

convolutional codes," IEEE Trans. Commun., vol. 53, no. 10, pp. 1630-1638, Oct. 2005.

NPL 4: C. Berrou, "The ten-year-old turbo codes are entering into service," IEEE Communication Magazine, vol. 41, no. 8, pp. 110-116, Aug. 2003.

NPL 5: DVB Document A122, Frame structure, channel coding and modulation for a second generation digital terrestrial television broadcasting system (DVB-T2), June 2008.

NPL 6: D.J.C. Mackay, "Good error-correcting codes based on very sparse matrices," IEEE Trans. Inform. Theory, vol. 45, no. 2, pp 399 - 431, March 1999.

NPL 7: S.M. Alamouti, "A simple transmit diversity technique for wireless communications," IEEE J. Select. Areas Commun., vol. 16, no. 8, pp. 1451-1458, Oct 1998.

NPL 8: V. Tarokh, H. Jafarkhani, and A.R. Calderbank, "Space-time block coding for wireless communications: Performance results," IEEE J. Select. Areas Commun., vol. 17, no. 3, no. 3, pp. 451-460, March 1999.

SUMMARY OF THE INVENTION

TECHNICAL PROBLEM

[0005]

A transmitting method, a receiving method, a transmitting apparatus, and a receiving apparatus which allow communication using a flexible frame configuration are provided.

SOLUTIONS TO PROBLEM

[0006]

According to a first aspect of the present invention, there is provided a

transmitting method including: configuring a preamble and one or more subframes following the preamble, the preamble carrying control information, the one or more subframes including a first subframe and a second subframe, the first subframe being configured by mapping first modulated signals of a first Physical Layer Pipe (PLP) and second modulated signals of a second PLP onto time-frequency resources used for data transmission in the first subframe, the second subframe being configured by mapping third modulated signals of a third PLP onto time-frequency resources used for data transmission in the second subframe; inserting pilot signals into the preamble and the one or more subframes; performing an Inverse Fast Fourier Transform (IFFT) processing on the preamble and the one or more subframes into which the pilot signals are inserted to generate an orthogonal frequency-division multiplexing (OFDM) signal; and transmitting the OFDM signal, wherein the time-frequency resources in the first subframe includes first resources and second resources that are provided for a first OFDM symbol and a second OFDM symbol, respectively, the first resources being arranged in a frequency direction and corresponding to respective OFDM subcarriers for data transmission, the second resources being arranged in the frequency direction and corresponding to the respective OFDM subcarriers for data transmission, the first resources being adjacent to the second resources in a time direction, the first modulated signals include a first sequence of first modulated signals and a second sequence of first modulated signals following the first sequence, the first sequence is mapped onto the first resources within a first range in the frequency direction, the second sequence is mapped onto the second resources within the first range, the second modulated signals include a third sequence of modulated signals and a fourth sequence of modulated signals following the third sequence, the third sequence is mapped onto the first resources within a second range in the frequency direction, the fourth sequence is mapped onto the second resources within the

second range, the control information includes first information, second information, and third information, the first information, specified as a position relative to a beginning of the first subframe, indicates a starting position of time-frequency resources provided for the first modulated signals, the second information, specified as a position relative to the beginning of the first subframe, indicates a starting position of time-frequency resources provided for the second modulated signals, and the third information, specified as a position relative to a beginning of the second subframe, indicates a starting position of time-frequency resources provided for the third modulated signals.

[0007]

According to a second aspect of the present invention, there is provided a receiving method including: receiving an orthogonal frequency-division multiplexing (OFDM) signal, wherein the OFDM signal is generated by inserting pilot signals into a preamble and one or more subframes following to the preamble and performing an Inverse Fast Fourier Transform (IFFT) process to the preamble and the one or more subframes into which the pilot signals are inserted, the preamble carries control information, the one or more subframes includes a first subframe and a second subframe, the first subframe is configured by mapping first modulated signals of a first Physical Layer Pipe (PLP) and second modulated signals of a second PLP onto time-frequency resources used for data transmission in the first subframe, the second subframe is configured by mapping third modulated signals of a third PLP onto time-frequency resources used for data transmission in the second subframe, the time-frequency resources in the first subframe includes first resources and second resources that are provided for a first OFDM symbol and a second OFDM symbol, respectively, the first resources being arranged in a frequency direction and corresponding to respective OFDM subcarriers for data transmission, the second

resources being arranged in the frequency direction and corresponding to the respective OFDM subcarriers for data transmission, the first resources being adjacent to the second resources in a time direction, the first modulated signals include a first sequence of first modulated signals and a second sequence of first modulated signals following the first sequence, the first sequence is mapped onto the first resources within a first range in the frequency direction, the second sequence is mapped onto the second resources within the first range, the second modulated signals include a third sequence of modulated signals and a fourth sequence of modulated signals following the third sequence, the third sequence is mapped onto the first resources within a second range in the frequency direction, the fourth sequence is mapped onto the second resources within the second range, the control information includes first information, second information, and third information, the first information, specified as a position relative to a beginning of the first subframe, indicates a starting position of time-frequency resources provided for the first modulated signals, the second information, specified as a position relative to the beginning of the first subframe, indicates a starting position of time-frequency resources provided for the second modulated signals, and the third information, specified as a position relative to a beginning of the second subframe, indicates a starting position of time-frequency resources provided for the third modulated signals, and the receiving method further comprises demodulating the received OFDM signal to obtain received data of the first PLP, the second PLP, or the third PLP by using the time-frequency resources provided for the PLP to be received.

[0008]

According to a third aspect of the present invention, there is provided a transmitting apparatus including: a frame configurator that, in operation, configures a preamble and one or more subframes following the preamble, the preamble carrying

control information, the one or more subframes including a first subframe and a second subframe, the first subframe being configured by mapping first modulated signals of a first Physical Layer Pipe (PLP) and second modulated signals of a second PLP onto time-frequency resources used for data transmission in the first subframe, the second subframe being configured by mapping third modulated signals of a third PLP onto time-frequency resources used for data transmission in the second subframe; a pilot inserter that, in operation, inserts pilot signals into the preamble and the one or more subframes; an Inverse Fast Fourier Transform (IFFT) processor that, in operation, performs an IFFT processing on the preamble and the one or more subframes into which the pilot signals are inserted to generate an orthogonal frequency-division multiplexing (OFDM) signal; and a transmitter that, in operation, transmits the OFDM signal, wherein the time-frequency resources in the first subframe includes first resources and second resources that are provided for a first OFDM symbol and a second OFDM symbol, respectively, the first resources being arranged in a frequency direction and corresponding to respective OFDM subcarriers for data transmission, the second resources being arranged in the frequency direction and corresponding to the respective OFDM subcarriers for data transmission, the first resources being adjacent to the second resources in a time direction, the first modulated signals include a first sequence of first modulated signals and a second sequence of first modulated signals following the first sequence, the first sequence is mapped onto the first resources within a first range in the frequency direction, the second sequence is mapped onto the second resources within the first range, the second modulated signals include a third sequence of modulated signals and a fourth sequence of modulated signals following the third sequence, the third sequence is mapped onto the first resources within a second range in the frequency direction, the fourth sequence is mapped onto the second resources within the second range, the

control information includes first information, second information, and third information, the first information, specified as a position relative to a beginning of the first subframe, indicates a starting position of time-frequency resources provided for the first modulated signals, the second information, specified as a position relative to the beginning of the first subframe, indicates a starting position of time-frequency resources provided for the second modulated signals, and the third information, specified as a position relative to a beginning of the second subframe, indicates a starting position of time-frequency resources provided for the third modulated signals.

[0009]

According to a fourth aspect of the present invention, there is provided a receiving apparatus including: a receiver that, in operation, receives an orthogonal frequency-division multiplexing (OFDM) signal, wherein the OFDM signal is generated by inserting pilot signals into a preamble and one or more subframes following to the preamble and performing an Inverse Fast Fourier Transform (IFFT) process to the preamble and the one or more subframes into which the pilot signals are inserted, the preamble carries control information, the one or more subframes includes a first subframe and a second subframe, the first subframe is configured by mapping first modulated signals of a first Physical Layer Pipe (PLP) and second modulated signals of a second PLP onto time-frequency resources used for data transmission in the first subframe, the second subframe is configured by mapping third modulated signals of a third PLP onto time-frequency resources used for data transmission in the second subframe, the time-frequency resources in the first subframe includes first resources and second resources that are provided for a first OFDM symbol and a second OFDM symbol, respectively, the first resources being arranged in a frequency direction and corresponding to respective OFDM subcarriers for data transmission, the second resources being arranged in the frequency direction and corresponding to the

respective OFDM subcarriers for data transmission, the first resources being adjacent to the second resources in a time direction, the first modulated signals include a first sequence of first modulated signals and a second sequence of first modulated signals following the first sequence, the first sequence is mapped onto the first resources within a first range in the frequency direction, the second sequence is mapped onto the second resources within the first range, the second modulated signals include a third sequence of modulated signals and a fourth sequence of modulated signals following the third sequence, the third sequence is mapped onto the first resources within a second range in the frequency direction, the fourth sequence is mapped onto the second resources within the second range, the control information includes first information, second information, and third information, the first information, specified as a position relative to a beginning of the first subframe, indicates a starting position of time-frequency resources provided for the first modulated signals, the second information, specified as a position relative to the beginning of the first subframe, indicates a starting position of time-frequency resources provided for the second modulated signals, and the third information, specified as a position relative to a beginning of the second subframe, indicates a starting position of time-frequency resources provided for the third modulated signals, and the receiving apparatus further comprises a demodulator that, in operation, demodulates the received OFDM signal to obtain received data of at least one PLP among the first PLP, the second PLP, and the third PLP by using the time-frequency resources provided for the at least one PLP.

ADVANTAGEOUS EFFECTS OF INVENTION

[0010]

According to the transmitting apparatus, the receiving apparatus, the

transmitting method, and the receiving method according to the present disclosure, communication can be performed using a flexible frame configuration. This yields advantageous effects that high efficiency in data transmission can be achieved in a communications system and furthermore the receiving apparatus can efficiently obtain data.

BRIEF DESCRIPTION OF DRAWINGS

[0011]

FIG. 1 is a view illustrating an example of a configuration of a transmitting apparatus.

FIG. 2 is a view illustrating an example of a frame configuration.

FIG. 3 is a view illustrating an example of a frame configuration.

FIG. 4 is a view illustrating an example of a frame configuration.

FIG. 5 is a view illustrating an example of a frame configuration.

FIG. 6 is a view illustrating an example of a frame configuration.

FIG. 7 is a view illustrating an example of a configuration in a case where a transmitting method using space time block codes is performed.

FIG. 8 is a view illustrating an example of a configuration in a case where the transmitting method using space time block codes is performed.

FIG. 9 is a view illustrating an example of a configuration in a case where a transmitting method using an MIMO method is performed.

FIG. 10 is a view illustrating an example of a configuration in a case where the transmitting method using the MIMO method is performed.

CLAIMS

1. A transmitting method comprising:

configuring a preamble and one or more subframes following the preamble, the preamble carrying control information, the one or more subframes including a first subframe and a second subframe, the first subframe being configured by mapping first modulated signals of a first Physical Layer Pipe (PLP) and second modulated signals of a second PLP onto time-frequency resources used for data transmission in the first subframe, the second subframe being configured by mapping third modulated signals of a third PLP onto time-frequency resources used for data transmission in the second subframe;

inserting pilot signals into the preamble and the one or more subframes;

performing an Inverse Fast Fourier Transform (IFFT) processing on the preamble and the one or more subframes into which the pilot signals are inserted to generate an orthogonal frequency-division multiplexing (OFDM) signal; and

transmitting the OFDM signal, wherein

the time-frequency resources in the first subframe includes first resources and second resources that are provided for a first OFDM symbol and a second OFDM symbol, respectively, the first resources being arranged in a frequency direction and corresponding to respective OFDM subcarriers for data transmission, the second resources being arranged in the frequency direction and corresponding to the respective OFDM subcarriers for data transmission, the first resources being adjacent to the second resources in a time direction,

the first modulated signals include a first sequence of first modulated signals and a second sequence of first modulated signals following the first sequence,

the first sequence is mapped onto the first resources within a first range in the frequency direction,

the second sequence is mapped onto the second resources within the first range,

the second modulated signals include a third sequence of modulated signals and a fourth sequence of modulated signals following the third sequence,

the third sequence is mapped onto the first resources within a second range in the frequency direction,

the fourth sequence is mapped onto the second resources within the second range,

the control information includes first information, second information, and third information,

the first information, specified as a position relative to a beginning of the first subframe, indicates a starting position of time-frequency resources provided for the first modulated signals,

the second information, specified as a position relative to the beginning of the first subframe, indicates a starting position of time-frequency resources provided for the second modulated signals, and

the third information, specified as a position relative to a beginning of the second subframe, indicates a starting position of time-frequency resources provided for the third modulated signals.

2. The transmitting method according to claim 1, wherein

a last modulated signal of the first sequence is mapped onto a resource among the first resources corresponding to a highest frequency in the first range, and

an initial modulated signal of the second sequence is mapped onto a resource among the second resources corresponding to a lowest frequency in the first range.

3. A receiving method comprising:

receiving an orthogonal frequency-division multiplexing (OFDM) signal, wherein the OFDM signal is generated by inserting pilot signals into a preamble and one or more subframes following to the preamble and performing an Inverse Fast Fourier Transform (IFFT) process to the preamble and the one or more subframes into which the pilot signals are inserted,

the preamble carries control information,

the one or more subframes includes a first subframe and a second subframe, the first subframe is configured by mapping first modulated signals of a first Physical Layer

Pipe (PLP) and second modulated signals of a second PLP onto time-frequency resources used for data transmission in the first subframe, the second subframe is configured by mapping third modulated signals of a third PLP onto time-frequency resources used for data transmission in the second subframe,

the time-frequency resources in the first subframe includes first resources and second resources that are provided for a first OFDM symbol and a second OFDM symbol, respectively, the first resources being arranged in a frequency direction and corresponding to respective OFDM subcarriers for data transmission, the second resources being arranged in the frequency direction and corresponding to the respective OFDM subcarriers for data transmission, the first resources being adjacent to the second resources in a time direction,

the first modulated signals include a first sequence of first modulated signals and a second sequence of first modulated signals following the first sequence,

the first sequence is mapped onto the first resources within a first range in the frequency direction,

the second sequence is mapped onto the second resources within the first range,

the second modulated signals include a third sequence of modulated signals and a fourth sequence of modulated signals following the third sequence,

the third sequence is mapped onto the first resources within a second range in the frequency direction,

the fourth sequence is mapped onto the second resources within the second range,

the control information includes first information, second information, and third information,

the first information, specified as a position relative to a beginning of the first subframe, indicates a starting position of time-frequency resources provided for the first modulated signals,

the second information, specified as a position relative to the beginning of the first subframe, indicates a starting position of time-frequency resources provided for the second modulated signals, and

the third information, specified as a position relative to a beginning of the second subframe, indicates a starting position of time-frequency resources provided for the third modulated signals, and

the receiving method further comprises

demodulating the received OFDM signal to obtain received data of the first PLP, the second PLP, or the third PLP by using the time-frequency resources provided for the PLP to be received.

4. The receiving method according to claim 3, wherein

a last modulated signal of the first sequence is mapped onto a resource among the first resources corresponding to a highest frequency in the first range, and

an initial modulated signal of the second sequence is mapped onto a resource among the second resources corresponding to a lowest frequency in the first range.

5. A transmitting apparatus comprising:

a frame configurator that, in operation, configures a preamble and one or more subframes following the preamble, the preamble carrying control information, the one or more subframes including a first subframe and a second subframe, the first subframe being configured by mapping first modulated signals of a first Physical Layer Pipe (PLP) and second modulated signals of a second PLP onto time-frequency resources used for data transmission in the first subframe, the second subframe being configured by mapping third modulated signals of a third PLP onto time-frequency resources used for data transmission in the second subframe;

a pilot inserter that, in operation, inserts pilot signals into the preamble and the one or more subframes;

an Inverse Fast Fourier Transform (IFFT) processor that, in operation, performs an IFFT processing on the preamble and the one or more subframes into which the pilot signals are inserted to generate an orthogonal frequency-division multiplexing (OFDM) signal; and

a transmitter that, in operation, transmits the OFDM signal, wherein

the time-frequency resources in the first subframe includes first resources and second resources that are provided for a first OFDM symbol and a second OFDM symbol, respectively, the first resources being arranged in a frequency direction and corresponding to respective OFDM subcarriers for data transmission, the second resources being arranged in the frequency direction and corresponding to the respective OFDM subcarriers for data transmission, the first resources being adjacent to the second resources in a time direction,

the first modulated signals include a first sequence of first modulated signals and a second sequence of first modulated signals following the first sequence,

the first sequence is mapped onto the first resources within a first range in the frequency direction,

the second sequence is mapped onto the second resources within the first range,

the second modulated signals include a third sequence of modulated signals and a fourth sequence of modulated signals following the third sequence,

the third sequence is mapped onto the first resources within a second range in the frequency direction,

the fourth sequence is mapped onto the second resources within the second range,

the control information includes first information, second information, and third information,

the first information, specified as a position relative to a beginning of the first subframe, indicates a starting position of time-frequency resources provided for the first modulated signals,

the second information, specified as a position relative to the beginning of the first subframe, indicates a starting position of time-frequency resources provided for the second modulated signals, and

the third information, specified as a position relative to a beginning of the second subframe, indicates a starting position of time-frequency resources provided for the third modulated signals.

6. The transmitting apparatus according to claim 5, wherein
a last modulated signal of the first sequence is mapped onto a resource among the first resources corresponding to the highest frequency in the first range, and
an initial modulated signal of the second sequence is mapped onto a resource among the second resources corresponding to the lowest frequency in the first range.
7. A receiving apparatus comprising:
a receiver that, in operation, receives an orthogonal frequency-division multiplexing (OFDM) signal, wherein
the OFDM signal is generated by inserting pilot signals into a preamble and one or more subframes following to the preamble and performing an Inverse Fast Fourier Transform (IFFT) process to the preamble and the one or more subframes into which the pilot signals are inserted,
the preamble carries control information,
the one or more subframes includes a first subframe and a second subframe, the first subframe is configured by mapping first modulated signals of a first Physical Layer Pipe (PLP) and second modulated signals of a second PLP onto time-frequency resources used for data transmission in the first subframe, the second subframe is configured by mapping third modulated signals of a third PLP onto time-frequency resources used for data transmission in the second subframe,
the time-frequency resources in the first subframe includes first resources and second resources that are provided for a first OFDM symbol and a second OFDM symbol, respectively, the first resources being arranged in a frequency direction and corresponding to respective OFDM subcarriers for data transmission, the second resources being arranged in the frequency direction and corresponding to the respective OFDM subcarriers for data transmission, the first resources being adjacent to the second resources in a time direction,
the first modulated signals include a first sequence of first modulated signals and a second sequence of first modulated signals following the first sequence,
the first sequence is mapped onto the first resources within a first range in the frequency direction,

the second sequence is mapped onto the second resources within the first range,
the second modulated signals include a third sequence of modulated signals and
a fourth sequence of modulated signals following the third sequence,

the third sequence is mapped onto the first resources within a second range in
the frequency direction,

the fourth sequence is mapped onto the second resources within the second
range,

the control information includes first information, second information, and third
information,

the first information, specified as a position relative to a beginning of the first
subframe, indicates a starting position of time-frequency resources provided for the first
modulated signals,

the second information, specified as a position relative to the beginning of the
first subframe, indicates a starting position of time-frequency resources provided for the
second modulated signals, and

the third information, specified as a position relative to a beginning of the second
subframe, indicates a starting position of time-frequency resources provided for the third
modulated signals, and

the receiving apparatus further comprises

a demodulator that, in operation, demodulates the received OFDM signal to
obtain received data of at least one PLP among the first PLP, the second PLP, and the
third PLP by using the time-frequency resources provided for the at least one PLP.

8. The receiving apparatus according to claim 7, wherein

a last modulated signal of the first sequence is mapped onto a resource among
the first resources corresponding to a highest frequency in the first range, and

an initial modulated signal of the second sequence is mapped onto a resource
among the second resources corresponding to a lowest frequency in the first range.