

(19) World Intellectual Property Organization  
International Bureau



(43) International Publication Date  
1 July 2004 (01.07.2004)

PCT

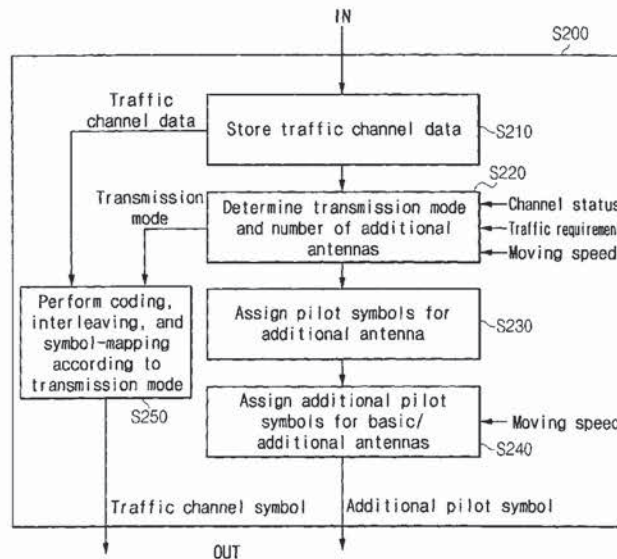
(10) International Publication Number  
WO 2004/056022 A2

- (51) International Patent Classification<sup>7</sup>: **H04J**
- (21) International Application Number:  
PCT/KR2003/001083
- (22) International Filing Date: 2 June 2003 (02.06.2003)
- (25) Filing Language: English
- (26) Publication Language: English
- (30) Priority Data:  
10-2002-0079598  
13 December 2002 (13.12.2002) KR
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- (81) Designated States (national): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NI, NO, NZ, OM, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.
- (84) Designated States (regional): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, RO, SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

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(54) Title: APPARATUS AND METHOD FOR SIGNAL CONSTITUTION FOR DOWNLINK OF OFDMA-BASED CELLULAR SYSTEM



(57) Abstract: Disclosed are an adaptive pilot symbol assignment method that flexibly controls the number of transmit antennas according to each user's moving speed, channel status, or user request, and assigns proper pilot symbols in the downlink of an OFDMA (Orthogonal Frequency Division Multiplexing Access) based cellular system; and a sub-carrier allocation method for high-speed mobile that allocates some sub-carriers to assign proper pilot symbols for ultrahigh-speed mobile users, and the rest of the sub-carriers to the other users to assign proper pilot symbols to the users, on the assumption that the ultrahigh-speed mobile users have a traffic volume almost insignificant to the whole traffic volume.

WO 2004/056022 A2



**Published:**

— without international search report and to be republished upon receipt of that report

*For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.*

## APPARATUS AND METHOD FOR SIGNAL CONSTITUTION FOR DOWNLINK OF OFDMA-BASED CELLULAR SYSTEM

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### BACKGROUND OF THE INVENTION

#### **(a) Field of the Invention**

The present invention relates to an apparatus and method for signal constitution for a downlink of an OFDMA (Orthogonal Frequency Division Multiplexing Access) based cellular system. More specifically, the present invention relates to an apparatus and method for adaptive pilot symbol assignment and sub-carrier allocation that reduces transmission power consumption and overhead caused by pilot symbols and increases the total data rate on the downlink of an OFDMA-based cellular system.

#### **(b) Description of the Related Art**

15 In the design of pilot assignment, it is necessary to use a sufficiently large number of pilot symbols for the sake of preventing a deterioration of reception performance caused by a channel variation, and to prevent an excessive increase of a power loss or a bandwidth loss caused by pilot symbols above an expected value. The positioning (assignment) of pilot symbols is of a great significance to the receiver of an OFDMA-based system, which estimates a transfer function value of channels in a two-dimensional (time, frequency) space. Hence, both the time domain and the frequency domain must be taken into consideration in pilot symbol assignment so as to transmit the pilot symbols. In case of using a plurality of  
20 antennas, the pilot symbols of the multiple antennas are assigned in  
25



consideration of both the time domain and the frequency domain.

The distance between pilot symbols must be quite small in designing pilot symbols in the worst environment, or when using non-optimal channel estimation filters having a lower complexity.

5 Let  $f_{sc}$  be a sub-carrier bandwidth, then the maximum pilot distance  $N_F$  in the frequency domain based on the conventional sampling theory (F. Classen, M. Speth, and H. Meyr, "Channel estimation units for an OFDM system suitable for mobile communication", in ITG Conference on Mobile Radio, Neu-Ulm, Germany, Sept. 1995) is determined by the following  
10 formula:

[Formula 1]

$$N_F \leq \frac{1}{\tau_{\max} f_{sc}}$$

where  $\tau_{\max}$  is the maximum exceedance delay time of a channel. The maximum pilot distance  $N_T$  in the frequency domain is determined by the  
15 following formula:

[Formula 2]

$$N_T \leq \frac{1}{2f_D T_s}$$

where  $f_D$  is the maximum Doppler frequency; and  $T_s$  is the symbol time.

The symbol time  $T_s$ , during which the maximum pilot distance is  
20 proportional to the coherent time, is normalized by the number of symbols. So, the maximum pilot distance in the time domain is proportional to the coherent bandwidth and normalized by the sub-carrier bandwidth.

The balanced design (P. Hoeher et al., "Pilot-symbol-aided channel estimation in time and frequency", Multi-carrier Spread-Spectrum, accepted for publication in *Kluwer Academic Publishers*, 1997) defines that the estimation uncertainty in the time domain is equal to that in the frequency domain. Here, P. Hoeher et al. suggest a design guide having two-fold oversampling as defined by a heuristic formula as follows:

[Formula 3]

$$2f_D T_s \cdot N_T \approx \tau_{\max} f_{sc} \cdot N_F \approx \frac{1}{2}$$

where  $N_F$  is the pilot distance in the frequency domain. The above-mentioned pilot symbol assignment is primarily a rectangular pilot symbol assignment, which is illustrated in FIG. 1. FIGS. 2 and 3 show a straight pilot symbol assignment and a hexagonal pilot symbol assignment, respectively. Generally, the hexagonal pilot symbol assignment allows more efficient sampling, compared with two-dimensional signals, and exhibits excellent performance relative to other assignments. An example of the pilot symbol assignment is disclosed in "Efficient pilot patterns for channel estimation in OFDM systems over HF channels" (M. J. Fernandez-Getino Garcia et al., in *Proc IEEE VTC1999*).

As the pilot symbol assignment becomes denser, the channel estimation performance becomes more excellent but the data rate is decreased. Hence, a trade-off lies between the data rate and the channel estimation performance (i.e., pilot symbol distance).

There exists a pilot symbol distance that optimizes the trade-off

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