SPREAD CODE ALLOCATING METHOD, DESPREADING METHOD, TRANSMITTING DEVICE, RECEIVING DEVICE, COMMUNICATING DEVICE, WIRELESS BASE STATION DEVICE, AND MOBILE TERMINAL DEVICE

CROSS REFERENCE TO RELATED APPLICATIONS

This present application is a continuation of U.S. application Ser. No. 11/808,999, filed Jun. 14, 2007, now pending, which is a continuation of international application number PCT/JP2004/018661, which was filed on Dec. 14, 2004, the contents of each are herein wholly incorporated by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a technique for transmitting/receiving data in units of channels by using a two-dimensional spread code with which spreading is made in a time direction and a frequency direction.

2. Description of the Related Art

In recent years, in a mobile communication field, attention has been focused on, for example, an OFDM-CDMA method, into which an OFDM (Orthogonal Frequency Division Multiplexing) modulation method and a CDMA (Code Division Multiple Access) method are combined, as a multi-carrier modulation method. The OFDM modulation method is a modulation method having a high frequency use efficiency utilizing a plurality of mutually orthogonal subcarriers, whereas the CDMA method is a modulation method using a spread spectrum communication method the interference immunity of which is high. The OFDM-CDMA method, into which these two methods are combined, spreads at least either of time and frequency directions by using a two-dimensional spread code with which spreading can be made in the time and the frequency directions. This method is recited, for example, in Patent Documents 1 and 2.

In a mobile communication, the state of a propagation path of a channel varies by situation. If the state of a propagation path becomes worse, a transmission characteristic or a system capacity degrades. With the conventional technique recited in Patent Document 1, a transmitting side sets spreading factors in time and frequency directions according to the state of a propagation path of a channel in order to prevent a transmission characteristic and a system capacity from degrading. For example, the spreading factor in the frequency direction is set to a smaller value as a maximum delay time in the propagation path becomes longer, so that orthogonality between spread codes is prevented from degrading. Additionally, the spreading factor in the time direction is set to a smaller value as a maximum Doppler frequency in the propagation path becomes higher, so that orthogonality between spread codes is prevented from degrading.

With the conventional technique recited in Patent Document 1, a spreading factor that differs by user (receiving side) is applied according to the state of a propagation path, or the same spreading factor is applied to a plurality of users, when a transmitting side transmits a pilot symbol or the like for estimating a channel.

If a different spreading factor is applied, spread codes the number of which is equal to that of users are required. As a result, the capacity of the entire system becomes small, leading to a decrease in the efficiency of using the system capacity.

Additionally, since power equivalent to the number of users is required, also power consumption becomes higher.

In the meantime, if the same spreading factor is applied, power consumption can be further reduced. This is because each user makes despreading with the same spreading factor. However, since the reception characteristic of each user differs depending on the state of each propagation path, it is very difficult to directly identify an optimum spreading factor for each user. Therefore, it is vital to enable a plurality of users to receive data with a spreading factor according to the state of each propagation path while keeping the efficiency of using the system capacity high.

Patent Document 1: Japanese Published Unexamined Patent Application No. 2003-46474

Patent Document 2: Japanese Published Unexamined Patent Application No. 2004-48117

SUMMARY OF THE INVENTION

An object of the present invention is to provide a technique for enabling a plurality of users to receive data with spreading factors according to the states of propagation paths while keeping the efficiency of using a system capacity high in a communication method, such as an OFDM-CDMA method, which makes spreading by using a two-dimensional spread code.

A spread code allocating method according to the present invention is a method for allocating a two-dimensional spread code, with which spreading is made in time and frequency directions, to each channel. With this method, spread codes at least one of the time and the frequency directions of which are mutually orthogonal, and with which despreading can be made with spreading factors that are smaller than original spreading factors in the respective directions are selected as selection targets, and a spread code to be allocated to each channel is determined from among the spread codes selected as the selection targets.

It is desirable that the above described allocation of a spread code to each channel is made by targeting a predetermined channel.

Despreading methods according to first to third modes of the present invention are methods for causing a receiving device that receives a symbol of a channel, which is spread with a spread code allocated with the above described spread code allocating method and transmitted, to despread the symbol. These methods respectively cause the receiving device to despread the symbol as follows.

With the despreading method according to the first mode, received symbols of the same channel are despread respectively with a plurality of spreading factors including at least one of spreading factors in the time and the frequency directions, which is smaller than an original spreading factor, and a spreading factor used to despread a symbol of a channel different from the same channel is determined from results of despreading made respectively.

It is desirable that the above described same channel is a channel on which a pilot symbol is transmitted. Additionally, it is desirable to update the determined spreading factor depending on need based on a pilot symbol received after the determination. Or, it is desirable to update the symbol of the different channel based on a result of despreading made with the spreading factor. Furthermore, it is desirable to identify the moving velocity of the receiving device as opposed to a transmitting device that transmits the symbol of the channel, and to update the determined spreading factor depending on need based on a result of the identification. Still further, it is