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Data Hiding Capacity of Spatial Domain Bit Replacement Steganography in an MIMO-OFDM Coding Channel

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Abstract—Based on the data hiding principle in the error correction coding channel, a data hiding system based on spatial domain LSB steganography and a capacity analysis model for an MIMO-OFDM coding channel are presented. The hiding capacity equation for the MIMO-OFDM coding channel is proposed and verified by analysis and experimental results. Then, the effect of the OFDM parameters, the FFT length and the guard interval on the data hiding capacity performance is also analysed. In addition, the impact of the antenna diversity technique, the maximum multi-path delay and the Doppler shift on the BER performance of the MIMO-OFDM data hiding system is presented and analysed. Finally, the data hiding capacity of the MIMO-OFDM channel is compared with the hiding capacity performance of the SISO channel, the OFDM channel and the MIMO channel in a MATLAB simulation. According to the experimental results, under the same conditions, the BER of the carrier data, the accuracy of the secret data and the data hiding capacity in the MIMO-OFDM system are better than those in the SISO, OFDM and MIMO coding channel systems.
Keywords—MIMO-OFDM, Coding channel, Data hiding, Hiding capacity

1. Introduction

Data hiding is one of the most important technologies in the information security research field, and it had been widely used in secure communication, copyright protection and other fields [1-4]. Traditional host carriers such as text, image, audio and video are generally used in data hiding, while the data hiding systems based on these carriers always change the statistical properties of the original host carriers [5,6]. We all know that noise interference is definitely inevitable when data are transmitted in real channels, but it is useful for data hiding. The secret data can be embedded into the channel carrier as a part of noise, and if the total errors caused by secret data and channel interference are not higher than the error correcting capability of the coding channel, data hiding in the coding channel can be achieved [7].

In fading channels, MIMO (multiple-input multiple-output) technology can make spatial multiplexing gain and spatial diversity by using space-time coding [8], but the inter symbol interference caused by frequency selectivity will hinder signals transmitting steadily in broadband wireless channels. So far, there are two ways, namely, equalization and OFDM (orthogonal frequency division multiplexing) modulation, to decrease the effect of frequency selectivity [9]. According to the previous study, when MIMO is applied, if the symbol period is shorter than the coherence time, the frequency selective fading can be limited and the design of the receiver can be simplified. For a communication system based on channel coding, both the MIMO and OFDM technologies can improve the communication performance. Thus, the combination of MIMO and OFDM provides a new implementation for the broadband wireless communication service [10].

Although encryption and error correction coding can improve the security and accuracy of secret data to a certain extent, data hiding based on traditional host carriers changes the statistical properties of the original carriers, which will arouse the suspicion of attackers and thus destroy the imperceptibility of the hiding system. When data are transmitted in a real communication channel, noise interference can be used to provide a new direction for data hiding in that the secret data are embedded within limits into the channel carrier as a part of noise, and data hiding in the coding channel can thereby be realized. A data hiding algorithm based on RS (reed-solomon) channel coding was presented in [11], data after RS channel coding serves as the host carrier, the secret data are embedded into the data stream as random noise and then the secret data are extracted and recovered in the receiver. Experimental results showed that when the total errors caused by secret data and channel interference are not higher than the error correcting capability of the coding channel, the receiver can recover the host carrier data and obtain the secret data correctly. Since then, with the development of the channel coding theory, data hiding schemes based on BCH (Bose, Ray, Hocquenghem) coding, convolution coding and LDPC (low density parity check) coding have been proposed [12]. It is also proven that the imperceptibility and security of the data hiding system can be improved with the enhancement of the error correcting capability in the coding channel.

As wireless communication is developing towards broadband, the combination of MIMO and OFDM technologies has drawn considerable attention. A data hiding algorithm based on MIMO technologies had been proposed in [13]. Because of the independence of sub-channels and the property that channel capacity increases linearly with the