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The Tight Bound for the Number of Pilots in Channel Estimation for OFDM Systems

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ABSTRACT

Coherent detection in OFDM systems requires accurate channel state information (CSI) at the receiver. Channel estimation based on pilot-symbol-assisted transmissions provides a reliable way to obtain CSI. Use of pilot symbols for channel estimation, introduces overhead and it is desirable to keep the number of pilot symbols as minimum as possible. This paper introduces a new tight bound for the number of pilots in channel estimation using adaptive scheme in OFDM systems. We calculate the minimum number of necessary pilots using two approaches. The first approach for the number of pilots is obtained based on Doppler frequency shift estimation and the second approach is acquired based on channel length estimation using second order statistics of received signal. Finally we obtain the tight bound for the number of pilots using attained values.

Keywords: Doppler Frequency Shift; Second Order Statistics; Channel Estimation; Pilot; OFDM

1. Introduction

Orthogonal frequency division multiplexing (OFDM) represents a valid choice for a variety of wireless applications since it has been shown to outperform single-carrier schemes especially in high data rate applications [1]. To correctly demodulate the received data symbols, the channel estimation plays an important role to the system performance greatly. The most common technique to obtain channel information is via pilot aided channel estimation [2]. Pilot symbols consume both power and spectrum and thus it is desirable to keep the number of pilot symbols as minimum as possible. Some approaches for reduction of pilot overhead were proposed in [3-5]. On the other hand the spacing between pilot symbols should be small enough to make channel estimates reliable. Adaptive resource allocation in order to achieve a proper trade-off between utilized resources and quality of channel estimates based on CSI is necessary. Some authors discussed the number of used pilots in channel estimation and represent some methods for reduction them in OFDM systems. Authors in [6] use deviation of corresponding signals as a parameter to predict the channel characteristics in the transmitter end. They transmit fixed length of test signal to the channel whenever connection setup initiation takes place. Then by using the response, number of pilot signals to insert is determined and correspondingly appended to the data signal. Thus by varying the number of pilots depending upon the channel environment, it certainly improves the channel estimation and reduction in number of pilots used for channel estimation and feedback. The proposed estimator in [7] employs a specific pilot structure which consists of two types of pilot symbols with different pilot density. The combination of interference alleviation and pilot rearrangement not only makes the channel estimation robust to the time selectivity of the channel but also reduces the number of pilot subcarriers needed to estimate the channel. Authors in [8] develop a method to obtain the optimal number of known pilot symbols for pilot-aided linear channel estimation in OFDM. They derive an expression for channel estimation error covariance from which performance measures can be numerically evaluated to obtain the optimal number of pilot symbols. In [9], the shortest preamble that attains a given mean square error in a sequence that under-samples the channel spectrum is found. A high mobile wireless channel is time-variant due to Doppler frequency shift. Then, the number of used pilots in channel estimation depends on the Doppler frequency shift. So, we represent a lower bound for the number of pilots based on it. Also, the number of used pilots depends on the length of channel. Thus, we evaluate channel length estimation problem for obtaining another lower bound for the number of pilots. Finally the tight bound is obtained.

The reminder of this paper is structured as follows: in Section 2 the system model is introduced. Bounds for

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