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(54) Title: METHOD AND APPARATUS FOR SHARING A GROUP RESOURCE IN A WIRELESS SDMA SYSTEM
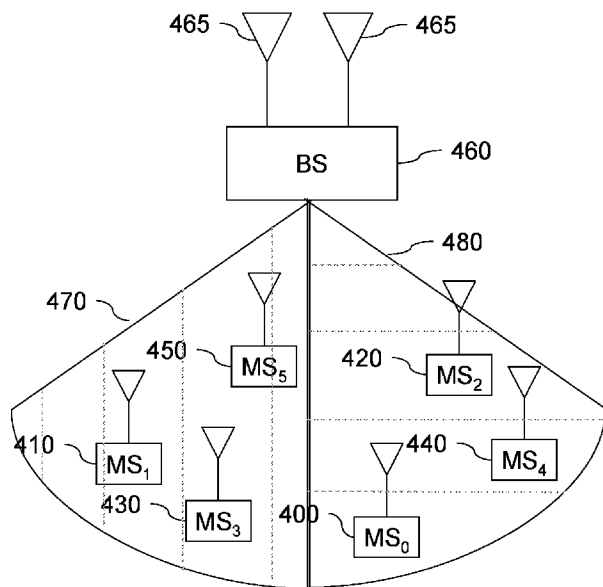
(57) Abstract: A method and apparatus of signaling radio resource allocation in a wireless communication system includes establishing groups of mobile stations which monitor a shared group scheduling bitmap; transmitting a group scheduling bitmap to the mobile stations, wherein the group scheduling bitmap contains a mobile station presence bitmap and an SDMA bitmap, wherein the SDMA bitmap is used to divide the group members into two or more subgroups; and transmitting packets to the mobile stations or receiving packets from the mobile stations using the radio resource which is derived from the value indicated in the group scheduling bitmap.

FIGURE 4

WO 2008/154853 A1

FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MT, NL, NO, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

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Method and Apparatus for Sharing a Group Resource in a Wireless SDMA System

[0001]   This application claims priority to United States Provisional Patent Application No. 60/944,477 filed June 15, 2007, entitled "Method and Apparatus For Sharing a Group Resource In A Wireless SDMA System", and U.S. Patent Application No. 12/135,916 filed June 9, 2008, entitled "Method and Apparatus for Sharing a Group Resource in a Wireless SDMA System", which applications are hereby incorporated herein by reference.

CROSS-REFERENCE TO RELATED APPLICATIONS

[0002]   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 June 15, 2007; U.S. Provisional Patent Application No. 60/944,466 filed June 15, 2007; and U.S. Provisional Patent Application No. 60/944,469 filed June 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 Serial No. 12/134,025, filed June 5, 2008 (Attorney Docket No. HW07FW049); U.S. Patent Application Serial No. 12/135,930, filed June 9, 2008 (Attorney Docket No. HW07FW050); and U.S. Patent Application Serial No. 12/135,599, filed   June   9,   2008   (Attorney   Docket   No.   HW07FW051).

FIELD OF THE INVENTION

[0003]   The present invention generally relates to allocation of radio resources for

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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 orthogonal frequency division multiplexing (OFDM) and orthogonal frequency division multiple access (OFDMA) communication systems, and resulting systems.

5

BACKGROUND OF THE INVENTION

[0004]   In wireless communication systems, for a given bandwidth, it is desirable to maximize capacity. To maximize capacity, it is known to use multiple antenna techniques such as spatial division multiple access (SDMA), wherein two or more

10   spatially separated mobile stations share the same radio resource. The base station allocates the same radio resource to the mobile stations and employs different effective antenna patterns to transmit the data for each of the mobile stations. Such techniques increase the spectral efficiency of the wireless communication system.

[0005]   The allocation of radio resources to the mobile stations has a corresponding

15   control channel overhead. If this overhead is not carefully managed, the overhead becomes prohibitively large and limits the capacity of the wireless communication system. This is particularly true for applications, such as voice over internet protocol (VoIP), that require the periodic delivery of small packets.

[0006]   It is known to use group scheduling to minimize the control channel

20   overhead associated with the delivery of VoIP packets. In group scheduling, a group of mobile stations monitor a shared control channel to determine their respective allocation from a set of shared radio resources, wherein the shared control channel typically contains a bitmap comprising at least one bit for each mobile station. The mobile stations

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monitor their respective bit of the bitmap to determine if one of the shared radio resources have been allocated by the base station, and determine which of the shared radio resources have been allocated based on the number of mobile stations, with smaller bit positions in the bitmap, that have been allocated a radio resource.

5   [0007]   Unfortunately, this group scheduling scheme does not currently handle multiple mobile stations sharing the same radio resource, which occurs for SDMA systems. Thus, there is a need for increasing the number of VoIP users by using spectrally efficient techniques such as SDMA, while efficiently controlling the control channel overhead using group scheduling.

10

SUMMARY OF THE INVENTION

[0008]   In one aspect, the present invention provides for a method of assigning a radio resource in wireless communication system. The method includes establishing a group of mobile stations for group scheduling, and transmitting a mobile station presence

15   bitmap to the group of mobile stations, the mobile station presence bitmap indicating which of the mobile stations are allocated a radio resource. The method further includes transmitting a spatial division multiple access (SDMA) bitmap to the group of mobile stations, the SDMA bitmap indicating a sub-group assignment for each of the mobile stations for which a radio resource is allocated.

20   [0009]   In another aspect, the present invention provides for a method of receiving a radio resource assignment in a wireless communication system. The method includes receiving a group assignment, the group assignment containing a position indication, and determining if a radio resource has been allocated based on the position corresponding to

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the indicated position in a received mobile station presence bitmap. The method further includes determining a sub-group assignment based on a received SDMA bitmap, and determining a resource assignment based on the sub-group assignment.

[0010]   In yet another aspect, the present invention provides for a base station having a processor and a computer readable medium storing programming for execution by the processor. The programming includes instructions to establish a group of mobile stations for group scheduling, and transmit a mobile station presence bitmap to the group of mobile stations, the mobile station presence bitmap indicating which of the mobile stations are allocated a radio resource. The programming includes further instructions to transmit a spatial division multiple access (SDMA) bitmap to the group of mobile stations, the SDMA bitmap indicating a sub-group assignment for each of the mobile stations for which a radio resource is allocated.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011]   FIG. 1 illustrates a wireless communications network.

[0012]   FIG. 2 illustrates a base station and several mobile stations from a wireless communications network.

[0013]   FIG. 3 illustrates an example set of OFDMA time-frequency radio resources suitable for group scheduling.

[0014]   FIG. 4 illustrates an SDMA base station and several mobile stations from a wireless communications network.

[0015]   FIG. 5 illustrates a group scheduling scheme.

[0016]   FIGS. 5A and 5B illustrate an alternative embodiment group scheduling

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scheme in which virtual resources are assigned and mapped to real resources.

[0017]   FIGS. 6, 7, and 8 are illustrative examples of the group scheduling scheme

of FIG. 5.

[0018]   FIGS. 9 and 10 illustrate an SDMA base station and several mobile stations

5   from a wireless communications network.

[0019]   FIG. 11 is a flow chart for exemplary base station operation.

[0020]   FIG. 12 is a flow chart for exemplary mobile station operation.

DETAILED DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS

10   [0021]   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.

[0022]   The present invention provides a unique method and apparatus for sharing

a group resource in a wireless SDMA system. It is understood, however, that the

15   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

20   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

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herein are omitted, as such control circuits are within the skills of persons of ordinary skill in the relevant art.

[0023]   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. The 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, sometimes referred to as a cell. 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.

[0024]   FIG. 2 illustrates one base station and several mobile stations from the wireless communications network of FIG. 1. In FIG. 2, the base station is employed with two transmit antennas 265 making the base station capable of transmitting packets using one of several well known multiple antenna schemes. As is known in the art, the

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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 as 270. Six exemplary mobile stations 200, 210, 220, 230, 240, 250 are in the shown coverage area.

[0025]   FIG. 3 is an example set of OFDMA time-frequency radio resources suitable for group scheduling. In OFDMA systems, the time-frequency resources are divided into OFDM symbols and OFDM subcarriers for allocation to the mobile stations by the base station scheduler. In an example OFDMA system, the OFDM subcarriers are approximately 10 kHz apart and the duration of each OFDM symbol is approximately 100 μsec. Referring to FIG. 3, the time-frequency resources correspond to a time division duplex (TDD) system, such as that defined by the IEEE 802.16e standard. In this exemplary embodiment, the resources in the time domain (x-axis) are divided into two equal portions; denoted as downlink (DL), and uplink (UL). The DL and UL are further divided into 24 OFDM symbols 320. The first DL OFDM symbol is allocated for the preamble, which is used for timing and frequency synchronization by the mobile stations. The second and third DL OFDM symbols are used to transmit control information. In this example, the fourth through eleventh DL OFDM symbols are allocated as a set of shared time-frequency resources 310 for group scheduling. The twenty-fourth OFDM DL OFDM symbol is allocated as a guard period 335. In the frequency domain (y-axis), the fourth through eleventh DL OFDM symbols are further divided into eight subchannels 330. The subchannels contain 48 usable OFDM subcarriers that are either contiguous or distributed across a larger bandwidth, where a usable OFDM subcarrier is one that can be used for data transmission, i.e. non-pilot. In FIG. 3, the set of shared time-frequency resources 310 are numbered 0-7.

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[0026]   In FIG. 3, each of the time-frequency resources (0-7) is a logical representation of a portion of the time-frequency resources of the system. Each logical time-frequency resource maps to a physical time-frequency resource. The mapping of logical time-frequency resources to physical time-frequency resources depends on which

5   subcarrier permutation is being used, such as the subcarrier permutations defined by the IEEE 802.16 standard. The mapping of logical time-frequency resources to physical time-frequency resources can change with time and can depend on one or more parameters defined by the system.

[0027]   FIG. 4 illustrates one base station and several mobile stations, such as from

10   the wireless communications network of FIG. 1. The configuration of the base station 460 and mobile stations 400, 410, 420, 430, 440, and 450 is identical to that of FIG. 2. Base station 460 is employed with two transmit antennas 465. Base station 460 uses its multiple transmit antennas 465 to employ a well known multiple antenna scheme known as SDMA. In SDMA, a base station serves multiple mobile stations on the same time-

15   frequency resource using different effective antenna patterns. For example, referring to FIG. 4, base station 460 creates six distinct coverage areas, two of which are shown 470 and 480. As a result, base station 460 can serve two different mobile stations on the same resource if the mobile stations are spatially separated. Base station 460 relies on measurements to determine in which coverage area a mobile station is located. The

20   measurements can be made at the mobile station and fed back to the base station on a feedback channel or can be made at the base station. TDD systems are well suited for making channel measurements at the base station, since channel reciprocity can be assumed by the base station. As an example, consider MS_1 and MS_4. In a TDD system,

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base station 460 can determine whether the mobile stations are in coverage area 470 or

coverage area 480. Then, a base station scheduler, such as scheduler 140 illustrated in

FIG. 1, can assign MS_1 and MS_4 to the same time frequency resources, for example

resource 0 of FIG. 3. Since base station 460 uses two distinct effective antenna patterns

5   for MS_1 and MS_4, interference seen at MS4 for transmission to MS_1 is minimized.

Similarly, for uplink traffic, the same resource can be shared using SDMA. To

distinguish the mobile stations sharing the same resource, different pilot patterns can be

transmitted by the two mobile stations.

[0028]   For a VoIP system, base station 460 can effectively double the number of

10   available time-frequency resources using a scheme similar to that shown in FIG. 4.

Current group scheduling schemes do not facilitate the assignment of the same resource

to different mobile stations, however. Thus, FIG. 5 is provided to illustrate a preferred

embodiment scheme for sharing a group resource. In FIG. 5, exemplary group

scheduling bitmap 500 is shown. Group scheduling bitmap 500 is divided into three parts,

15   a resource availability bitmap (RAB) 510, a mobile station presence bitmap 520, and an

SDMA bitmap 530. The resource availability bitmap is further sub-divided into N RAB

sub-bitmaps, denoted RAB sub-bitmap$_0$ 512, RAB sub-bitmap$_1$ 514, and RAB sub-

bitmap$_{N-1}$ 516. In some embodiments, resource availability bitmap 510 is not used. As in

the prior art, a group of mobile stations is established which monitor group scheduling

20   bitmap 500 to determine a resource allocation. The group of mobile stations is assigned a

set of shared time-frequency resources, such as resource 0 through 7 of FIG. 3. Each

mobile station is assigned a bit position in mobile station presence bitmap 520 to

determine if it is allocated one of the shared time-frequency resources. For example, if

the bit of mobile station presence bitmap 520 corresponding to a particular mobile station is a '1', the mobile station is assigned one of the shared time-frequency resources, and if the bit is a '0', the mobile station is not assigned one of the shared time-frequency resources.

5   [0029]   SDMA bitmap 530 is used to divide the mobile stations monitoring the mobile station presence bitmap 520 into two or more sub-groups. The mobile station corresponding to the Nth '1' in the mobile station presence bitmap 520 determines its sub-group assignment by examining the Nth position in the SDMA bitmap 530. The number of sub-groups is equal to the number of times the same time-frequency resource can be used by a base station. For example, referring to FIG. 4, each resource can be used twice, since there are two coverage areas 470, 480. Therefore, there are two sub-groups. If there are two sub-groups, the Nth position in the SDMA bitmap is one bit wide, if there are four sub-groups, the Nth position in the SDMA bitmap is two bits wide, etc.

[0030]   Mobile stations determine their sub-group assignment using SDMA bitmap 530, and create an effective mobile station presence bitmap, by, e.g., setting all of the '1's in the mobile station presence bitmap to '0' for mobile stations that are not in the same sub-group.

[0031]   For supporting SDMA, resource availability bitmap 510 contains RAB sub-bitmaps 512, 514, 516. Like the number of sub-groups, the number of RAB sub-bitmaps is equal to the number of times the same time-frequency resource can be used by the base station. Each bit in each of the RAB sub-bitmaps corresponds to one of the shared time-frequency resources. If the corresponding resource is used, base station 460 indicates this to the mobile stations 410, 420, 430, etc., by, e.g., setting the bit to '1'. The mobile

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stations determine which of the RAB sub-bitmaps to monitor based on the value in SDMA bitmap 530. Mobile stations assigned to sub-group 0 monitor RAB sub-bitmap$_0$, mobile station assigned to sub-group 1 monitor RAB sub-bitmap$_1$, etc.

[0032]   Mobile stations determine their resource assignment within the set of available resources preferably by determining the number of mobile stations with smaller bitmap positions in the effective mobile station presence bitmap that have been allocated a resource. The Nth mobile station indicated as active in the effective mobile station presence bitmap for sub-group j is allocated the Nth available resource from the set of shared resources for sub-group j.

[0033]   If resource availability bitmap 510 is not used, the set of available resources is the entire set of shared time-frequency resources. If resource availability bitmap 510 is used, the set of available resources for the jth group is the entire set of shared time-frequency resources minus those resources that are indicated as being used by RAB sub-bitmap$_j$.

[0034]   Figure 5A illustrates an alternate preferred embodiment in which virtual resources, which correspond to real resources, are assigned to the mobile stations. Group scheduling bitmap 500a includes virtual resource bitmap 511, which maps virtual resources for assignment to the mobile stations. The use of virtual resources for assigning resources is discussed in great detail in commonly assigned and co-pending Patent Application No. 12/134,025 (Attorney Docket No. HW07FW049R) and in Provisional Patent Application No. 60/944,462, both of which are incorporated herein by reference. As shown, virtual resource bitmap 510a contains RAB sub-bitmaps 512a, 514a, 516a, for supporting SDMA. These virtual resource sub-bitmaps operate on a per

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group basis analogously to real resource sub-bitmaps 512, 514, and 516. Although group scheduling bitmap 500a is shown without a mobile station presence bitmap, this bitmap could be included as well in some embodiments.

[0035]   Figure 5B illustrates and exemplary manner in which virtual assigned resources are mapped to real resources using SDMA bitmap 530. In the illustrated example were the coverage area is divided into two groups, SDMA bitmap 530 indicates whether virtual resources in sub-group 0 or sub-group 1 are being mapped to real resources in sub-group 0 or sub-group 1. Consistent with the above described exemplary algorithm (described with respect to FIG. 5), the mobile station corresponding to the Nth '1' in virtual resource bitmap 510a monitors the Nth position in SDMA bitmap 530 to determine whether it should monitor RAB0 or RAB1 for determining its real resources. It will be apparent to one skilled in the art that the use of virtual resource bitmap 510a in conjunction with real resource bitmap 510 can be applied to each of the following described embodiments.

[0036]   FIG. 6 provides an illustrative example of the group scheduling bitmap 500 of FIG. 5. Referring to FIG. 6, consider that a group of 6 mobile stations, denoted MS_0, MS_1, MS_2, MS_3, MS_4, and MS_5, has been established by the base station. The base station establishes the group by transmitting a group assignment message to each mobile station containing an indication of its position assignment within the group and optionally an indication of the set of shared time-frequency resources (the group resources). If the entire set of OFDMA resources is used for group scheduling, the base station does not need to transmit an indication of the set of shared time-frequency resources. Further, consider that the mobile stations are situated as shown in FIG. 4, and that the base station

has established coverage areas 470 and 480 of FIG. 4. Each mobile station in the group

monitors a group scheduling bitmap containing a mobile station presence bitmap 610 and

an SDMA bitmap 620. The group is assigned two shared resources 650 and 660, denoted

resource 0 and resource 1. Further, consider that the base station scheduler has

5   determined to allocate resources to MS_1, MS_2, MS_3, and MS_4. The scheduler then

constructs the group scheduling bitmap based on the known algorithm of processing the

group scheduling bitmap at the mobile station. Based on mobile station presence bitmap

610, MS_1, MS_2, MS_3, and MS_4 are indicated as active. MS_1 and MS_3 are in coverage area

470, and MS_2 and MS_4 are in coverage area 480. Base station 460 uses the SDMA

10   bitmap 620 to establish sub-group 0 and sub-group 1. MS_1 and MS_3 are assigned to sub-

group 0 using SDMA bitmap 620, and MS_2 and MS_4 are assigned to sub-group 1 using

SDMA bitmap 620. The mobile station corresponding to the Nth '1' in mobile station

presence bitmap 610 determines its sub-group assignments based on the Nth position in

the SDMA bitmap 620, illustrated by the arrows connecting the mobile station presence

15   bitmap 610 to the SDMA bitmap 620. Mobile stations in sub-group 0 create an effective

mobile station presence bitmap 630 by inserting '0's in the mobile station presence

bitmap for all mobile stations not assigned to sub-group 0. Mobile stations in sub-group

1 create an effective mobile station presence bitmap 640 by inserting '0's in the mobile

station presence bitmap for all mobile stations not assigned to sub-group 1.

20   [0037]   Mobile stations in sub-group 0 determine their resource allocation based on

the effective mobile station presence bitmap for sub-group 0 630. The mobile station

corresponding to the Nth '1' in the effective mobile station presence bitmap for sub-group

0 630 is allocated the Nth available resource from the set of shared time-frequency

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resources. In this case, the available resources are resource 0 and resource 1, since a resource availability bitmap is not being used. Consequently, MS_1 determines that it is allocated resource 0 650 and MS_3 determines that it is allocated resource 1 660.

[0038]   Mobile stations in sub-group 1 determine their resource allocation based on the effective mobile station presence bitmap for sub-group 1 640. The mobile station corresponding to the Nth '1' in the effective mobile station presence bitmap for sub-group 1 640 is allocated the Nth available resource from the set of shared time-frequency resources. In this case, the available resources are resource 0 and resource 1, since a resource availability bitmap is not being used. Consequently, MS_2 determines that it is allocated resource 0 650 and MS_4 determines that it is allocated resource 1 660. Due to the spatial separation of mobile stations in sub-group 0 and sub-group 1, the mobile stations in one sub-group do not need to know how resources are allocated to the mobile stations in the other sub-group.

[0039]   Once a mobile station determines its allocated resource, the mobile station receives a packet on the physical time-frequency resources corresponding to the determined time-frequency resource or transmits a packet to the base station on the physical time-frequency resource corresponding to the determined time-frequency resource.

[0040]   FIG. 7 provides another illustrative example of the group scheduling bitmap of FIG. 5. Referring to FIG. 7, consider that a group of 6 mobile stations, denoted MS_0, MS_1, MS_2, MS_3, MS_4, and MS_5, has been established by the base station. The base station establishes the group by transmitting a group assignment message to each mobile station containing an indication of its position assignment within the group and optionally

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an indication of the set of shared time-frequency resources (the group resources).
Further, consider that the mobile stations are situated as shown in FIG. 4, and that the
base station has established the two coverage areas 470 and 480 of FIG. 4. Each mobile
station in the group monitors a group scheduling bitmap containing a resource availability

5   bitmap 710 comprising RAB sub-bitmap$_0$ 712 and RAB sub-bitmap$_1$ 714, a mobile
station presence bitmap 720 and an SDMA bitmap 730. The group is assigned three
shared resources 740, 750, and 760, denoted resource 0, resource 1, and resource 2.
Further, consider that the base station scheduler has determined to allocate resources to
MS_0, MS_2, and MS_5. The scheduler then constructs the group scheduling bitmap based

10   on the known algorithm of processing the group scheduling bitmap at the mobile station.
Based on the mobile station presence bitmap 720, MS_0, MS_2, and MS_5 are indicated as
active. MS_5 is in coverage area 470, and MS_0 and MS_2 are in coverage area 480. The
base station uses the SDMA bitmap 730 to establish sub-group 0 and sub-group 1. MS_5
is assigned to sub-group 0 using the SDMA bitmap 730, and MS_0 and MS_2 are assigned

15   to sub-group 1 using the SDMA bitmap 730. The mobile station corresponding to the
Nth '1' in the mobile station presence bitmap 720 determines its sub-group assignments
based on the Nth position in the SDMA bitmap 730, illustrated by the arrows connecting
the mobile station presence bitmap 720 to the SDMA bitmap 730. Mobile stations in
sub-group 0 create an effective mobile station presence bitmap 722 by inserting '0's in

20   the mobile station presence bitmap for all mobile stations not assigned to sub-group 0.
Mobile stations in sub-group 1 create an effective mobile station presence bitmap 724 by
inserting '0's in the mobile station presence bitmap for all mobile stations not assigned to
sub-group 1.

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[0041]   Mobile stations in sub-group 0 determine their respective resource allocation based on the effective mobile station presence bitmap for sub-group 0 722 and RAB sub-bitmap$_0$. The Nth bit position in each RAB sub-bitmap corresponds to the Nth resource from the set of shared time-frequency resources. In this case, bit position 0 corresponds to resource 0, bit position 1 corresponds to resource 1, and bit position 2 corresponds to resource 2. The base station sets a bit to '1' in RAB sub-bitmap$_j$ to indicate to the mobile stations of sub-group j that the corresponding resource is currently in use. Based on RAB sub-bitmap$_0$, the mobile stations of sub-group 0 determine that resource 1 and resource 2 are not available. Similarly, based on RAB sub-bitmap$_1$, the mobile stations of sub-group 1 determine that resource 0 is not available.

[0042]   The mobile station corresponding to the Nth '1' in the effective mobile station presence bitmap for sub-group 0 722 is allocated the Nth available resource from the set of shared time-frequency resources. In this case, the mobile stations in sub-group 0 determine the set of available resources by subtracting those resources that are indicated as being used by RAB sub-bitmap$_0$ 712 from the entire set of shared time-frequency resources. Consequently, MS$_5$ determines that it is allocated resource 0 740.

[0043]   The mobile station corresponding to the Nth '1' in the effective mobile station presence bitmap for sub-group 1 724 is allocated the Nth available resource from the set of shared time-frequency resources. In this case, the mobile stations in sub-group 1 determine the set of available resources by subtracting those resources that are indicated as being used by RAB sub-bitmap$_1$ 714 from the entire set of shared time-frequency resources. Consequently, MS$_0$ determines that it is allocated resource 1 750 and MS$_2$ determines that it is allocated resource 2. Again, due to the spatial separation of mobile

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stations in sub-group 0 and sub-group 1, the mobile stations in one sub-group do not need to know how resources are allocated to the mobile stations in the other sub-group.

[0044]   FIG. 8 provides another illustrative example of the group scheduling bitmap of FIG. 5. Referring to FIG. 8, consider that a group of 6 mobile stations, denoted MS$_0$, MS$_1$, MS$_2$, MS$_3$, MS$_4$, and MS$_5$, has been established by the base station. Further, consider that the base station will use mobile station presence bitmap 810 and SDMA bitmap 820 for resource allocation. Finally, consider that the base station has four transmit antennas, thereby allowing four effective antenna patterns and four distinct coverage areas. In such a system, the base station can use each radio resource four times. As a result, SDMA bitmap 820 contains two bits per active mobile station, thereby allowing the creation of four sub-groups. Referring to FIG. 8 and the arrows connecting the mobile station presence bitmap 810 to the SDMA bitmap 820, MS$_1$ is assigned to subgroup '10', MS$_2$ is assigned to subgroup '01', and MS$_4$ is assigned to sub-group '00'. Other variations to the assignment scheme will be apparent to those skilled in the art.

[0045]   FIGS. 9 and 10 illustrate an SDMA base station and several mobile stations from a wireless communications network. Referring to FIG. 9, the configuration of the base station 960 and mobile stations 900, 910, 920, 930, 940, and 950 is identical to that of FIG. 4. Base station 960 is employed with two transmit antennas 965. Similar to the base station of FIG. 4, base station 960 creates six distinct coverage areas, two of which are shown 970 and 980. In this embodiment, base station 960 intentionally creates coverage areas which do not cover the entire desired coverage area. This is done to increase the channel quality of mobile stations in the shown coverage areas 970 and 980. To allow service to all mobile stations, the base station changes the coverage areas with

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time. For example, FIG. 10 is provided to show two different coverage areas that can be created by the same base station at an instant in time subsequent to the instant of time illustrated in FIG. 9. Based on FIGS. 9-10, each mobile station is in the base stations coverage area at one of the two instants in time. The base station alternates between the

5   coverage area of FIG. 9 and the coverage area of FIG. 10. Other coverage areas could be included at yet other instances of time.

[0046]   FIG. 11 is a flow chart for base station operation. Referring to FIG. 11, at step 1110, the base station establishes a group of mobile stations which monitor a shared group scheduling bitmap to determine their respective resource allocation. The base

10   station establishes a group of mobile stations by informing the mobile stations of their respective position assignments within the group (which bitmap position to monitor) and optionally an indication of the set of shared time-frequency resources. This indication can be sent using a group assignment message. At step 1120, the base station scheduler determines which of the mobile stations in the group are to be allocated a radio resource.

15   At step 1130, the base station transmits a group scheduling bitmap to the group of mobile stations. The group scheduling bitmap contains a mobile station presence bitmap, an SDMA bitmap, and optionally, a resource availability bitmap. The bitmaps are used by the base station to indicate the allocation of specific resources to specific mobile stations within the group. The SDMA bitmap is used by the base station to create sub-groups,

20   wherein members of different sub-groups can share the same time-frequency resource using antennas techniques such as SDMA. The resource availability bitmap, if used, contains RAB sub-bitmaps, which indicate which of the set of shared time-frequency resources are in use for each sub-group. At step 1140, the base station transmits packets

to the determined mobile stations or receives packets from the determined mobile stations
using the radio resource corresponding to the resource indicated in the group scheduling
bitmap.

[0047]   FIG. 12 is a flow chart for mobile station operation. Referring to FIG. 12, at
step 1210, the mobile station receives a group assignment from the base station. The
group assignment contains an indication of the mobile stations position within the group
(which bitmap position to monitor) and optionally an indication of the set of shared time-
frequency resources.   At step 1220, the mobile station receives a group scheduling
bitmap from the base station. The group scheduling bitmap contains a mobile station
presence bitmap, an SDMA bitmap, and optionally, a resource availability bitmap. The
bitmaps are used by the mobile station to determine its specific resource assignment from
within a set of shared time-frequency resources. The SDMA bitmap is used by the
mobile station to determine its sub-group assignment, wherein members of different sub-
groups can share the same time-frequency resource using antennas techniques such as
SDMA. The resource availability bitmap, if used, contains RAB sub-bitmaps, which
indicate which of the set of shared time-frequency resources are in use for each sub-group.
At step 1230, the mobile station determines its resource allocation using the group
scheduling bitmap. At step 1240, the mobile station transmits a packet to the base station
or receives a packet from the base station on the determined resource.

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CLAIMS

1.   A method of assigning a radio resource in wireless communication system, the method comprising:

establishing a group of mobile stations for group scheduling;

transmitting a mobile station presence bitmap to the group of mobile stations, the mobile station presence bitmap indicating which of the mobile stations are allocated a radio resource; and

transmitting a spatial division multiple access (SDMA) bitmap to the group of mobile stations, the SDMA bitmap indicating a sub-group assignment for each of the mobile stations for which a radio resource is allocated.

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

3   The method of claim 1, further comprising establishing two groups of mobile stations for group scheduling.

4.   The method of claim 1, wherein sub-group assignment is assigned as a virtual resource, which virtual resource is mapped to a real resource using a bitmap that maps virtual resources to real resources.

5.   The method of claim 1, further including transmitting a resource availability bitmap that identifies resources that are available.

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6.   The method of claim 5, wherein the resource availability bitmap is divided into N
resource availability sub-bitmaps, wherein N is equal to the number of groups of mobile
stations.

7.   The method of claim 5, wherein each bit of the resource availability bitmap
corresponds to a shared time-frequency resource.

8.   A method of receiving a radio resource assignment in a wireless communication
system, the method comprising:

        receiving a group assignment, the group assignment containing a position
indication;

        determining if a radio resource has been allocated based on the position
corresponding to the indicated position in a received mobile station presence bitmap;

        determining a sub-group assignment based on a received SDMA bitmap; and

        determining a resource assignment based on the sub-group assignment.

9.   The method of claim 8, wherein the wireless communication system is an
OFDMA-based system.

10.   The method of claim 8, wherein the sub-group assignment is assigned as a virtual
resource and further comprising receiving a bitmap that maps virtual resources to real
resources.

11   The method of claim 8, further including receiving a resource availability bitmap
that identifies time-frequency resources that are available.

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12.   The method of claim 11, wherein the resource availability bitmap is divided into

N resource availability sub-bitmaps, wherein N is equal to the number of groups of

mobile stations in a base station cell.

13   The method of claim 11, wherein each bit of the resource availability bitmap

corresponds to a shared time-frequency resource.

14.   A base station comprising:

a processor;

a computer readable medium storing programming for execution by the processor,

the programming including instructions to:

establish a group of mobile stations for group scheduling;

transmit a mobile station presence bitmap to the group of mobile stations,

the mobile station presence bitmap indicating which of the mobile stations are allocated a

radio resource; and

transmit a spatial division multiple access (SDMA) bitmap to the group of

mobile stations, the SDMA bitmap indicating a sub-group assignment for each of the

mobile stations for which a radio resource is allocated.

15.   The base station of claim 14, wherein the base station is a component of an

orthogonal frequency division multiplexing based (OFDMA-based) wireless

communication system.

16.   The base station of claim 14, wherein the programming further includes

instruction to establish two groups of mobile stations for group scheduling.

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17.   The base station of claim 14, wherein sub-group assignment is assigned as a

virtual resource, which virtual resource is mapped to a real resource using a bitmap that

maps virtual resources to real resources.

18.   The base station of claim 14, further including transmitting a resource availability

5   bitmap that identifies resources that are available.

19.   The base station of claim 18, wherein the resource availability bitmap is divided

into N resource availability sub-bitmaps, wherein N is equal to the number of groups of

mobile stations.

20.   The base station of claim 14, wherein each bit of the resource availability bitmap

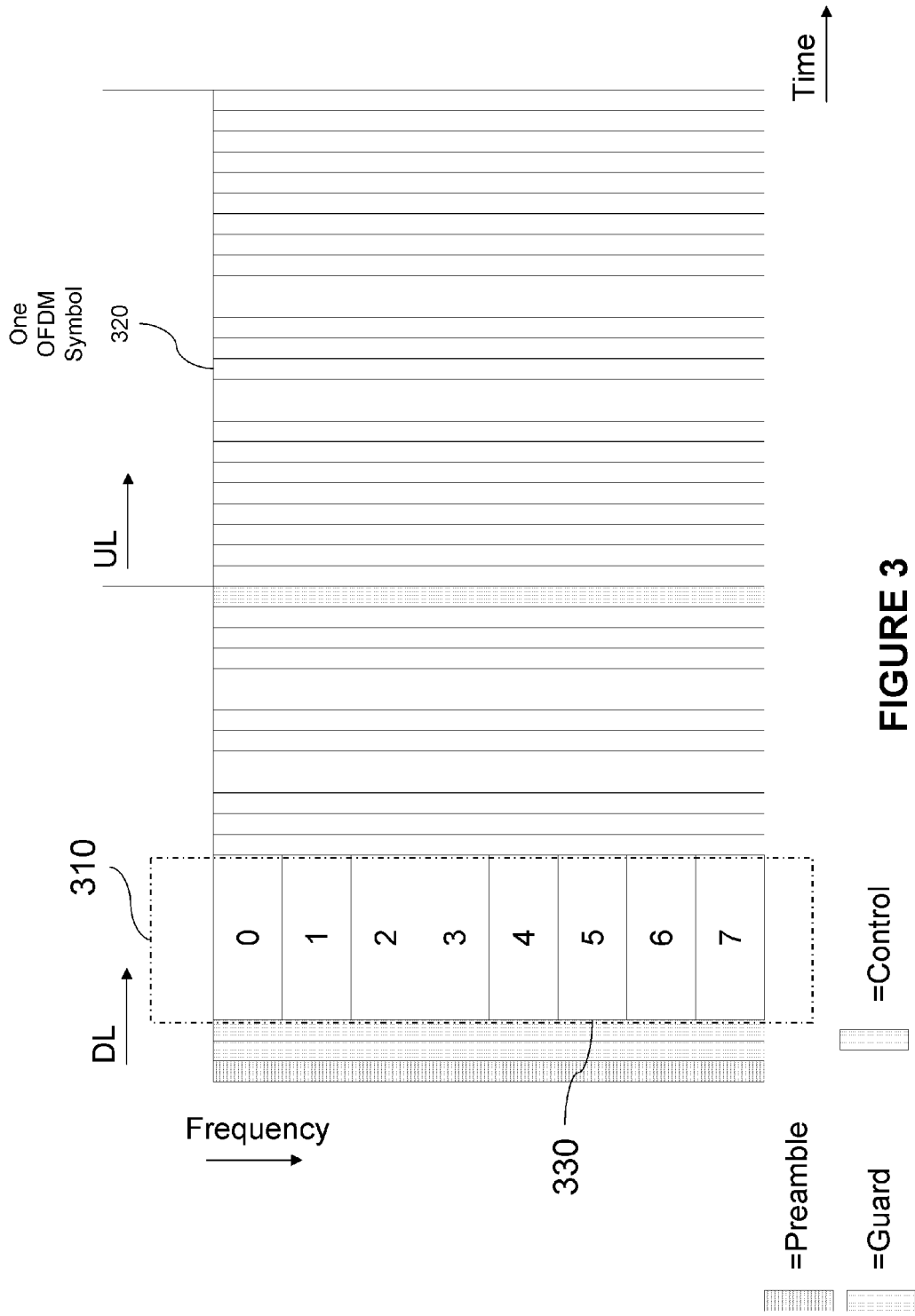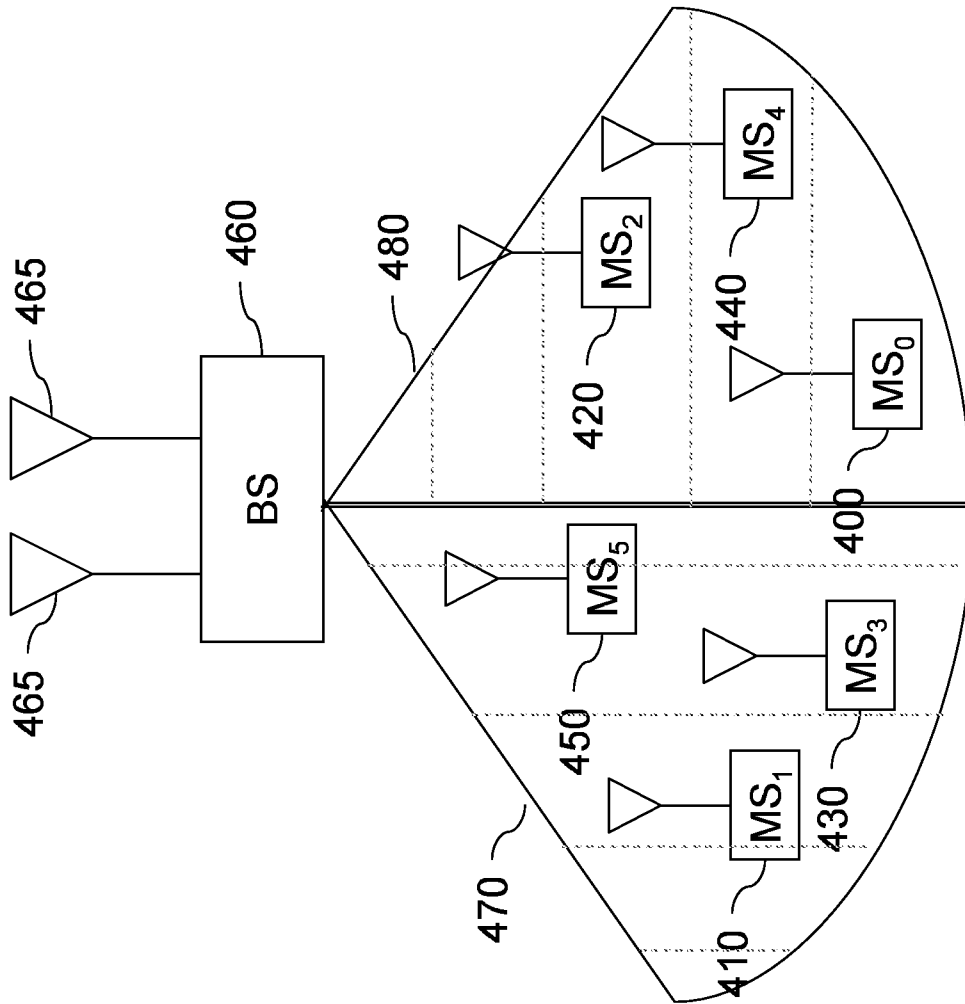10   corresponds to a shared time-frequency resource.
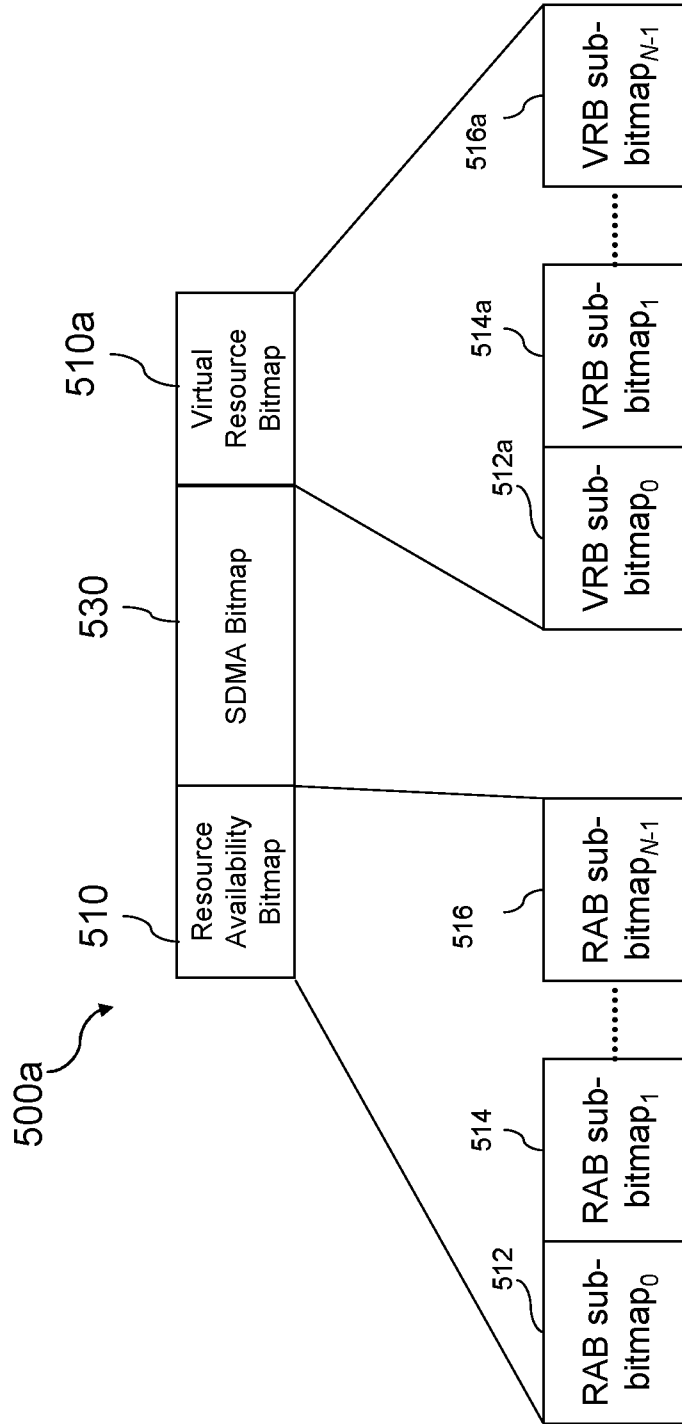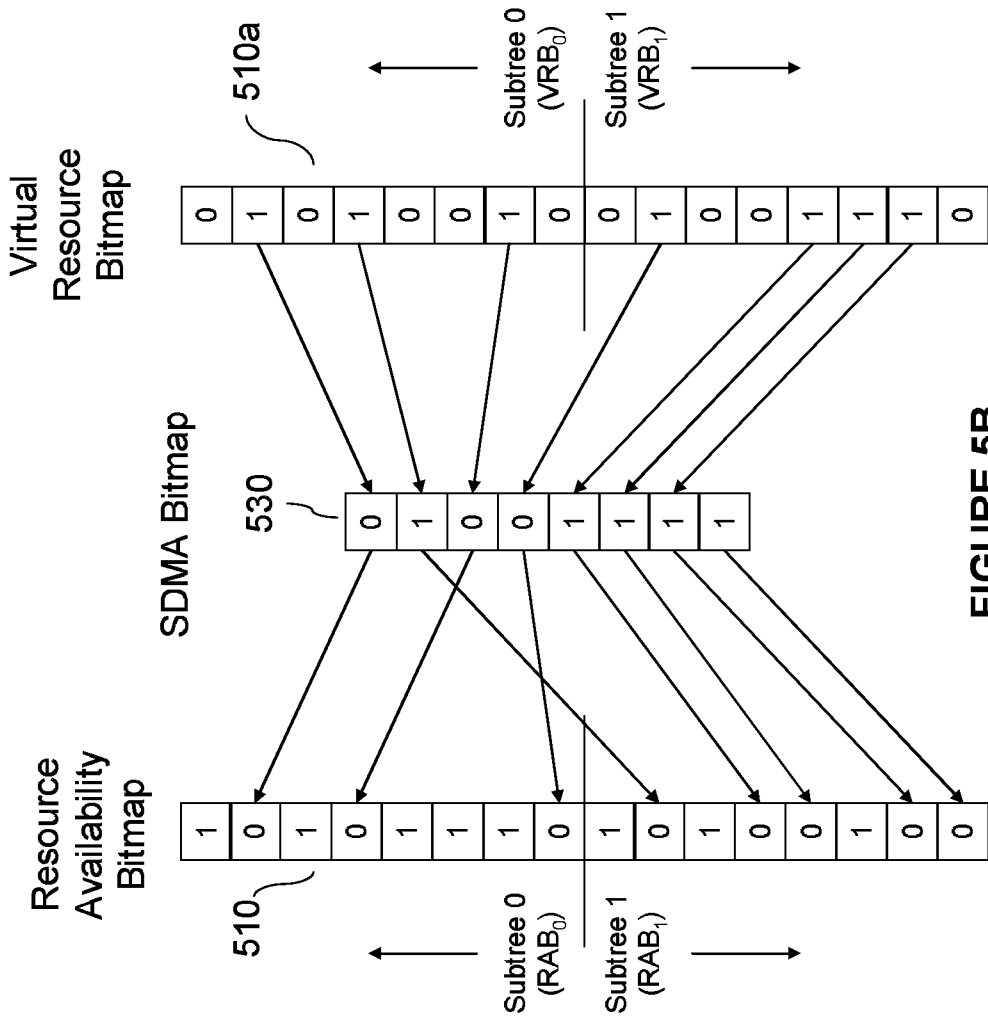
FIGURE 1

—2/14—
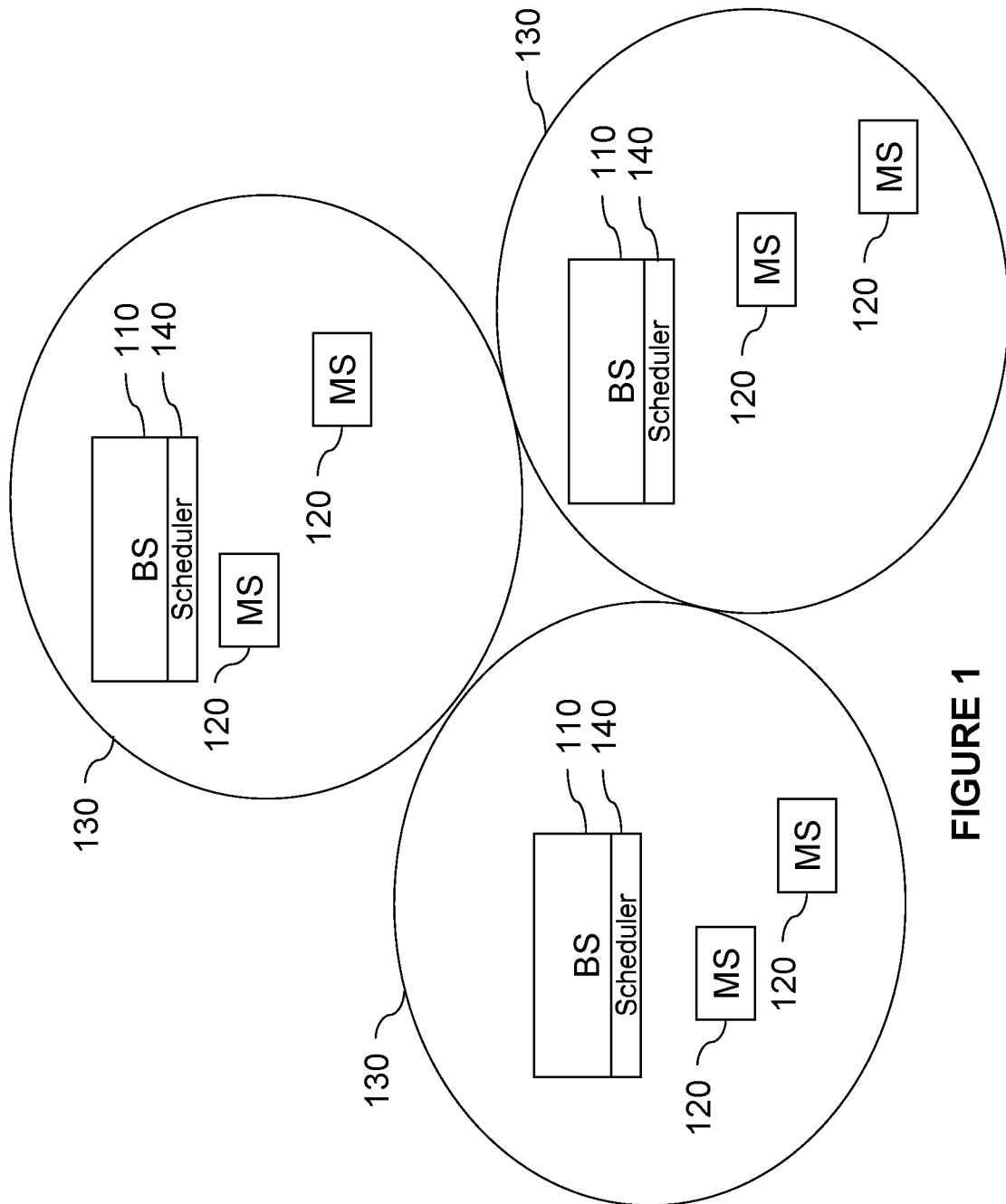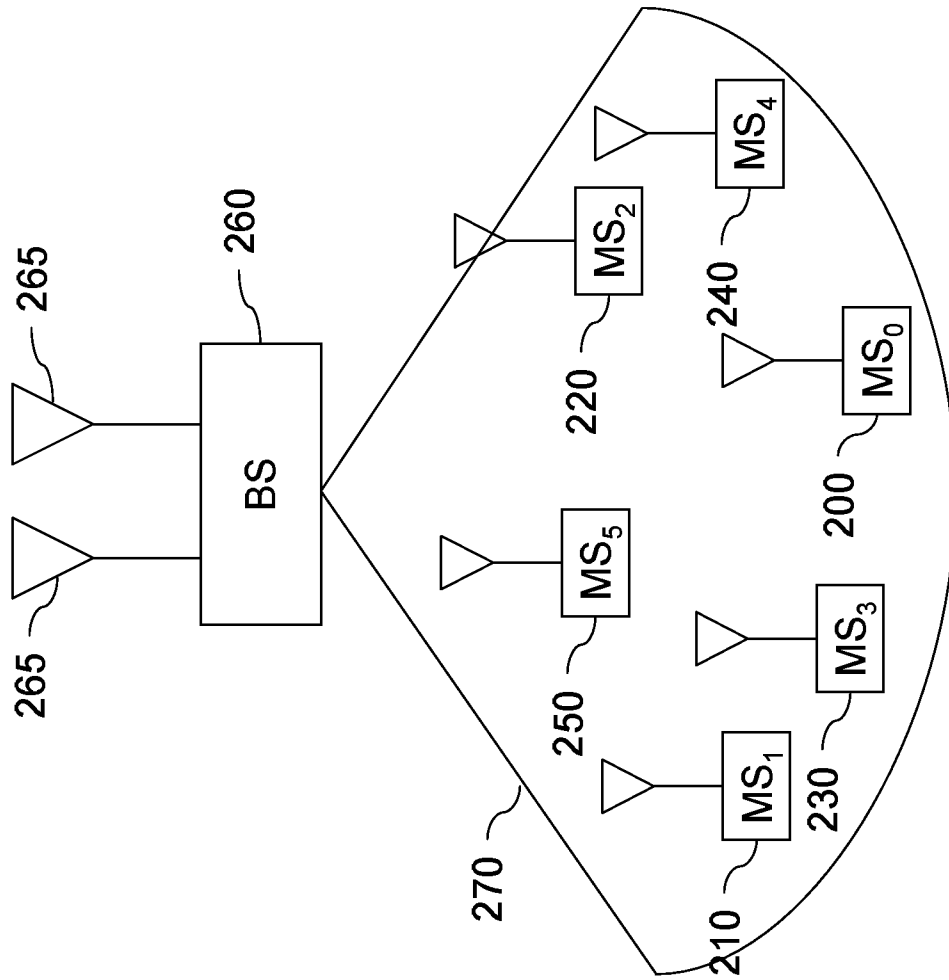
FIGURE 2

FIGURE 3

FIGURE 4
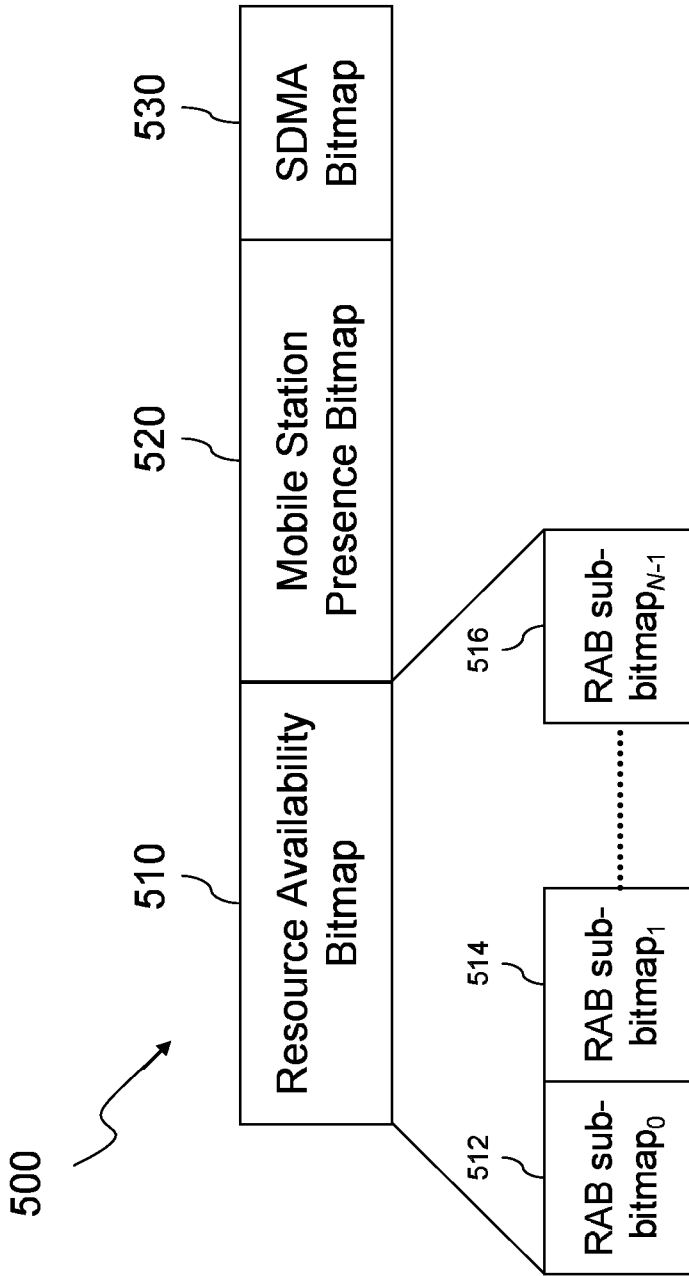
FIGURE 5

FIGURE 5A

FIGURE 5B
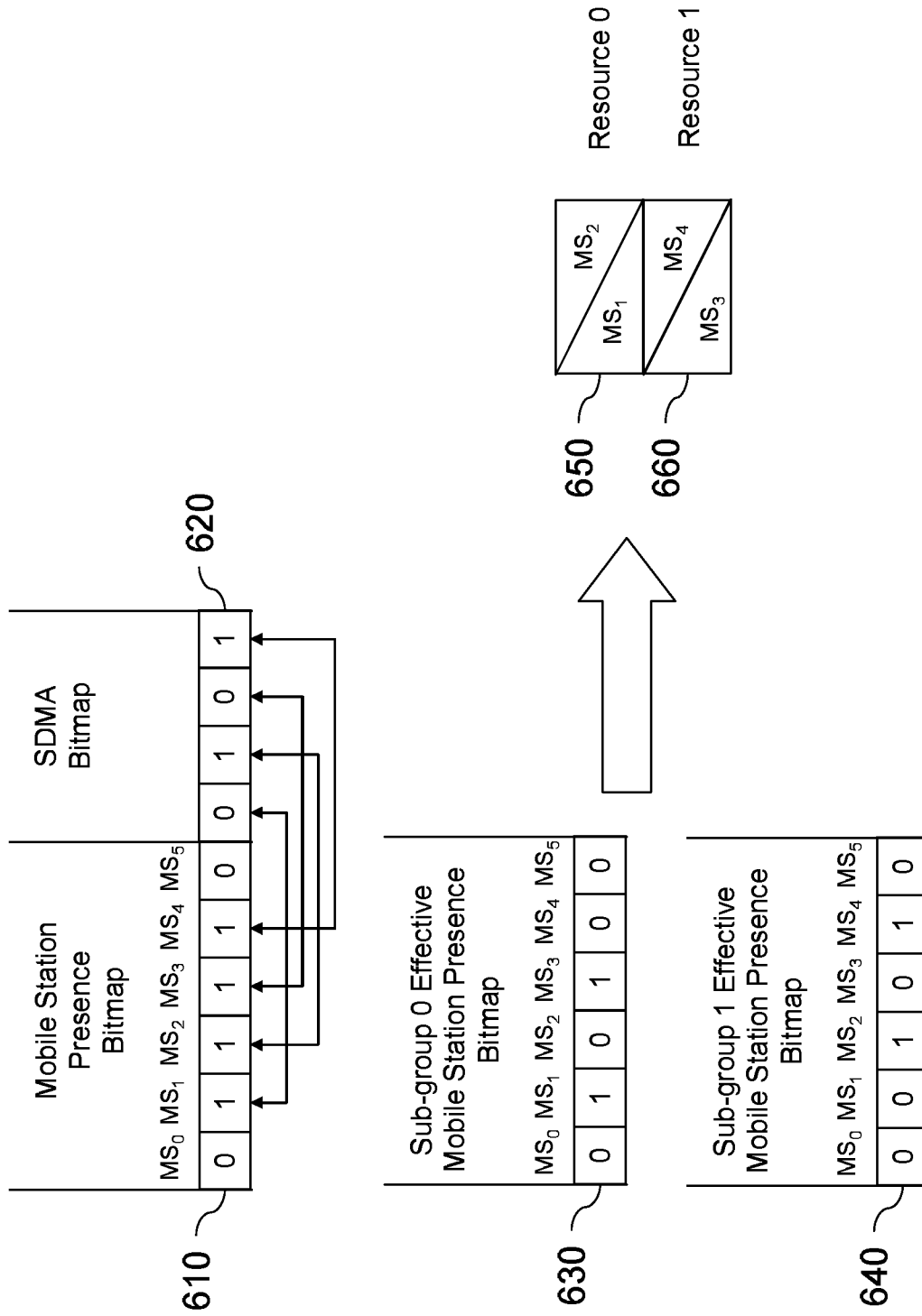
FIGURE 6
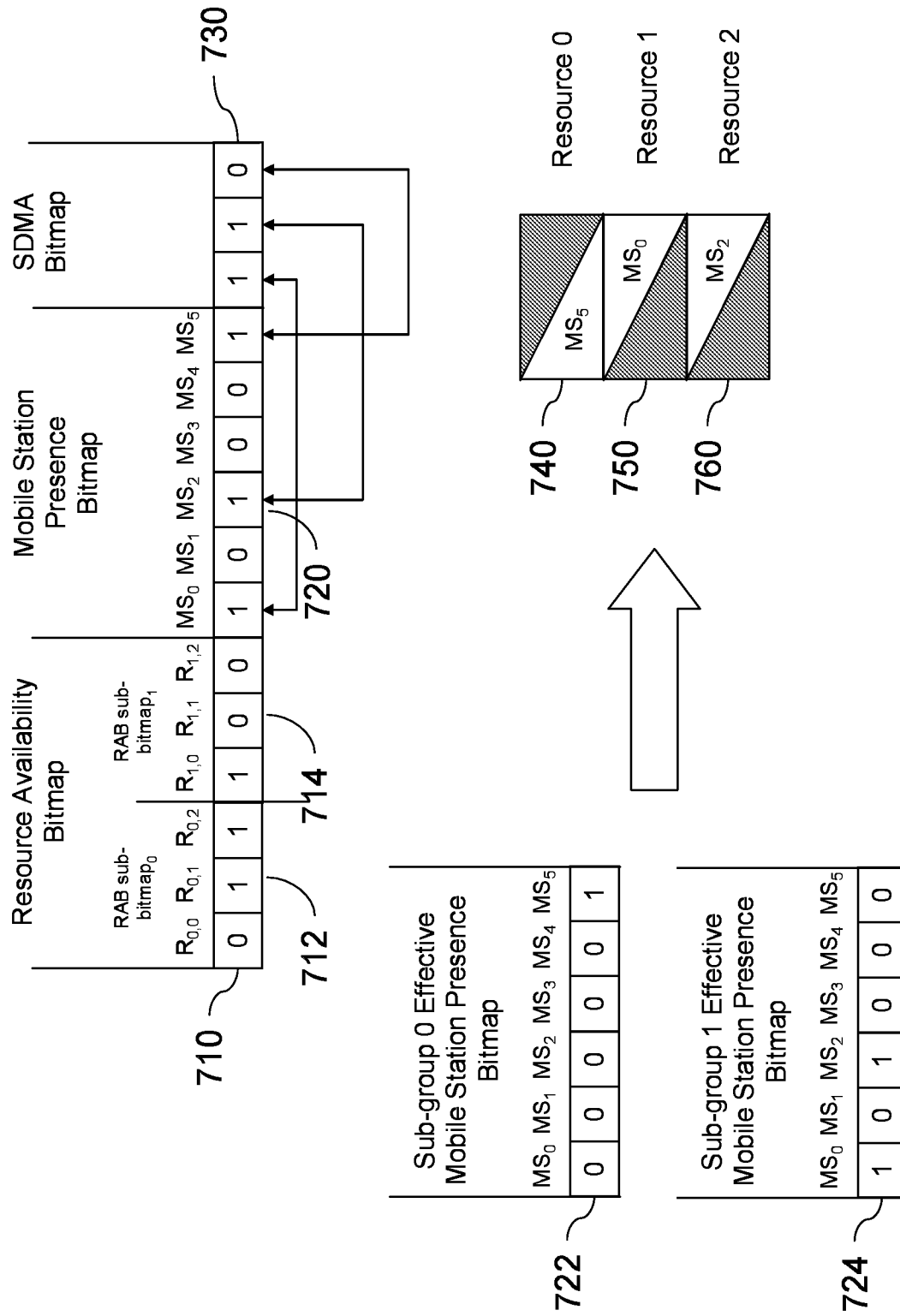
FIGURE 7
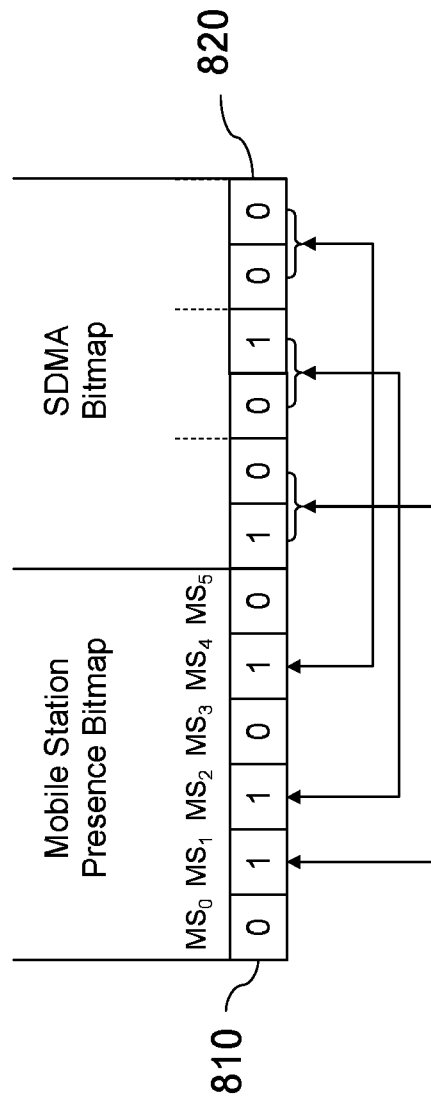
FIGURE 8

FIGURE 9

FIGURE 10

Establish a group of mobile stations which monitor a shared group scheduling bitmap to determine their respective resource allocation ⟶ 1110

Determine which of the mobile stations in the group are to be allocated a radio resource ⟶ 1120

Transmit a group scheduling bitmap to the group of mobile stations, wherein the group scheduling bitmap comprises at least a mobile station presence bitmap and an SDMA bitmap ⟶ 1130

Transmit packets to the determined mobile stations or receive packets from the determined mobile stations using the radio resource corresponding to value indicated in the group scheduling bitmap ⟶ 1140

FIGURE 11

1210

Receive a group assignment from the base station

1220

Receive a group scheduling bitmap from the base station, wherein the group scheduling bitmap comprises at least a mobile station presence bitmap and an SDMA bitmap

1230

Determine a resource allocation based on the group scheduling bitmap

1240

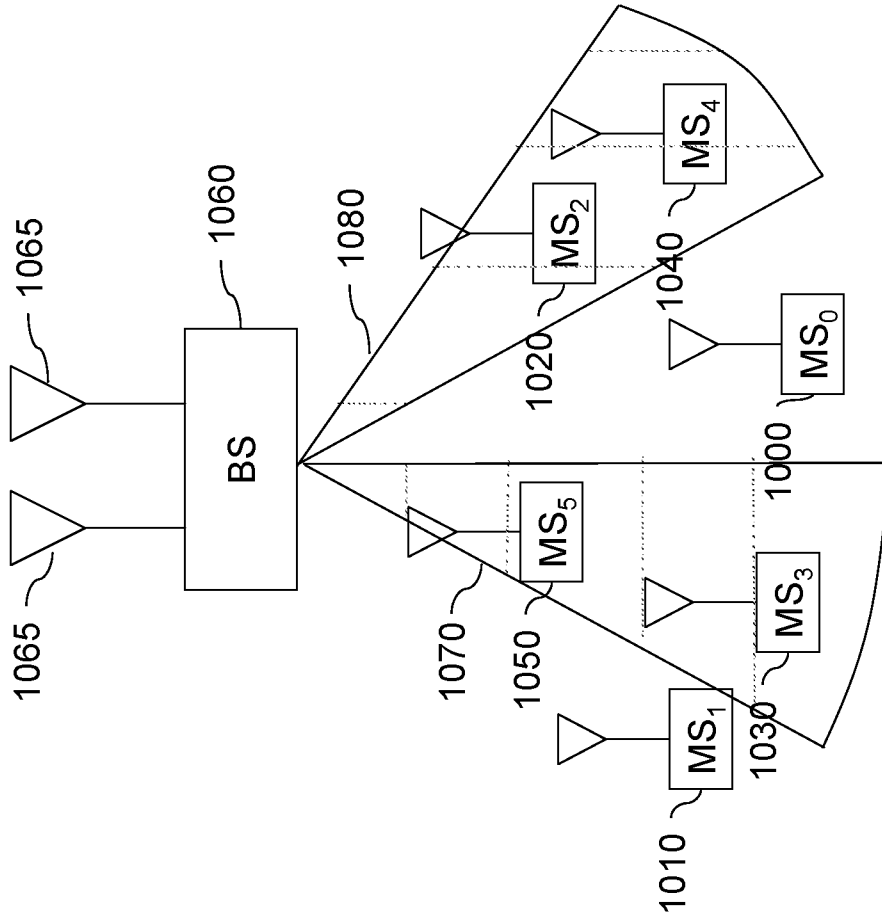Transmit a packet to the base station or receive a packet from the base station on the determined resource
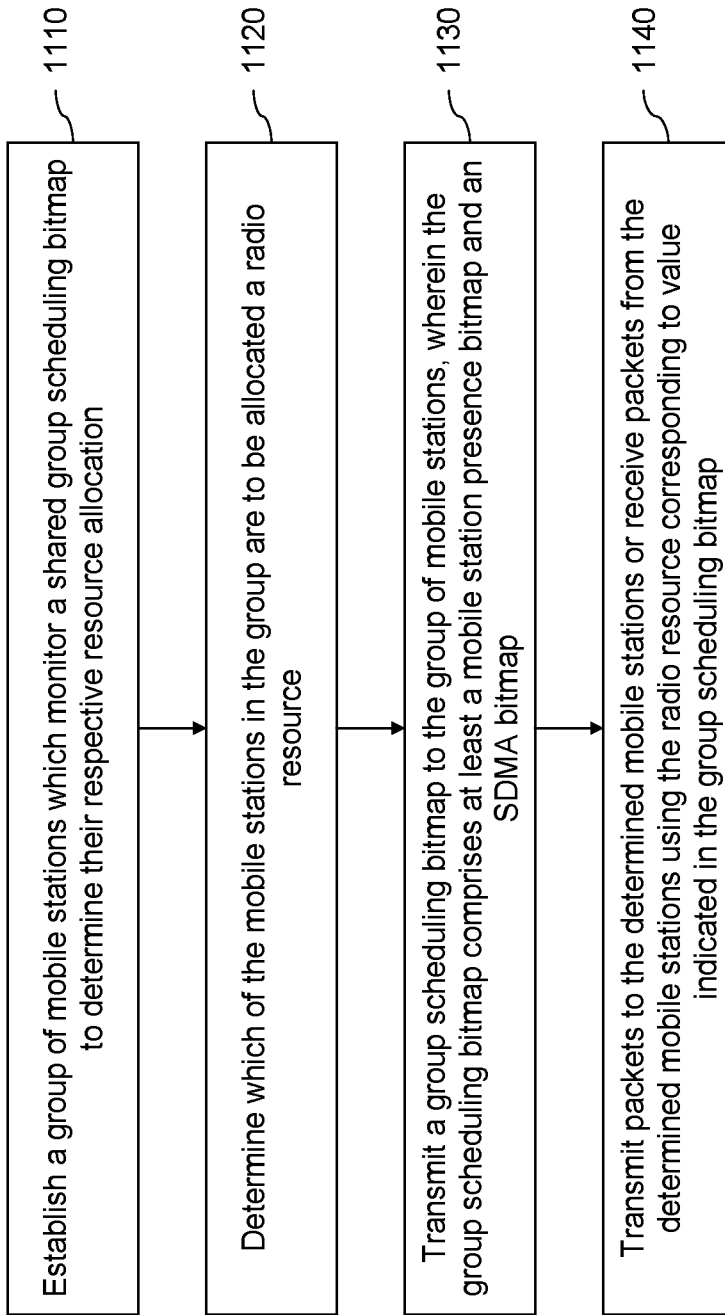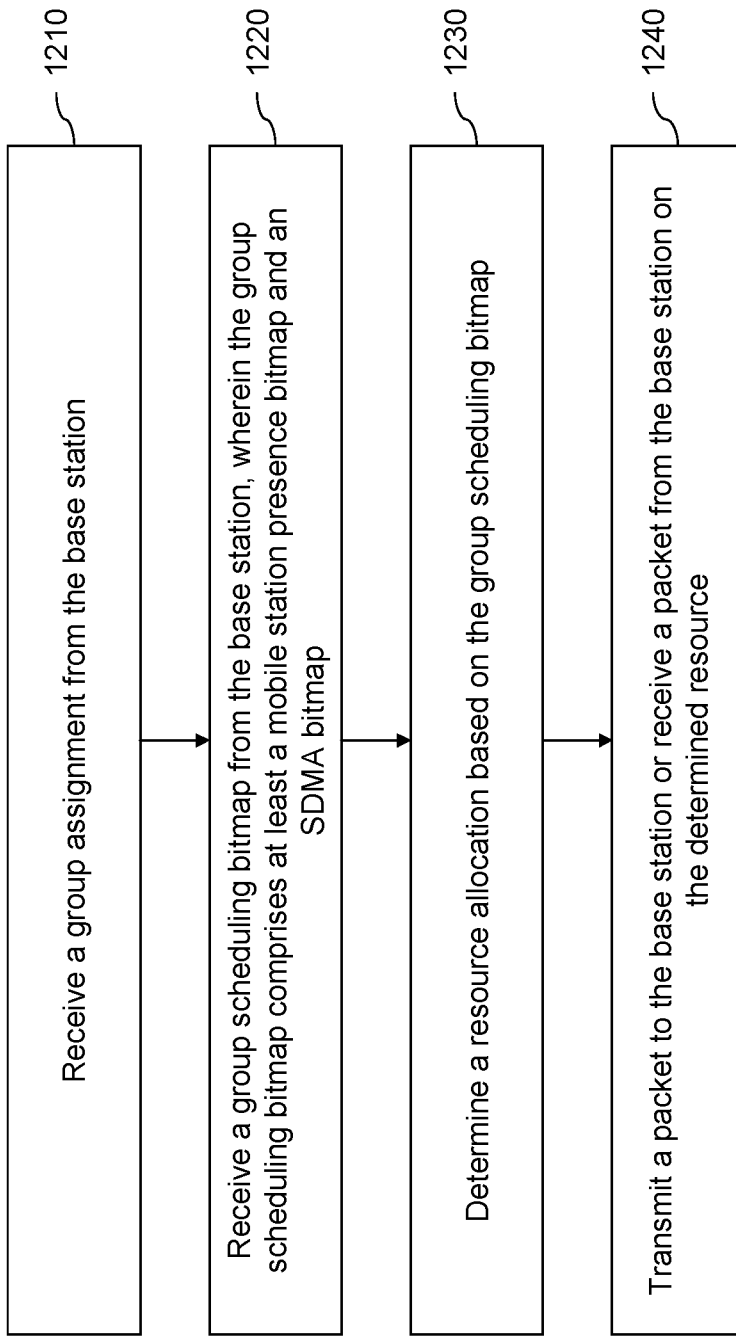
FIGURE 12

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2008/071316

A. CLASSIFICATION OF SUBJECT MATTER

See extra sheet

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: H04L, H04Q, H04B,H04J

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

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

WPI;EPODOC;PAJ; CNPAT;CNKI: bitmap, pattern, resource, allocat+, indicat+, wireless, radio, network, SDMA, OFDM, VoIP, group, cell, mobile station, base station, UMB

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CN1728695A (HUAWEI TECHNOLOGIES CO., LTD.) 01 Feb. 2006 (01.02.2006) Page 4, lines 12-22	1-20
A	CN1219306A (MOTOROLA INC.) 09 Jun. 1999 (09.06.1999) the whole document	1-20
A	CN1968453A (RES IN MOTION LTD.) 23 May 2007 (23.05.2007) the whole document	1-20
A	WO2007/033997A1 (UNIV. ILMENAU TECH.) 29 Mar. 2007 (29.03.2007) the whole document	1-20
A	US2006/0109865A1 (Park et al.) 25 May 2006 (25.05.2006) the whole document	1-20

☐ Further documents are listed in the continuation of Box C.   ☒ See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance		
"E"	earlier application or patent but published on or after the international filing date	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"L"	document which may throw doubts on priority claim (S) or which is cited to establish the publication date of another citation or other special reason (as specified)	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed	"&"	document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
10 Sep. 2008 (10.09.2008)	**25 Sep. 2008 (25.09.2008)**

Name and mailing address of the ISA/CN The State Intellectual Property Office, the P.R.China 6 Xitucheng Rd., Jimen Bridge, Haidian District, Beijing, China 100088 Facsimile No. 86-10-62019451	Authorized officer Li Tingting Telephone No. (86-10)62413487

Form PCT/ISA/210 (second sheet) (April 2007)

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CN1968453A	23.05.2007	US2007/0104135A1	10.05.2007
		EP1786225A1	16.05.2007
		SG132594A1	28.06.2007
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		KR20070050364A	15.05.2007
WO2007/033997A1	29.03.2007	DE102006043847A1	24.05.2007
US2006/0109865A1	25.05.2006	EP1662825A1	31.05.2006
		KR20060057937A	29.05.2006

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2008/071316

CLASSIFICATION OF SUBJECT MATTER

H04L29/08 (2006.01) i

H04Q7/24 (2006.01) i