A Combined Algorithm of Kalman Estimator and Guard Interval Optimization for Mobile WiMAX

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ABSTRACT

Mobile WiMAX (Worldwide Interoperability for Microwave Access) system has been recently applied widely in wireless communication systems. In this paper, the channel estimation algorithms were studied for the mobile WiMAX system. The comb-type pilot was used for channel estimation algorithms. The authors proposed an adaptive algorithm of channel estimation based on Kalman filter which had good performance in fading channels. Then, based on the result of channel estimation, we proposed an advanced algorithm of GI (Guard Interval) optimization. The results showed that the Kalman estimator combined with GI optimization algorithm showed the best performance in this paper. This algorithm was verified by computer simulation.

Keywords: *Adaptive Cycle Prefix Length, Adaptive Guard Insertion, Channel Estimation, Kalman Filter, Mobile Worldwide Interoperability for Microwave Access (WiMAX)*

INTRODUCTION

This paper focuses on channel estimation system, one of the important blocks in the WiMAX receivers (WiMAX Forum, 2008). WiMAX uses OFDM (Orthogonal Frequency Division Multiplexing) as a technical platform because of high spectral efficiency (F. Wang, &A. Ghosh, 2008). Chanel estimation in OFDM systems is traditional topic and researched in many papers because of its important roles (Song & Lim, 2003) and Tirthankar Paul, & Priyabrata Karmakar, & Sourav Dhar (2011)). Many algorithms of channel estimation for OFDM were explained and simulated for mobile WiMAX by Muhammad Saad Akram (2007). Waldo Kleynhans (2008) analyzed algorithms of channel estimation with block-type pilot and comb-type pilot

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for mobile WiMAX. The algorithm of adaptive LS (Least Square) with Wiener interpolation was proposed in the paper. Another algorithm as Discrete Cosine Transform (DCT) based Channel estimation was researched by Saqib Saleem, &Qamar Islam (2011).

In this paper, channel estimation and ISI/ ICI (Inter Symbol Interference/ Inter Carrier Interference) reduction solutions are studied for comb-type pilot. The comb-type pilot channel estimation consists of algorithms to estimate the channel at pilot sub-carriers and to interpolate at the data sub-carriers. The interpolation of the channel for comb-type pilot can be one of the different interpolation methods such as linear interpolation, second order interpolation, low-pass interpolation, spline cubic interpolation, and time domain interpolation (Coleri, Ergen, Puri, & Bahai, 2002). For a comb-type pilot system, some algorithms of channel estimation can be used such as LS (Least Square), MMSE (Minimum Mean Square Error) (Alam, 2010). LS or MMSE algorithm is traditional estimator which is popularly used in devices for mobile WiMAX although LS or MMSE estimator is not an optimal estimator. Altera Corporation (2007) describes a channel estimation structure for mobile WiMAX system with LS estimation and bi-directional interpolation for comb-type pilot. FreeScale Semiconductor Corporation also uses LS estimation and the average algorithm of interpolation for comb-type pilot for devices of mobile WiMAX (Shen & Martinez, 2007). There are other estimators enhancing better performance than LS. A LMS (Least Mean Square) estimator uses information of previous state to determine next state (Elangovan & Priyadarsini, 2010). Daniel Larrson (2006) also proposed Kalman estimator with 1D interpolation and 2D interpolation and simulation proved this estimator had better performance than LS estimator. Kalman estimator was also analyzed by K. Elangovan, &PLK Priyadarsini (2010).

In addition to channel estimation topic, an ISI/ICI (Inter Symbol Interference/ Inter Carrier Interference) reduction solution is also proposed in this paper. To remove the ISI/ICI, the solution is adding a GI (Guard Interval) to the head of each symbol to reduce the influence of adjacent symbol interference. Fixed GI may force devices that encounter smaller delay spread to use unnecessarily large GI length, which in turn, causes a considerable loss in spectral efficiency and wastes transmitter energy of the system. An adaptive GI will provide the ability to reliably send information at the lowest possible power level, which has advantage of extending the battery life of mobile devices. Tae Won Ban andBang Chul Jung (2011) proved power efficient transmission scheme with adaptive cyclic prefix. Waiel Elsayed Osman, &Tharek Abd. Rahman (2008) presented optimization of GI for mobile WiMAX standard over multi-path channels by using different guard intervals, whereas Md. Zahid Hasan (2009) presented the study of different Guard Intervals to improve the BER (Bit Error Rate) performance of fixed WiMAX.

In this paper, we proposed the combined algorithm of adaptive channel estimation based on Kalman Filter and GI optimization for comb-type pilot system. This combined algorithm was also proposed by Quang Nguyen Duc (RIVF 2012). This paper is an extended version of this algorithm. In this paper, we extended this combined algorithm with many different designing rules of GI optimizations so that we can find out the best designing rule to calculate optimal length of GI.

In next section, we explain system model for simulation. Next, we explain and apply the algorithm with simulation parameters of mobile WiMAX. Computer simulations are verified under different modulation schemes and different channel models for mobile WiMAX. Performance comparisons were tested in many cases and conclusion is the final section.

SYSTEM MODEL

We simulate an OFDM system for mobile WiMAX based on pilot channel estimation which is given in Figure 1. We transmit a data file as input bits. Then, we create a time varying fading channel to make change this input