



- (51) **International Patent Classification:**  
*H04W 72/04* (2009.01) *H04W 16/28* (2009.01)
- (21) **International Application Number:**  
PCT/EP2012/051646
- (22) **International Filing Date:**  
1 February 2012 (01.02.2012)
- (25) **Filing Language:** English
- (26) **Publication Language:** English
- (30) **Priority Data:**  
11290105.3 28 February 2011 (28.02.2011) EP
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- (81) **Designated States (unless otherwise indicated, for every kind of national protection available):** AE, AG, AL, AM,

AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

- (84) **Designated States (unless otherwise indicated, for every kind of regional protection available):** ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

**Declarations under Rule 4.17:**

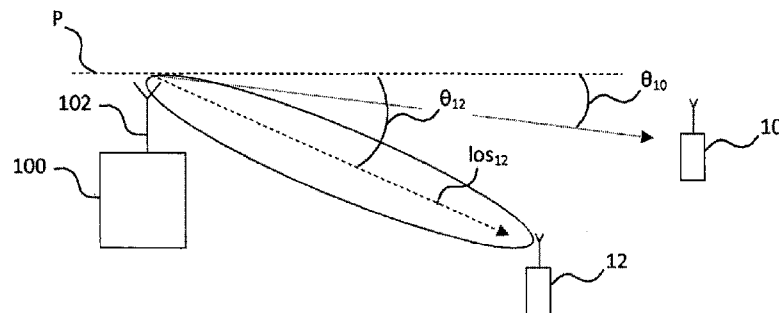
- as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))
- of inventorship (Rule 4.17(iv))

**Published:**

- with international search report (Art. 21(3))

(54) **Title:** METHOD OF ASSIGNING RADIO RESOURCES TO MOBILE TERMINALS BASED ON THE RELATIVE DISTANCE BETWEEN SAID MOBILE TERMINALS AND A BASE STATION

Fig. 2



(57) **Abstract:** The present invention relates to a method of operating a base station (100) for a cellular communications network, said method comprising: - the base station (100) determining (200) at least two terminals (10, 11, 12) which are served by the base station (100) and which are scheduled for the same primary radio resource, - the base station (100) assigning (210) individual portions of a secondary radio resource, which is different from said primary radio resource, to said at least two terminals (10, 11, 12) depending on a parameter which characterizes a vertical angle (θ<sub>12</sub>) between a virtual horizontal plane (P) associated with said base station (100) and a specific one of said terminals (10, 11, 12).

WO 2012/116868 A1

**METHOD OF ASSIGNING RADIO RESOURCES TO MOBILE TERMINALS  
BASED ON THE RELATIVE DISTANCE BETWEEN SAID MOBILE  
TERMINALS AND A BASE STATION**

5

**Specification**

10

Field of the Invention

The invention relates to a method of operating a base station for a cellular communications network. The invention further relates to a base station for a cellular communications network.

Background

Conventional base stations for cellular communications networks comprise antenna systems having one or more antennas which are mounted and adjusted during an installation of the base station in the field. Particularly, a tilt angle between a main beam direction of the antenna's characteristic beam pattern and a horizontal plane is manually adjusted by service technicians during the installation. After the installation, the tilt angle remains fixed, or it is adjusted electronically in a long-term scale, e.g. adapting to the traffic load during a day. However, this conventional installation generally applies the same tilt angle to all terminals in the cell.

There is a need to provide a more sophisticated base station and method of operating a base station which offer increased flexibility regarding the operational characteristics of the base station.

## 5 Summary

According to the present invention, regarding the above mentioned method of operating a base station, this object is achieved by: the base station determining at least two terminals which are served by the base station and which  
10 are scheduled for the same primary radio resource, the base station assigning individual portions of a secondary radio resource, which is different from said primary radio resource, to said at least two terminals depending on a parameter which characterizes a vertical angle between a  
15 virtual horizontal plane associated with said base station and a specific one of said terminals.

The vertical angle can be interpreted as an optimum downtilt or tilt angle which, when implemented by the base station, leads to optimum transmission conditions with  
20 respect to a specific terminal because a main lobe of a beam pattern of the base station's antenna would then be directed at said specific terminal. By assigning the second radio resource to said at least two terminals depending on a parameter which characterizes said vertical angle, a  
25 particularly efficient reduction of interference between neighboring cells may be achieved.

According to an embodiment, the vertical angle may e.g. correspond with a direction of the most distinctive propagation path (i.e., the path which offers a maximum  
30 received signal power) between the base station and the terminal. It is to be noted that, especially due to the effect of multipath propagation, a direction between the base station and the terminal as characterized by the vertical angle may differ from an angle that corresponds  
35 with a "direct line of sight" - type direction, because, due to reflections and other effects associated with

5 multipath propagation, the "direct line of sight" - type direction may not necessarily be associated with the most distinctive propagation path (i.e., the path which offers a maximum received signal power).

Advantageously, the method according to the embodiments  
10 does not require assessing feedback information or transmission quality information. Further, the method according to the embodiments does not require any inter-base station communication, e.g. between neighbouring base stations.

15 According to a preferred embodiment, said base station comprises an antenna a tilt angle of which can be controlled, wherein said base station uses individual tilt angles for single terminals and/or groups of terminals depending on said parameter which characterizes said  
20 vertical angle. Thus, individual terminals may optimally be served by the base station by adapting its antenna beam pattern to the respective terminals. However, if the antenna system is capable of implementing only comparatively few different values of the tilt angle, the  
25 terminals under consideration by the base station (i.e. those terminals which are scheduled for the same primary radio resource) are grouped into various terminal groups according to their respective vertical angles. I.e., several terminals having similar vertical angles may be put  
30 into one terminal group which is associated with one of the discrete tilt angles that may be used by the base station.

According to a particularly preferred embodiment, said primary radio resource is time, preferably transmission time slots, and said secondary radio resource is frequency,  
35 preferably frequency subchannels. For instance, cellular communications networks according to the LTE standard provide using transmission time slots and frequency

5 subchannels as primary and secondary radio resources.  
However, the present embodiments are not limited to this  
particular combination of radio resources. For instance,  
besides allocating frequency resources (such as e.g.  
frequency subchannels) to users/terminals that are served  
10 during the same time slot as described above, the principle  
according to the embodiments can generally also be applied  
by allocating different time resources (i.e., time slots)  
to users/terminals that are served on the same frequency  
resource (i.e., in this case, frequency is considered as  
15 the primary radio resource).

Apart from time and frequency, preferably orthogonal, codes  
may also be considered as radio resource in the sense of  
the present invention. Thus, a first radio resource may be  
frequency, and a second radio resource may be a specific  
20 code, and the like. In this case, the radio resource "code"  
is assigned to the various terminals served on the same  
frequency resources depending on the vertical angle.

According to a further preferred embodiment, said base  
station assigns a first number of, preferably adjacent,  
25 frequency subchannels to a first one of said at least two  
terminals, and said base station assigns a second number  
of, preferably adjacent, frequency subchannels to a second  
one of said at least two terminals. Within LTE systems, for  
example, resource blocks (RB) may be used to represent said  
30 frequency subchannels according to the present embodiment.  
The first and/or second number of frequency subchannels,  
are not necessarily adjacent to each other. Other types of  
assignment, i.e. comprising non-adjacent subchannels, are  
also possible.

35 According to a further preferred embodiment, said base  
station sorts said at least two terminals depending on said  
parameter which characterizes said vertical angle

- 5 associated with said terminals to obtain a sorted list of terminals, and said base station assigns said portions of said secondary radio resource depending on said sorted list of terminals, which represents a particularly efficient assignment technique.
- 10 Generally, said parameter which characterizes said vertical angle may e.g. be estimated and/or approximated, e.g. by determining a relative distance between the base station and the specific terminal (using signal strength measurements, delay measurements, and the like).
- 15 Destination of arrival estimation techniques may also be employed.

According to a further preferred embodiment, said step of assigning said secondary radio resource is performed according to a predetermined scheme, particularly

20 independent of feedback information that characterizes an actual quality of transmission between the base station and individual terminals. Thus, the embodiments represent a very simple, decentralized measure to distribute secondary radio resources to different terminals in the sense of

25 decreasing an overall interference between neighbouring cells. It is particularly advantageous, if neighboring base stations employ different variants of the scheme according to the embodiments so as e.g. not to assign the same secondary radio resources (e.g., frequency bands) to those

30 of their terminals which are in a cell border region, i.e. close to the neighboring base station. This may e.g. be ensured when deploying the base stations by providing different "start values" to the inventive radio resource assignment scheme such that neighboring base stations do

35 not employ identical variants of the scheme.

According to a further preferred embodiment, said predetermined scheme associates values and/or value ranges

5 of said parameter which characterizes a vertical angle with  
respective portions of said secondary radio resources.

Generally, an adjustment of the tilt angle may be performed  
in different ways. Firstly, if the base station's antenna  
is a phase-controlled antenna the beam pattern of which can  
10 be dynamically controlled by altering a phase of at least  
one signal supplied to an antenna element of said antenna  
(which is usually done by a corresponding antenna  
controller), an adjustment of the tilt angle may possibly  
be achieved by correspondingly controlling the beam  
15 pattern. I.e., the antenna may be electrically controlled  
so as to alter the tilt angle between an axis of a main  
lobe of said beam pattern and a horizontal plane.

Secondly, if the base station's antenna is not a phase-  
controlled antenna but rather a conventional antenna  
20 without the possibility of electrically controlling the  
beam pattern, and especially the tilt angle of the main  
lobe axis, a tilt angle adjustment in the sense of the  
embodiments may be accomplished by mechanical driving means  
which rotate the antenna around a predetermined axis such  
25 as e.g. an axis in the horizontal plane which extends  
substantially perpendicularly to the direction of  
propagation defined by the main lobe of the beam pattern.

Third, antennas with a limited number of adjustable  
downtilts, realized by different feeder networks within the  
30 antenna for the antenna elements, and selection of the  
appropriate one by mechanically or electronically switching  
between the available feeder networks, may also be employed  
for tilt angle adjustment according to an embodiment.

Of course, a combination of the aforementioned methods may  
35 also be employed for tilt angle adjustment.

5 A further solution to the object of the present invention is given by a base station according to claim 9. Further advantageous embodiments of the invention are given in the dependent claims.

#### Brief Description of the Figures

10 Further features, aspects and advantages of the present invention are given in the following detailed description with reference to the drawings in which:

Figure 1 depicts a simplified block diagram of a communications scenario according to an embodiment,  
15

Figure 2 depicts a simplified block diagram of a base station according to an embodiment,

Figure 3 schematically depicts frequency subchannels as employed by a method according to the embodiments,  
20

Figure 4 depicts a simplified flow chart of a method according to the embodiments, and

Figure 5a,

5b, 5c depict different resource assignment schemes according to an embodiment.  
25

#### Description of the Embodiments

Figure 1 depicts a simplified block diagram of a communications scenario according to an embodiment.

5 A base station 100 of a cellular communications network is depicted. The base station 100 may serve a number of terminals 10, 11, 12 by providing radio coverage in form of a radio cell 110 in a per se known manner. For instance, the base station 100 may operate according to at least one  
10 of the following standards: GSM (Global System for Mobile Communications), UMTS (Universal Mobile Telecommunications System), LTE (Long Term Evolution), WiMax (Worldwide Interoperability for Microwave Access), WLAN (Wireless Local Area Network). For the further exemplary  
15 explanations, it is assumed that the base station 100 is an LTE-compatible base station.

Further neighbouring radio cells 120, 130 of the communications network are also depicted by Fig. 1 which may correspondingly be served by further base stations that  
20 are not depicted in Fig. 1 for the sake of clarity. However, the further base stations which provide the further neighbouring radio cells 120, 130 may be co-located with the first base station 100.

Generally, even further base stations and their associated  
25 cells may also be provided within the network. Those further devices and cells are only indicated by dashed lines within Fig. 1 and form a generally hexagonal cell pattern for the communications network together with the cells 110, 120, 130.

30 As can be gathered from Fig. 2, the base station 100 comprises an antenna 102, a characteristic beam pattern of which is symbolized by the elliptical shape presently directed to the terminal 12. I.e., the main lobe of the beam pattern is currently aligned with the direction  $\text{los}_{12}$   
35 of the most distinctive propagation path (i.e., the path which offers a maximum received signal power) between the

5 base station 100 and the terminal 12. An associated vertical angle  $\theta_{12}$  between a virtual horizontal plane P associated with said base station 100 and said terminal 12, is obtained. Obviously, the vertical angle  $\theta_{12}$  depends, inter alia, on a distance between base station 100 and  
10 terminal 12. Moreover, a vertical position of the terminal 12, of course, may also influence the vertical angle  $\theta_{12}$ .

Generally, the direction  $\text{los}_{12}$  associated with the vertical angle  $\theta_{12}$  does not necessarily represent a direction of a "line of sight" between the devices 100, 12, because due to  
15 effects such as multipath propagation, the most distinctive propagation path (i.e., the path which offers a maximum received signal power) between the base station 100 and the terminal 12 may require a vertical angle  $\theta_{12}$  different from a direction of the "line of sight" between the devices 100,  
20 12. Presently, for illustration and simplification purposes, however, Figure 2 depicts a situation where the vertical angle  $\theta_{12}$  and a direction of the "line of sight" between base station 100 and terminal 12 are roughly equal to each other.

25 For instance, the further terminal 10, which is presently further away from the base station 100 (also cf. Fig. 1), correspondingly has another associated vertical angle  $\theta_{10} < \theta_{12}$ .

Generally, the vertical angle  $\theta_{12}$  associated with a  
30 terminal 12 corresponds with an optimum downtilt angle for the antenna 102. I.e., if the base station 100 controls its antenna pattern to assume the respective vertical angle  $\theta_{12}$  as downtilt angle, optimum communications conditions for communications with the specific terminal 12 are ensured.

5 According to a preferred embodiment, the base station 100 is configured to determine 200 (cf. the flow chart of Fig. 4) at least two terminals 10, 11, 12 which are served by the base station 100 and which are scheduled for the same primary radio resource, and to assign 210 (Fig. 4)  
10 individual portions of a secondary radio resource, which is different from said primary radio resource, to said at least two terminals 10, 11, 12 depending on a parameter which characterizes said vertical angle  $\theta_{12}$ , .. of the respective terminal 10, 11, 12.

15 In the exemplary context of an LTE system, the primary radio resource is time, preferably transmission time slots according to LTE standard, and said secondary radio resource is frequency, preferably frequency subchannels according to LTE standard.

20 I.e., in the first step 200 (Fig. 4), the base station determines, which terminals 10, 11, 12 (Fig. 1) are scheduled for e.g. the same transmission time slot (=“primary radio resource”). Then, in the second step 210 (Fig. 4), the base station assigns individual portions of a  
25 secondary radio resource, i.e. frequency subchannels, to said terminals 10, 11, 12 depending on a specific vertical angle  $\theta_{12}$ , .. of the terminals.

For instance, in step 200, the base station 100 determines that the two terminals 10, 11 are scheduled for a same  
30 transmission time slot. Thus, the assignment of the secondary radio resource, i.e. frequency subchannels, is performed as follows:

The base station 100 determines, which of the terminals 10, 11 has the smallest vertical angle. Presently, terminal 10  
35 has the smallest vertical angle  $\theta_{10}$ , since it is at a

5 border of the radio cell 110 (Fig. 1). Thus, the further terminal 11 is determined to have a larger vertical angle.

Depending on this sequence of the terminals 10, 11 regarding their vertical angles, the base station 100 assigns frequency subchannels to the terminals for a future data communications which is performed on the same primary radio resource, i.e., transmission time slot. For instance, a first group  $C_i$  of frequency subchannels, cf. Fig. 3, is assigned to the terminal 10, and a second group  $C_j$  of frequency subchannels, cf. Fig. 3, is assigned to the terminal 11. Of course, the number of frequency subchannels within the respective group  $C_i$ ,  $C_j$  is not necessarily the same as in the other groups assigned to other terminals. As per se known, the number of assigned frequency subchannels may actually depend on a desired data rate and the like.

20 The above explained resource assignment depending on the vertical angle of the terminals 10, 11 is particularly efficient and requires no coordination of the base station 100 with neighbour base stations in order decrease interference.

25 Moreover, according to the present embodiment, the base station 100 is not required to alter its tilt angle at all. It may rather "only" perform the inventive assignment of the secondary radio resource depending on the vertical angle that results from the relative position between base station and the terminals, i.e. without providing individual tilt angles for the respective terminals.

30 However, according to a further advantageous embodiment, the base station 100 may also adapt its tilt angle, preferably on a per-terminal basis. With this embodiment, in addition to the above explained assignment of

5 subchannels according to Fig. 3, the base station 100 additionally provides specific tilt angles for the transmissions with the terminals 10, 11, wherein the tilt angles are chosen to be identical or close to the actual vertical angles resulting from the positions of the  
10 terminals.

According to an embodiment, said base station 100 is configured to use individual tilt angles for single terminals 10, 11, 12. This can e.g. be done, if the base station comprises an electric tilt angle control which  
15 allows to control the tilt angle within a wide range of tilt angle values.

However, if the base station 100 can only provide for comparatively few different tilt angles, groups of terminals which have similar vertical angles may be served  
20 with the same tilt angle.

According to an embodiment, said base station 100 is configured to sort said at least two terminals 10, 11, 12 depending on said parameter which characterizes said vertical angle  $\theta_{12}$ , .. associated with said terminals 10,  
25 11, 12 to obtain a sorted list of terminals 10, 11, 12, and to assign said portions of said secondary radio resource depending on said sorted list of terminals 10, 11, 12. I.e., each terminal 10, 11, 12 is sorted according to its associated vertical angle  $\theta_{10}$ , ...,  $\theta_{12}$ .

30 Generally, said parameter which characterizes said vertical angle may e.g. be estimated and/or approximated, e.g. by determining a relative distance between the base station 100 and the specific terminal 10 (using signal strength measurements, delay measurements, and the like).

5 Destination of arrival estimation techniques may also be employed.

After the sorting step, the assignment of the secondary radio resource is performed.

According to a further preferred embodiment, said step 210  
10 of assigning said secondary radio resource is performed according to a predetermined scheme, particularly independent of feedback information that characterizes an actual quality of transmission between the base station 100 and individual terminals 10, 11, 12. Thus, the embodiments  
15 represent a very simple, decentralized measure to distribute secondary radio resources to different terminals 10, 11, 12 in the sense of decreasing an overall interference between neighbouring cells.

It is particularly advantageous, if neighboring base  
20 stations employ different variants of the scheme according to the embodiments so as e.g. not to assign the same secondary radio resources (e.g., frequency bands) to those of their terminals which are in a cell border region, i.e. close to the neighboring base station. This may e.g. be  
25 ensured when deploying the base stations by providing different "start values" to the inventive radio resource assignment scheme such that neighboring base stations do not employ identical variants of the scheme.

For example, considering that the base station 100 (Fig. 1)  
30 is co-located with two further base stations (not shown), each one of the three neighboring radio cells 110, 120, 130 is served by one of said base stations. If all three base stations adhere to the method according to the embodiments, they can assign secondary radio resources to their  
35 terminals according to respective vertical angles associate with the terminals. Generally, this assigning step will be

5 performed individually by each base station, i.e.  
separately and independently for each cell. However, to  
further reduce interference, according to an embodiment,  
each of the three considered base stations applies a  
slightly different variant of the inventive assigning  
10 scheme.

For instance, the first base station 100 employs the table  
depicted by Fig. 5a to assign specific resource blocks  
(i.e., frequency subchannels of the LTE system) as a  
secondary resource to its terminals 10, 11, 12. From the  
15 table of Fig. 5a it can be gathered that terminals with a  
vertical angle  $\theta$  ranging from a value  $\theta_0$  to a value  $\theta_1$  are  
assigned the resource blocks RB0 to RB16 (assuming a 10 MHz  
bandwidth LTE system which thus comprises a an overall  
range of resource blocks from RB0 to RB50). Terminals with  
20 a vertical angle  $\theta$  ranging from a value  $\theta_1$  to a value  $\theta_2$  are  
assigned the resource blocks RB17 to RB32. Terminals with a  
vertical angle  $\theta$  ranging from a value  $\theta_2$  to a value  $\theta_3$  are  
assigned the resource blocks RB33 to RB50.

For instance, the first terminal 10 is assigned the  
25 secondary resources RB0..RB16, the second terminal 11 is  
assigned the secondary resources RB17..RB32, and the third  
terminal 12 is assigned the secondary resources RB33..RB50  
within the radio cell 110 of the first base station 100.

The second base station (not shown), which provides the  
30 neighboring radio cell 120 for the terminals 20, 21, 22,  
however, uses a slightly different variant of the  
assignment scheme, namely the table according to Fig. 5b  
instead of Fig. 5a. As can be seen, the second table of  
Fig. 5b is a shifted variant of the table of Fig. 5a, with  
35 respect to the resource blocks, since it starts with RB17  
to RB32 for the smallest vertical angle.

- 5 Thus, in the second radio cell 120, the first terminal 20 is assigned the secondary resources RB17..RB32, the second terminal 21 is assigned the secondary resources RB33..RB50, and the third terminal 22 is assigned the secondary resources RB0..RB16 by its base station (not shown).
- 10 Likewise, the third base station (not shown), which is also co-located with the first base station 100, will assign frequency resources according to the table depicted by Fig. 5c to its terminals 30, 31, 32. Thus, it is advantageously ensured that inter-cell interference is reduced.
- 15 In effect, because the vertical angle usually correlates with a distance of a terminal to its base station, the above explained assignment schemes ensure that a distance-dependent distribution / assignment of secondary radio resources is performed within a cell. By employing
- 20 permutations of said assignment schemes as exemplified by Fig. 5a to 5c between neighboring base stations, it is possible to reduce interference without requiring communication of said base stations related to resource assignment.
- 25 The resource assignment according to the embodiments may rather be performed individually by each base station 100, independent of other base station. To ensure that neighboring base stations each start with different secondary resources values for the assignment, e.g. an
- 30 offset within a respective table (Fig. 5a) may be employed which depends on an identifier of the specific base station 100.

According to a particularly preferred embodiment, said primary radio resource is time, preferably transmission

35 time slots, and said secondary radio resource is frequency, preferably frequency subchannels, as already explained

5 above. For instance, cellular communications networks according to the LTE standard provide using transmission time slots and frequency subchannels as primary and secondary radio resources. However, the present embodiments are not limited to this particular combination of radio  
10 resources. For instance, besides allocating frequency resources (such as e.g. frequency subchannels) to users/terminals that are served during the same time slot as described above, the principle according to the embodiments can generally also be applied by allocating  
15 different time resources (i.e., time slots) to users/terminals that are served on the same frequency resource (i.e., in this case, frequency is considered as the primary radio resource).

Apart from time and frequency, preferably orthogonal, codes  
20 may also be considered as radio resource in the sense of the present invention. Thus, a first radio resource may be frequency, and a second radio resource may be a specific code, and the like. In this case, the radio resource "code" is assigned to the various terminals served on the same  
25 frequency resources depending on the vertical angle.

The above described examples comprise a particularly simple assignment rule for assignment of secondary radio resources to the terminals. However, more complex assignment schemes may also be applied.

30 The embodiments explained above are not limited to base stations 100 of cellular communications networks. The inventive principle may rather be applied to any base station serving a plurality of terminals and employing primary and secondary radio resources. Typically, the  
35 principle may be applied with GSM-, UMTS-, LTE-, and WiMAX-base stations.

5 The description and drawings merely illustrate the principles of the invention. It will thus be appreciated that those skilled in the art will be able to devise various arrangements that, although not explicitly described or shown herein, embody the principles of the invention and are included within its spirit and scope. 10 Furthermore, all examples recited herein are principally intended expressly to be only for pedagogical purposes to aid the reader in understanding the principles of the invention and the concepts contributed by the inventor(s) 15 to furthering the art, and are to be construed as being without limitation to such specifically recited examples and conditions. Moreover, all statements herein reciting principles, aspects, and embodiments of the invention, as well as specific examples thereof, are intended to 20 encompass equivalents thereof.

The functions of the various elements shown in the Figures, including any functional blocks labelled as 'processors', may be provided through the use of dedicated hardware as well as hardware capable of executing software in 25 association with appropriate software. When provided by a processor, the functions may be provided by a single dedicated processor, by a single shared processor, or by a plurality of individual processors, some of which may be shared. Moreover, explicit use of the term 'processor' or 30 'controller' should not be construed to refer exclusively to hardware capable of executing software, and may implicitly include, without limitation, digital signal processor (DSP) hardware, network processor, application specific integrated circuit (ASIC), field programmable gate array (FPGA), read only memory (ROM) for storing software, 35 random access memory (RAM), and non volatile storage. Other hardware, conventional and/or custom, may also be included. Similarly, any switches shown in the FIGS. are conceptual

5 only. Their function may be carried out through the  
operation of program logic, through dedicated logic,  
through the interaction of program control and dedicated  
logic, or even manually, the particular technique being  
selectable by the implementer as more specifically  
10 understood from the context.

5

**Claims**

- 10 1. Method of operating a base station (100) for a cellular communications network, said method comprising:
- 15 - the base station (100) determining (200) at least two terminals (10, 11, 12) which are served by the base station (100) and which are scheduled for the same primary radio resource,
  - 20 - the base station (100) assigning (210) individual portions of a secondary radio resource, which is different from said primary radio resource, to said at least two terminals (10, 11, 12) depending on a parameter which characterizes a vertical angle ( $\theta_{12}$ ) between a virtual horizontal plane (P) associated with said base station (100) and a specific one of said terminals (10, 11, 12).
- 25 2. Method according to claim 1, wherein said base station comprises an antenna (102) a tilt angle of which can be controlled, and wherein said base station (100) uses individual tilt angles for single terminals (10, 11, 12) and/or groups of terminals depending on said parameter which characterizes said vertical angle
- 30 ( $\theta_{10}, \dots, \theta_{12}$ ).
3. Method according to one of the preceding claims, wherein said primary radio resource is time, preferably transmission time slots, and wherein said

- 5 secondary radio resource is frequency, preferably  
frequency subchannels.
4. Method according to claim 3, wherein said base station  
(100) assigns a first number of, preferably adjacent,  
frequency subchannels ( $C_i$ ) to a first one of said at  
10 least two terminals (10, 11, 12), and wherein said  
base station (100) assigns a second number of,  
preferably adjacent, frequency subchannels ( $C_j$ ) to a  
second one of said at least two terminals (10, 11,  
12).
- 15 5. Method according to one of the preceding claims,  
wherein said base station (100) sorts said at least  
two terminals (10, 11, 12) depending on said parameter  
which characterizes said vertical angle ( $\theta_{12}$ )  
associated with said terminals (10, 11, 12) to obtain  
20 a sorted list of terminals (10, 11, 12), and wherein  
said base station (100) assigns said portions of said  
secondary radio resource depending on said sorted list  
of terminals (10, 11, 12).
6. Method according to one of the preceding claims,  
25 wherein said step of assigning (210) said secondary  
radio resource is performed according to a  
predetermined scheme, particularly independent of  
feedback information that characterizes an actual  
quality of transmission between the base station (100)  
30 and individual terminals (10, 11, 12).
7. Method according to claim 6, wherein said  
predetermined scheme associates values and/or value  
ranges of said parameter which characterizes a  
vertical angle ( $\theta_{12}$ ) with respective portions of said  
35 secondary radio resources.

- 5 8. Base station (100) for a cellular communications network, said base station (100) being configured to:
- 10 - determine (200) at least two terminals (10, 11, 12) which are served by the base station (100) and which are scheduled for the same primary radio resource, and to
  - 15 - assign (210) individual portions of a secondary radio resource, which is different from said primary radio resource, to said at least two terminals (10, 11, 12) depending on a parameter which characterizes a vertical angle ( $\theta_{12}$ ) between a virtual horizontal plane (P) associated with said base station (100) and a specific one of said terminals (10, 11, 12).
- 20 9. Base station (100) according to claim 8, wherein said base station comprises an antenna (102) a tilt angle of which can be controlled, and wherein said base station (100) is configured to use individual tilt angles for single terminals (10, 11, 12) and/or groups of terminals depending on said parameter which
- 25 characterizes said vertical angle ( $\theta_{12}$ ).
- 30 10. Base station (100) according to one of the claims 8 to 9, wherein said primary radio resource is time, preferably transmission time slots, and wherein said secondary radio resource is frequency, preferably frequency subchannels.
- 35 11. Base station (100) according to one of the claims 8 to 10, wherein said base station (100) is configured to assign a first number of, preferably adjacent, frequency subchannels ( $C_i$ ) to a first one of said at least two terminals (10, 11, 12), and to assign a

- 5           second number of, preferably adjacent, frequency  
subchannels (Cj) to a second one of said at least two  
terminals (10, 11, 12).
12.       Base station (100) according to one of the claims 8 to  
11, wherein said base station (100) is configured to  
10       sort said at least two terminals (10, 11, 12)  
depending on said parameter which characterizes said  
vertical angle ( $\theta_{12}$ ) associated with said terminals  
(10, 11, 12) to obtain a sorted list of terminals (10,  
11, 12), and to assign said portions of said secondary  
15       radio resource depending on said sorted list of  
terminals (10, 11, 12).
13.       Base station (100) according to one of the claims 8 to  
12, wherein said base station (100) is configured to  
perform said step of assigning (210) said secondary  
20       radio resource according to a predetermined scheme,  
particularly independent of feedback information that  
characterizes an actual quality of transmission  
between the base station (100) and individual  
terminals (10, 11, 12).
- 25       14.       Base station (100) according to one of the claims 8 to  
13, wherein said predetermined scheme associates  
values and/or value ranges of said parameter which  
characterizes a vertical angle ( $\theta_{12}$ ) with respective  
portions of said secondary radio resources.

Fig. 1

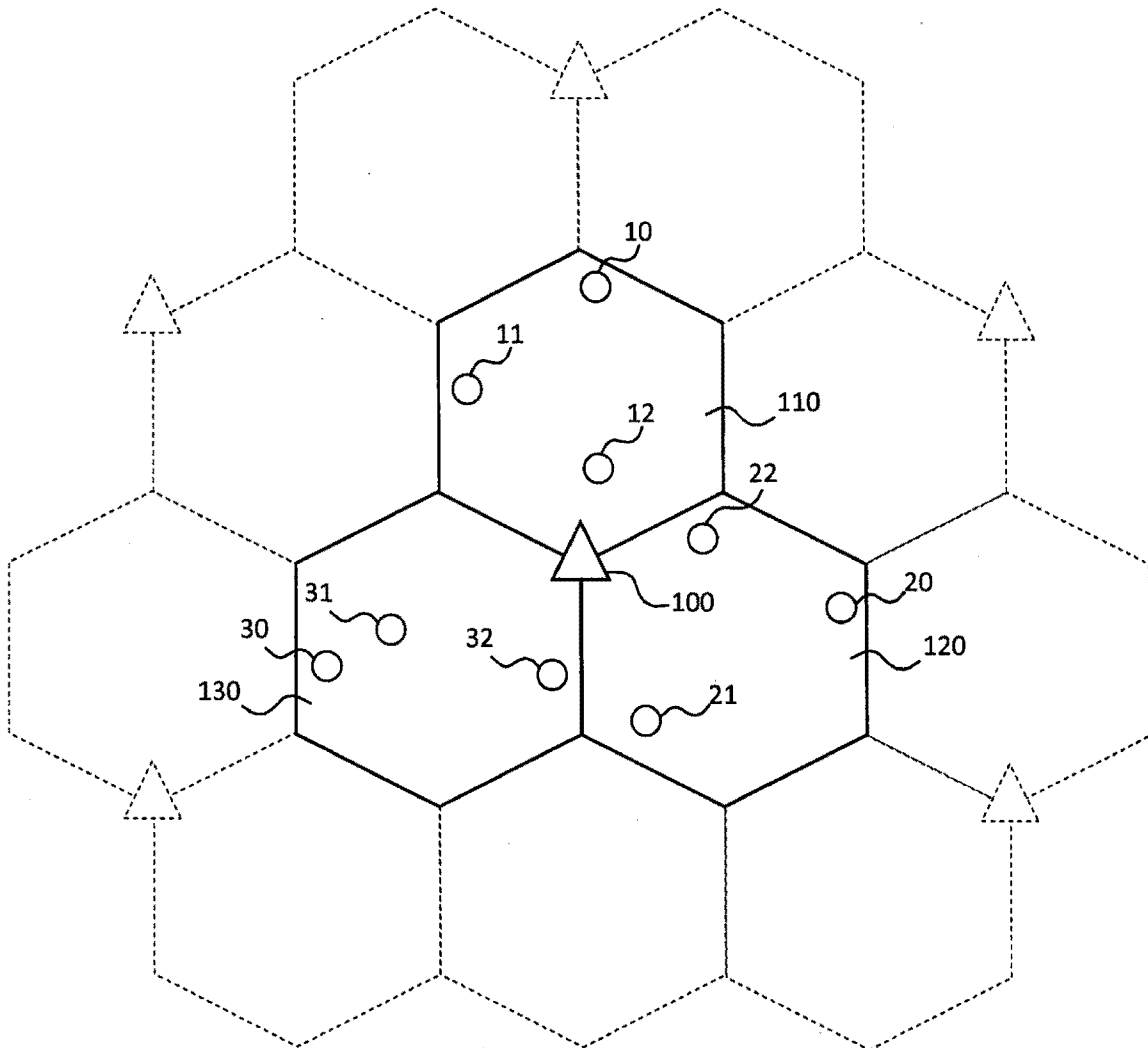


Fig. 2

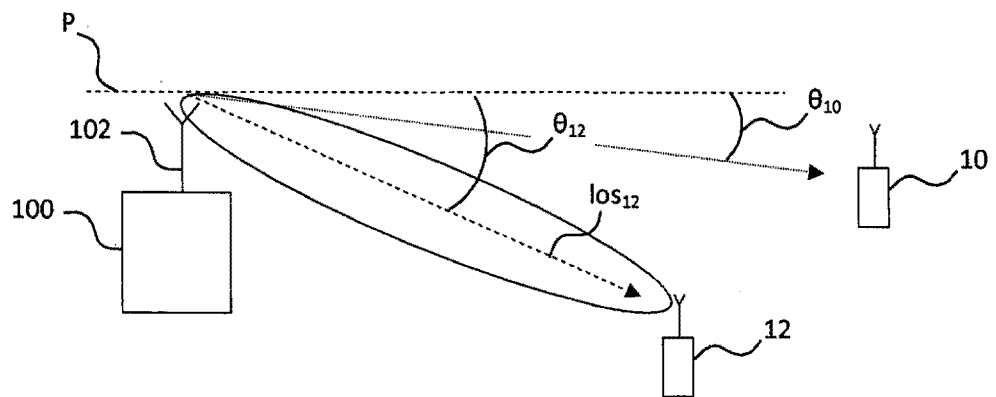


Fig. 3

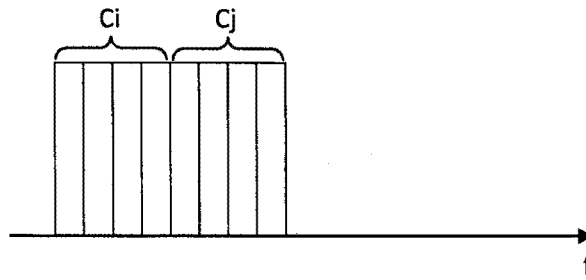


Fig. 4

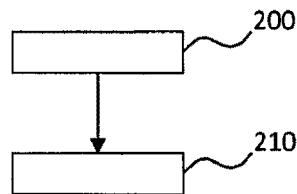


Fig. 5a

$\theta_0 < \theta \leq \theta_1$	$\theta_1 < \theta \leq \theta_2$	$\theta_2 < \theta \leq \theta_3$
RB0 .. RB16	RB17 .. RB32	RB33 .. RB50

Fig. 5b

$\theta_0 < \theta \leq \theta_1$	$\theta_1 < \theta \leq \theta_2$	$\theta_2 < \theta \leq \theta_3$
RB17 .. RB32	RB33 .. RB50	RB0 .. RB16

Fig. 5c

$\theta_0 < \theta \leq \theta_1$	$\theta_1 < \theta \leq \theta_2$	$\theta_2 < \theta \leq \theta_3$
RB33 .. RB50	RB0 .. RB16	RB17 .. RB32

INTERNATIONAL SEARCH REPORT

International application No  
PCT/EP2012/051646

A. CLASSIFICATION OF SUBJECT MATTER  
INV. H04W72/04  
ADD. H04W16/28

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)  
H04W

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 practical, search terms used)  
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2004/229651 A1 (HULKKONEN JARI [FI] ET AL) 18 November 2004 (2004-11-18) abstract figure 2 paragraph [0011] paragraph [0012] - paragraph [0018] paragraph [0042] paragraph [0045] - paragraph [0047] paragraph [0059] paragraph [0063] - paragraph [0064] paragraph [0071] paragraph [0075] claims 1-12  -----  -/--	1-14

Further documents are listed in the continuation of Box C.

See patent family annex.

\* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"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)

"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

"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

"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

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Date of the actual completion of the international search  27 February 2012	Date of mailing of the international search report  06/03/2012
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Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Authorized officer  Möll, Hans-Peter
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## INTERNATIONAL SEARCH REPORT

International application No  
PCT/EP2012/051646

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	EP 2 111 065 A1 (ALCATEL LUCENT DEUTSCHLAND AG [DE]) 21 October 2009 (2009-10-21) abstract paragraph [0006] - paragraph [0008] paragraph [0011] - paragraph [0013] paragraph [0022] - paragraph [0024] figure 2 -----	1-14
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