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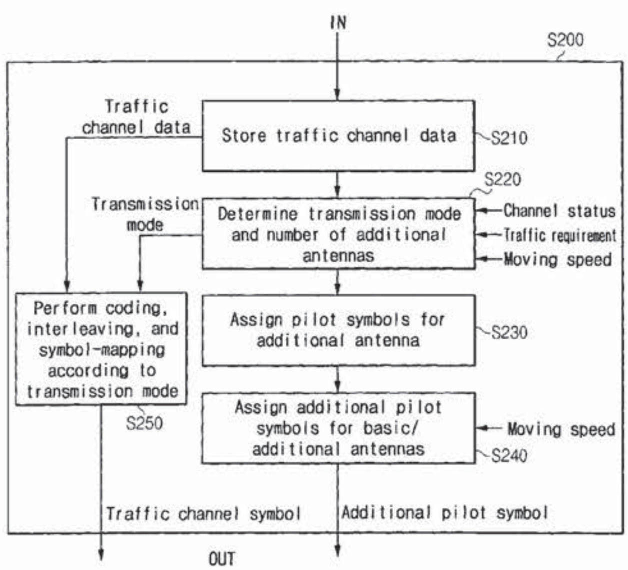
(54) Title: APPARATUS AND METHOD FOR SIGNAL CONSTITUTION FOR DOWNLINK OF OFDMA-BASED CELLULAR SYSTEM



(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.

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

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

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 antennas, the pilot symbols of the multiple antennas are assigned in 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.

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 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 following formula:

[Formula 2]

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

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 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 exits a pilot symbol distance that optimizes the trade-off

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