** has base nodes numbered **31**-**62**. Some of the base nodes are imaginary base nodes **760**, wherein imaginary base nodes **760** are used to maintain a tree structure and do not correspond to any physical time-frequency resources. DL control and legacy region **710** and UL legacy region **740** are not shown to have channel trees, since legacy mobile stations will typically not be able to interpret the channel tree, although a channel tree can be defined in these regions for the mobile stations that do understand the channel tree in order to multiplex new mobile stations with legacy mobile stations. Within each region, a channel tree is constructed with the size of the channel tree dependent on the size of the region and the size of a base node. These parameters determine the number of base nodes in the region, and therefore the overall size of the channel tree. For example, the channel tree in DL PUSC region **720** is 5 levels "deep" (referring back to FIG. **4**, it can be seen that parent node **0** is at a first level, nodes **1** and **2** are at a second level, nodes **3**-**6** are at a third level, nodes **7**-**14** are at a fourth level, and nodes **15**-**30** are at a fifth level), and can be indexed with 5 bits. The channel tree in DL FUSC region **730** has 7 levels and can be index with 7 bits.

To establish the regions of FIGS. **6**-**7**, the base station transmits one more region definition messages to the mobile stations. FIG. **8** provides an exemplary location for transmitting the region definition messages. Referring to FIG. **8**, DL control and legacy region **610** preferably contain four types of information (as well as other information not shown). First, DL control and legacy region **610** contains one or more region definition messages **810**, one or more DL traffic assignments **830**, one or more UL traffic assignments **820**, and one or more DL traffic transmission **840**. Region definition messages **810** may contain one or more of the following: region starting point, region ending point, region width, and region subcarrier permutation. Region definitions can be dependent on other each other or can be independent. For example, referring to FIGS. **6**-**7**, a base station can transmit an indication of OFDM symbol **3** and an indication of the DL PUSC subcarrier permutation using a region definition message **810** to define DL PUSC region **720**. Likewise, a base station and can transmit an indication of OFDM symbol number **9** and an indication of the DL FUSC subcarrier permutation using a region definition message **810** to define DL FUSC region **730**. The mobile stations preferably determine the ending point of DL PUSC region **720** based on the starting point of DL FUSC region **730**. In other embodiments, the starting point of one region can be determined based upon the ending point of an adjacent region, as will be apparent to those skilled in the art. Alternatively, the base station can include the number of OFDM symbols in each region definition message **810** to eliminate the interdependence. Multiple regions can be defined in each region definition message **810** or each region definition message **810** can include one region definition.

Once a base station establishes regions, the base station transmits DL traffic assignments **830** and UL traffic assignments **820** in order to allocate time-frequency resources to the mobile stations. The assignments are typically generated in a base station scheduler (such as base station scheduler **140** illustrated in FIG. **1**). FIG. **9** provides fields of an exemplary assignment message **910**, which can be either DL traffic assignments **830** or UL traffic assignments **820**. Referring to FIG. **9**, the assignment message **910** preferably contains a 16 bit field indicating connection identifier **912** of the mobile station, wherein connection identifier **912** corresponds to one or more mobile stations. Typically, connection identifier **912** corresponds to a single mobile station, but in the case of a multi-cast or broadcast transmission, connection identifier **912** could correspond to several mobile stations. Note that, in some embodiments, connection identifier **912** is not included in assignment message **910**, but is rather used to scramble assignment message **910**. In this way, only the intended mobile station can correctly decode assignment message **910**. Assignment message **910** also preferably contains a 3 bit region identifier field **913** and a 7 bit channel identifier field **914**, wherein the region identifier corresponds to a region and the channel identifier corresponds to one of the nodes from a channel tree. Note that, in this example, channel identifier field **912** is preferably set to the maximum number of bits needed to represent the channel trees of FIG. **7**, in order to have a constant assignment message **910** size. Assignment message **910** preferably also contains a multiple input multiple output (MIMO) field **915** for indicating parameters related to the MIMO scheme. MIMO field **915** is used to indicate the type of MIMO parameters used by a base station, such as precoding scheme, antenna configuration, and the like. Finally, assignment message **910** may contain a four bit field indicating modulation and coding **916** of the packet. It should be clear to those skilled in the art that there are a variety of ways of communicating the parameters delineated in FIG. **9**. While one or more of these parameters are preferably communicated to the mobile station, not all parameters are used in all embodiments, and some parameters can be omitted based on the value of other parameters.

As an illustrative example of a DL traffic assignment **830**, an exemplary base station can assign a mobile station with CID '0100100101010101' to channel tree node **29** (binary '0011101') in the DL PUSC region **720** (the DL PUSC region **720** is the second region where '000' corresponds to the first region, '001' corresponds to the second region, etc) using the assignment message **910**. To make this assignment, the base station sets Connection Identifier field **912** to '0100100101010101', Region Identifier field **913** to '001', Channel Identifier field **914** to '0011101', and MIMO field **915** and modulation/coding field **916** to the appropriate values as is well known in the art.

DL traffic assignments **830** and UL traffic assignments **820** represent a significant portion of the control channel overhead of the system. Since reducing control channel overhead is important for wireless communication systems, FIG. **10** illustrates a mechanism for reducing the control channel overhead by eliminating some of the bits in the assignment message **910**. Referring to FIG. **10**, DL traffic assignments **1010** and **1050** are moved from DL control legacy region **610** to each of DL PUSC region **620** and DL FUSC region **630**, respectively. In this way, the base station does not need to transmit an indication of the region to the mobile station, since assignments for each region are carried within the region. In addition, the number of bits for indicating the channel identifier can be exactly what is needed to represent the channel tree in that specific region. Exemplary assignment messages **1090** and **1095** for DL PUSC **620** region and DL FUSC **630** region are provided to illustrate these advantages. Referring to FIG. **10**, assignment message **1090** does not include a region identifier and includes 5 bits for indicating the channel identifier **1092**. Assignment message **1095** does not include a region identifier and includes 7 bits for indicating the channel identifier **1097**. Mobile stations determine the size of the assignment message in the respective region based on the parameters with fixed size (connection identifier, MIMO, Modulation/Coding) plus the parameters with a size that is dependent on the region definition (channel identifier). In some embodiments, certain fields are only included for certain region types. For example, the MIMO field could be omitted for DL PUSC regions.

Assignments for uplink transmissions are carried on the downlink. Therefore, each uplink region must be associated with a downlink region. For example, assignments for UL PUSC region **650** can be transmitted in DL FUSC region **630**. These assignments can be made using the UL traffic assignments **1070** for DL FUSC region **630**. The term corresponding regions will be used to denote the relationship between a DL region in which a UL assignment is made and a UL region in which a UL assignment is valid.

If assignment messages are located within the same region as the data transmission, the mobile station must decode assignment messages in each region in order to determine if it is assigned a time-frequency resource. This is not as desirable as the case where assignment message are transmitted at the beginning of the frame, since this approach does not allow a mobile station to enter a reduced power mode after decoding the assignment message. To mitigate this problem, two solutions are proposed (at a beginning of a frame). FIG. **11** illustrates a preferred solution.

Referring to FIG. **11**, the base station includes a CID list **1150** or a hashed bitmap **1160** in the DL control and legacy region **610**. The mobile stations determine if they are assigned a time-frequency resource in the current frame by processing either the CID list **1150** or the hashed bitmap **1160**. The CID list **1150** may only include the N least significant bits of each CID. When the CID list **1150** is transmitted in the DL control and legacy region **610**, the mobile stations determine if their CID matches a CID from the CID list **1150**. If so, the mobile stations process the DL traffic assignments in each region. If not, the mobile station can enter a reduced power state until the next frame. When the hashed bitmap **1160** is transmitted in DL control and legacy region **610**, the mobile station apply a hashing algorithm to their CID and if a match is determined with one or more values in hashed bitmap **1160**, the mobile station process the DL traffic assignments in each region. If not, the mobile station can enter a reduced power state until the next frame. Also shown in FIG. **11** are: field **1110**, where zone definitions can be provided, field **1120**, where UL traffic assignments are provided, field **1130** where DL traffic assignments are provided, and field **1140** wherein is provided the DL traffic.

FIG. **12** illustrates an alternative solution to that illustrated in FIG. **11**. In some embodiments, the overhead associated with CID list **1150** or hashed bitmap **1160** is not desirable. Therefore, each mobile station is assigned one or more preferred regions in this embodiment. The preferred region assignment is typically transmitted using higher layer signaling and can be a region identifier, region type, and the like. For example, a base station can indicate to a mobile station that its preferred region is "DL PUSC." Alternatively, a base can indicate to a mobile station that its preferred region is '001', where '001' corresponds to the second region. FIG. **12** provides exemplary assignments of preferred regions to multiple mobile stations. Referring to FIG. **12**, MS_5 and MS_1 are each assigned DL PUSC region **1220** as their respective preferred region. MS_3 is assigned both DL PUSC region **1220** and DL FUSC region **1230** as its preferred regions. MS_0, MS_2, and MS_4 are each assigned DL FUSC region **1230** as their respective preferred region. Once the mobile stations are assigned a preferred region, the mobile stations then monitor the DL traffic assignments only in their respective preferred region(s). In some embodiments, each mobile station monitors the DL control and legacy region **1210**, which allows base station to make assignments in any region using the normal assignment message, such as assignment message **910**.

Once preferred regions are established as in FIG. **12**, a base station can relocate an entire set of assignment messages to a new region, denoted the control region. Then, the mobile station processes the assignment messages under the hypothesis that the message has the fields associated with its preferred region(s). Again, in some embodiments, some of the field lengths are determined from the region length. If the mobile station is able to successfully decode the assignment message, it knows that the region for which the assignment is valid is the preferred region of the mobile station. If a mobile station has more than one preferred region, the base station can differentiate between the regions using unique scrambling, if the number of bits in the assignment messages for the multiple regions are the same. Exemplary UL region is preferably divided into a 24 symbol legacy UL region **1240** and a 24 symbol UL PUSC region **1250**. One skilled in the art will recognize other configurations and permutations for UL region are equally possible.

FIG. **13** is a flow chart for exemplary base station operation. At step **1310**, a base station divides time-frequency resources into two or more regions, wherein each region is identified by at least one region boundary. The region boundaries can be an OFDM symbol number, an offset from another region, and the like. At step **1320**, the base station transmits an indication of at least one region boundary to a mobile station. The indication can be sent on a control channel. Note that some region boundaries can be known at the mobile station or derived at the mobile station based on a parameter received from the base station. At step **1330**, the base station determines a time-frequency resource assignment for a mobile station. The assignment is typically determined by a base station scheduler and can be an index to a channel tree, an explicit indication of OFDM symbols and OFDM subchannels, and the like. At step **1340**, the base station transmits an indication of the determined time-frequency resource in the same region as the determined time-frequency resource for DL assignments and in a region corresponding to the determined time-frequency resource for UL assignments. At step **1350**, the base station transmits a packet to the mobile station or receives a packet from the mobile station on the physical time-frequency resources corresponding to the determined time-frequency resource.

FIG. **14** is a flow chart for exemplary mobile station operation. At step **1410**, the mobile station receives an indication of at least one region boundary from the base station. At step **1420**, the mobile station processes one or more control channels in at least one of the regions to determine if a time-frequency resource has been assigned. The control channels can be DL assignment or UL assignments as previously described. At step **1430**, the mobile station determines the assigned time-frequency resource as the time-frequency resource within the region in which the control channel was received for DL assignments and within the region corresponding to the region in which the control channel was received for UL assignments. At step **1440**, the mobile station transmits a packet to the base station or receives a packet from the base station using the physical time-frequency resources corresponding to the determined time-frequency resource.

One skilled in the art will recognize that the terms base station, mobile station, and the like are intentionally general terms and are not to be interpreted as limited to a particular system, protocol, communications standard, or the like. Those skilled in the art will also recognize that the various methods and steps described herein can be accomplished by a radio device, such as a base station including either a general purpose or a special purpose processor appropriately programmed to accomplish, e.g., the presently described methods and steps. The base station preferably includes storage medium for storing programming instructions for the processor.

Although specific embodiments of the present invention have been described, it will be understood by those of skill in the art that there are other embodiments that are equivalent to the described embodiments. Accordingly, it is to be understood that the invention is not to be limited by the specific illustrated embodiments, but only by the scope of the appended claims.

What is claimed is:

1. A method of receiving resource assignments in a wireless communication system, the method comprising:

receiving at least one region boundary indicating a division of radio resources into at least two regions;

receiving, by a mobile station, a radio resource assignment in a downlink partial usage of subcarriers (PUSC) region of a frame, the frame comprising at least the downlink PUSC, a downlink full usage of subcarriers (FUSC), and a control channel region, at least one data burst being allocated in each of the downlink PUSC and the downlink FUSC; and

receiving, by the mobile station, a data packet on a physical time-frequency resource in the downlink PUSC region of the frame, wherein the radio resource assignment assigns the physical time-frequency resource in the downlink PUSC region of the frame to carry the data packet to the mobile station, and wherein the data packet and the radio resource assignment are received in the same downlink PUSC region of the same frame and the radio resource assignment excludes identifiers (IDs) that identify the downlink PUSC region carrying the data packet, wherein the radio resource assignment comprises a multiple-input and multiple-output (MIMO) parameter identifier.

2. The method of claim **1**, further comprising receiving an indication of at least one preferred region.

3. The method of claim **2**, further comprising processing control channel resources only in the regions corresponding to the at least one preferred region.

4. The method of claim **1**, wherein the wireless communication system is an orthogonal frequency division multiplexing (OFDMA) based system.

5. The method of claim **1**, wherein the at least one region boundary, the radio resource assignment, and the data packet are received from a base station.

6. The method of claim 1, wherein the physical time-frequency resource is a resource in an orthogonal frequency division multiplexing (OFDMA) based system.

7. The method of claim 1, wherein the downlink PUSC region of the frame carries both the physical time-frequency resource used to transport the data packet and the radio resource assignment assigning the physical time-frequency resource to the mobile station.

8. The method of claim 1, wherein receiving the radio resource assignment in one of the at least two regions includes receiving at least one of:

a connection identifier;

a channel identifier; and

a modulation coding parameter identifier.

9. A mobile station comprising:

a processor;

a computer readable medium storing programming for execution by the processor, the programming including instructions to:

receive at least one region boundary indicating a division of radio resources into at least two regions;

receive a radio resource assignment in a downlink partial usage of subcarriers (PUSC) region of a frame, the frame comprising at least the downlink PUSC, a downlink full usage of subcarriers (FUSC), and a control channel region, at least one data burst being allocated in each of the downlink PUSC and the downlink FUSC; and

receive a data packet on a physical time-frequency resource in the downlink PUSC region of the frame, wherein the radio resource assignment assigns the physical time-frequency resource in the downlink PUSC region of the frame to carry the data packet to the mobile station, and wherein the data packet and the radio resource assignment are received in the same downlink PUSC region of the same frame and the radio resource assignment excludes identifiers (IDs) that identify the downlink PUSC region carrying the data packet, and wherein the radio resource assignment comprises a multiple-input and multiple-output (MIMO) parameter identifier.

10. The mobile station of claim 9, wherein the programming further includes instructions to receive an indication of at least one preferred region.

11. The mobile station of claim 10, wherein the programming further includes instructions to process control channel resources only in the regions corresponding to the at least one preferred region.

12. The mobile station of claim 9, wherein the at least one region boundary, the radio resource assignment, and the data packet are received from a base station.

13. The mobile station of claim 9, wherein the physical time-frequency resource is a resource in an orthogonal frequency division multiplexing (OFDMA) based system.

14. The mobile station of claim 9, wherein the downlink PUSC region of the frame carries both the physical time-frequency resource used to transport the data packet and the radio resource assignment assigning the physical time-frequency resource to the mobile station.

15. A mobile station for processing a control channel, the mobile station comprising:

a processor;

a computer readable medium storing programming for execution by the processor, the programming including instructions to:

receive a radio resource assignment in a downlink full usage of subcarriers (FUSC) region of a frame, the frame comprising at least the downlink FUSC, a downlink partial usage of subcarriers (PUSC), and a control channel region, at least one data burst being allocated in each of the downlink PUSC and the downlink FUSC; and

receive a data packet on a physical time-frequency resource in the downlink FUSC region of the frame, the data packet and the radio resource assignment being received in the same downlink FUSC region of the same frame and the radio resource assignment excludes identifiers (IDs) that identify the downlink FUSC region carrying the data packet, wherein the radio resource assignment comprises a multiple-input and multiple-output (MIMO) parameter identifier, and wherein the radio resource assignment assigns the physical time-frequency resource in the downlink FUSC region of the frame to carry the data packet to the mobile station.

16. The mobile station of claim 15, wherein the radio resource assignment is received from a base station, and wherein the data packet is received from the same base station as the radio resource assignment.

17. The method of claim 1, further comprising processing the control channel region.

18. The mobile station of claim 9, further comprising processing the control channel region.

19. The mobile station of claim 15, wherein the downlink FUSC region of the frame carries both the physical time-frequency resource used to transport the data packet and the radio resource assignment assigning the physical time-frequency resource to the mobile station.

20. A method of receiving resource assignments in a wireless communication system, the method comprising:

receiving at least one region boundary indicating a division of radio resources into at least two regions;

receiving, by a mobile station, a radio resource assignment in a downlink full usage of subcarriers (FUSC) region of a frame, the frame comprising at least the downlink FUSC, a downlink partial usage of subcarriers (PUSC), and a control channel region, at least one data burst being allocated in each of the downlink PUSC and the downlink FUSC; and

receiving, by the mobile station, a data packet on a physical time-frequency resource in the downlink FUSC region of the frame, wherein the radio resource assignment assigns the physical time-frequency resource in the downlink FUSC region of the frame to carry the data packet to the mobile station, and wherein the data packet and the radio resource assignment are received in the same downlink FUSC region of the same frame and the radio resource assignment excludes identifiers (IDs) that identify the downlink FUSC region carrying the data packet, and wherein the radio resource assignment comprises a multiple-input and multiple-output (MIMO) parameter identifier.

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