IJCSMS International Journal of Computer Science & Management Studies, Vol. 12, Issue 02, April 2012
ISSN (Online): 2231 –5268
www.ijcsms.com

Analysis of OFDM System using Pilot Channel Estimation

Amit[1], Rajesh Kumar[2], Priyanka Jangra[3]

[1]M.Tech. Research Scholar, UIET, Kurukshetra,
amitsoni005@gmail.com

[2]M.Tech. Research Scholar, UIET, Kurukshetra
rajeshkundu24@gmail.com

[3]Assistant Professor, UIET, Kurukshetra
priyanka.jangra@gmail.com

ABSTRACT

Orthogonal Frequency Division Multiplexing (OFDM) is multiplexing technology of orthogonal multicarrier, and the channel estimation model based on pilot in OFDM systems is analyzed; Now that, the channel estimation based on pilot needs interpolation, in order to reduce the complexity of the interpolation algorithm, the FFT channel estimation algorithm based on pilot is studied. Because of the direct FFT channel estimation algorithm existing energy spectrum leakage problems, the optimized FFT channel estimation algorithm based on the Hamming windowed function is put forward. A lot of conventional algorithms have tried to cancel the residual frame synchronization error (RFSE), which causes the performance degradation of channel estimation when using interpolation between pilot sub-carriers in comb-type pilot-aided OFDM systems. Orthogonal frequency-division multiplexing (OFDM) is a transmission technique that is based on many orthogonal carriers that are transmitted simultaneously. Channel estimation techniques for OFDM systems, based on comb-type pilot arrangement, over frequency-selective Rican and time-varying fading channel are investigated. The advantage of comb-type pilot arrangement, in channel estimation, is the ability to track the variation in the channel, which is the main reason for inter-carrier interference modeled as an additive white Gaussian noise, leading to an increase in the noise level.

Keywords: *Frame synchronization error, comb-type pilot-aided OFDM, channel estimation, IEEE802.16e mobile Wi-MAX system.*

Introduction

OFDM is wireless broadband access and the key technology of 4G communication in the future, because of its high spectrum efficiency and combat multi-path interference, etc. OFDM is becoming a hot research field of communication. In OFDM system, due to wireless channel in time domain and frequency domain selective fading characteristics, channel estimation is necessary to obtain channel information. Channel estimation can be divided into non-blind estimation and blind estimation, and this paper focuses on the non-blind pilot-based estimation. The basic process of OFDM channel Estimation based on pilot is: First, in sending the appropriate insert pilot symbols; Then, in the receiver by using the pilot symbols to recover the pilot position of the channel information; finally, the interpolation algorithm, access to all the time channel information. To reduce the complexity of the interpolation algorithm, we use channel estimation of FFT interpolation based on pilot as in, which Van De Beek carry out. However, the algorithm based on FFT requirements that the multipath channel delay spread is an integer multiple of the sampling period, as, while the actual system, the channel does not meet the conditions, which will result in the energy spectrum of leakage, leading to aliasing errors. Therefore, this paper proposes the optimized windowed FFT algorithm based on Hamming window function for channel estimation.

System Description

A simplified diagram of conventional OFDM system with pilot signal assisted is shown in Fig. 1. The binary information data are grouped and then mapped onto signals that may have multi-amplitude and multi-phase. After pilot insertion, the Mapped data, $X(k)$, are sent to an IFFT block and are modulated into $x(n)$, which are given by

$$x(n) = \mathbf{IFFT}\{X(k)\} = \frac{1}{\sqrt{N}} \sum_{k=0}^{N-1} X(k) e^{j\frac{2\pi kn}{N}}, \ 0 \le n \le N-1$$

Where N is the number of sub-carriers

After the modulation, a cyclic extension of the output with a length of G is added as a guard interval.

IJCSMS International Journal of Computer Science & Management Studies, Vol. 12, Issue 02, April 2012
ISSN (Online): 2231 –5268
www.ijcsms.com

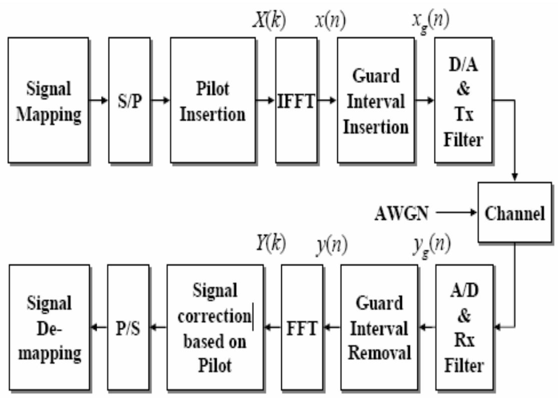

Fig. 1 Baseband model of a typical pilot-aided OFDM system.

Selection and insert of pilot

In this paper, comb pilot pattern, is shown in Figure gure 2, *D*f _*N*/*M* is a frequency domain pilot spacing. The pilot structure of the channel frequency is selectivity sensitive to channel, which is help to overcome the adverse effects of fast fading. Carrier for each OFDM symbol is the pilot number of N, which is integer multiple of the number of M, and each symbol is the pilot of the first point of the carrier.

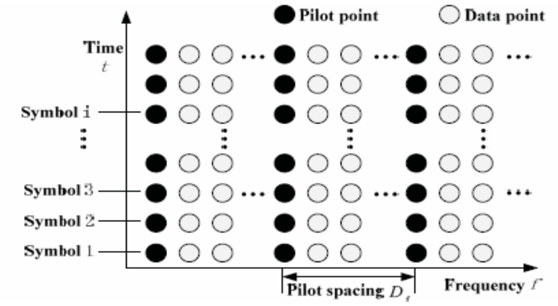

Figure 2.The comb pilot pattern in OFDM signal

Residual Frame Error Synchronization

In OFDM systems, frame synchronization uses a correlation technique in order to detect the starting point of FFT window. In this method, it is very difficult to estimate the exact starting point in multi-path fading channel, when a channel

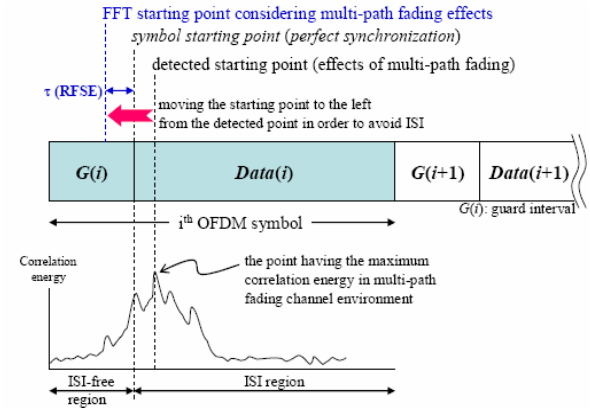

Fig 2 An example of frame synchronization in time-domain.

Impulse response does not have the maximum energy at the first path, $\max\{h(k)\} \neq h(0)$. Therefore, the synchronization may take a delayed point with the maximum correlation energy as the starting point, causing ISI. For avoiding ISI, as shown in Fig. 2, we have to move the starting point of FFT window from the originally detected point to the left considering the effects of multi-path fading, which causes the RFSE, τ. From (5), the received signal should be modified when we consider the RFSE and can be given by

$$Y(k) = H(k)X(k)e^{-j\frac{2\pi}{N}\tau k} + W(k)e^{-j\frac{2\pi}{N}\tau k}, \quad 0 \le k \le N-1$$

Proposed Method

The proposed RFSE estimation method uses the correlation with the channel information of pilot sub-carriers and their neighbors as shown in Fig. 3. At first, the channel information of pilot sub-carrier is obtained by using a pilot signal. Then, the channel information of its neighbor sub-carriers is estimated by using linear interpolation with the channel information of pilot sub-carriers.

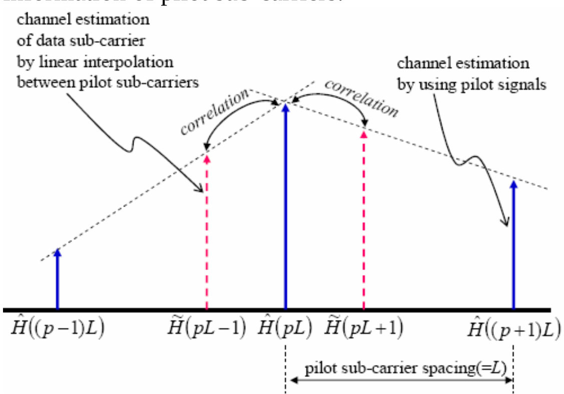

Fig. 3.Proposed RFSEs estimation scheme.

IJCSMS International Journal of Computer Science & Management Studies, Vol. 12, Issue 02, April 2012
ISSN (Online): 2231 –5268
www.ijcsms.com

Channel Estimation Using LS Estimator

A. Channel estimation based on FFT interpolation

To further reduce the OFDM channel estimation complexity, this paper adopt DFT-based interpolation algorithm, the basic idea of whose algorithm is: zero interpolation in the time domain signal is equivalent to interpolation in the frequency domain, thereby restoring the channel frequency response. DFT has a fast algorithm FFT, so its implementation complexity can be reduced. The basic process of the algorithm is shown in Figure 4.

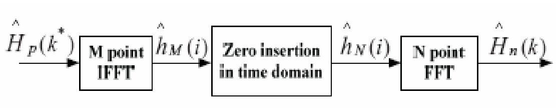

Figure 4.Channel estimation based on FFT interpolation

B. Channel estimation based on windowed FFT

In order to reduce leakage energy spectrum this paper proposes windowed FFT algorithm to reduce the impact of estimation error. The algorithm uses channel frequency response windowed filter in the frequency domain, and then selects a specific side-lobe characteristics of the data window to reduce the inverse Fourier transformed channel impulse response of proliferation, thereby improving the channel estimation results. The process of windowed implementation is shown in Figure 5

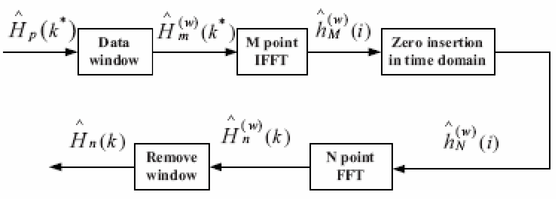

Figure 5.Channel estimation based on windowed FFT

Simulation Results

In this paper, bit error rate (BER) is used to measure the performance of channel estimation, by comparing the direct FFT channel estimation and window FFT channel estimation. The simulation parameters of this paper are set as follows: base-band bandwidth of 2MHz, for each OFDM symbol sub-carriers N = 128, the pilot number of M = 32, the pilot spacing = 4, the cyclic prefix CP = 4, using 16QAM modulation; channel selection Random sampling multi-path fading channel, multi-path number is 6, article 1 of multi-path delay is fixed to 0, the other more than five were 1,2,3,4,5 delay path, the average power of each multi-path comply with exponential distribution, Doppler frequency shift is 100Hz. The simulation results are shown in Figure 6.

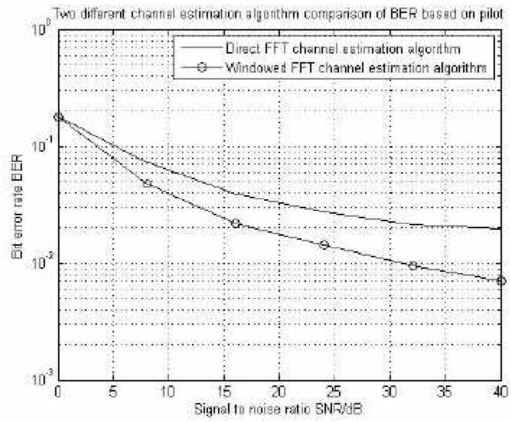

Figure 6 The performance comparison of channel

We also obtain simulation results for the proposed algorithm's BER performance under the same multi-path fading channel model with 3 Hz and 128 Hz Doppler frequencies. To evaluate the BER performance, we set the RFSE to five samples and also use the pilot pattern of Partial Usage Sub-Carrier (PUSC) adopted in IEEE 802.16e systems as shown in Fig. 7. The pilot pattern can be considered as a comb-type pilot pattern, which has pilot signals every 4 sub-carriers, applying the interpolation of pilot signal in time-domain. OFDM systems with symbols modulated by 64QAM are employed with 1.25 MHz bandwidth using a 128-point FFT.

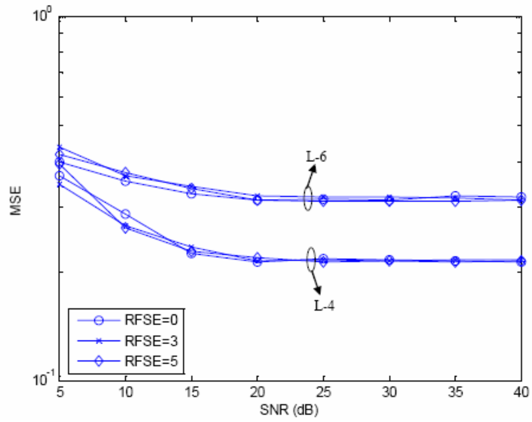

Fig. 7 The MSE performance of the proposed RFSE estimation method for pilot spacing (sub-carrier spacing: 9.7 kHz) under

IJCSMS International Journal of Computer Science & Management Studies, Vol. 12, Issue 02, April 2012
ISSN (Online): 2231 –5268
www.ijcsms.com

a multipath fading channel (IMT-2000, vehicular. A) with 128 Hz Doppler frequency.

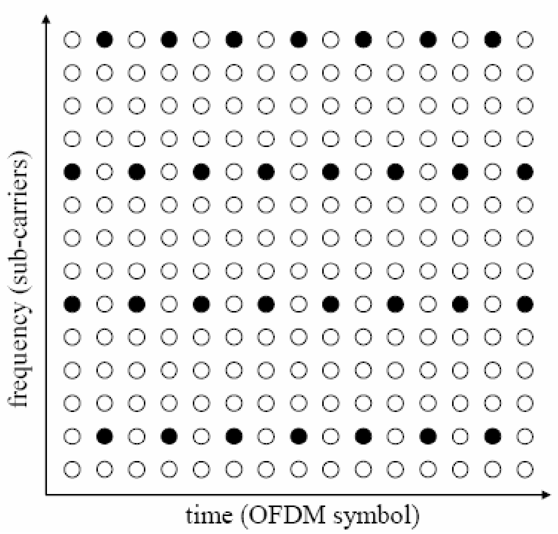

Fig. 8 The pilot pattern of Partial Usage Sub-Carrier (PUSC) in IEEE 802.16e systems

It shows the BER performance of conventional and proposed algorithms when pilot sub-carrier spacing (*L*) is set to four. As shown in Fig.8, we can see that both the tracking method and proposed one, which compensate for the RFSE effectively, have the similar performance to the ideal case using perfect synchronization regardless of Doppler frequency. The performance, however, degrades significantly without compensating for the RFSE, and there is also error floor at high SNR because the RFSE increases channel estimation error. From Fig. 8, we can find that the proposed method can compensate for the RFSE effectively compared to the tracking algorithm.

Conclusion

In this paper, we proposed a method in order to prevent the RFSE. The method lowered computational costs by adjusting the starting point of FFT window with the proposed estimation algorithm of RFSE in comb-type pilot-aided OFDM systems. The algorithm used correlation with not only channel information of pilot sub-carriers but also their neighbors. The simulation and power estimation results showed that the proposed algorithm had similar performance and lower power consumption compared to the tracking method. Therefore, the proposed method is very useful for mobile communications such as IEEE 802.16e systems, where the low power implementation was a very important issue. Based on the study pilot-based estimate estimation, this paper use FFT interpolation to channel estimation; however, because of the direct FFT channel estimation algorithm existing energy spectrum leakage problems, the optimized FFT channel estimation algorithm based on the Hamming windowed function is put forward. Simulation results show that, in the multipath fading channel conditions, the algorithm can effectively improve the channel estimation performance in OFDM systems, which has a great value and significance in the next generation of OFDM-based communication system.

References

[1] Zhang Ji-dong, Zheng Bao-yu. OFDM based on pilot channel estimation and its research progress [J]. *Communications*, 2010,11 (24),pp116-123.

[2] Edfors O, Sandel M, Winlson SK, et al. On channel estimation in OFDM systems [C] Proc. *IEEE VTC'95*, 2009,pp 815-819.

[3] Yang BG, Letaief KB, Cheng RS, et al. Windowed DFT based pilot-symbol-aided channel estimation for OFDM systems in multi-path fading channels [C]. *Proc. IEEE VTC'2000*, 2009,pp 1480-1484.

[4] Kwong Yu Jun, YUE Guang-xin OFDM system channel estimation interpolation algorithm performance analysis[J]. Beijing University of Posts and Telecommunications, 2008,26 (1) ,pp 41-46.

[5] YEN R.Y., LIU H.-Y., TSAI W.K.: 'QAM symbol error rate in OFDM systems over frequency selective fast fading channels', IEEE Trans. Veh. Technol., 2008, 57, (2), pp. 1322–1325.

[6] PROAKIS J.G., SALEHI M.: 'Communication system engineering' (Prentice-Hall, Upper Saddle River, New Jersey, 2002, 2nd edn.)

[7] TRIVEDI A., GUPTA R.: 'On the analysis of envelope correlation and spectra for Rician fading channel', Wirel. Pers. Commun., 2008, 47, pp. 281–292.

[8] BELLO P.A.: 'Characterization of randomly time-variant linear channels', IEEE Trans. Commun., 1963, 11, (4), pp. 360–393.

[9] J. J. van de Beek, M. Sandell, M. Isaksson and P. O. Borjesson, "Low complex frame synchronization in OFDM systems," in Proc. *IEEE International Conference Universal Personal Communications*, Toronto, Canada, pp. 982-986, Sept. 27-29, 1995.

[10] Guidelines for Evaluation of Radio Transmission Technique for IMT- 2000, ITU-R M.1225, 1997.