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Adaptive Orthogonal Frequency Division Multiplexing using Switching Method

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ABSTRACT

In this paper the transmitter intelligently adapts the transmission parameters like coding scheme, modulation symbol, power etc. w.r.t the varying wireless CSI. If channel is having poor transmission conditions then a channel code with smaller code rate and a smaller modulation symbol can be used. Similarly, if channel conditions are good, a comparatively high code rate or even no coding need be used. Paper gives an overview about the WiMAX standard and studies the performance of a WiMAX transmitter and receiver.

Introduction

Orthogonal Frequency Division Multiplexing (OFDM) is the standard being used throughout the world to achieve the high data rates necessary for data intensive applications that must now become routine [2]. Orthogonal Frequency Division Multiplexing (OFDM) is a Multi-Carrier Modulation technique in which a single high rate data-stream is divided into multiple low rate data-streams and is modulated using sub-carriers which are orthogonal to each other. Some of the main advantages of OFDM are its multi-path delay spread tolerance and efficient spectral usage by allowing overlapping in the frequency domain. Also one other significant advantage is that the modulation and demodulation can be done using IFFT and FFT operations, which are computationally efficient. Adaptation of Digital modulation can be done as simple as multiplexing methods or using neural network. The combination of adaptive modulation with OFDM was proposed as early as 1989 by Kalet which was further developed by Chow and Czylwik .Specifically the results obtained by Czylwik showed that the required SNR for the BER target 10E-3 can be reduced by 5dB to 15dB compared to fixed OFDM depending on the scenario of radio propagation. The performance of linear block coded modulation is investigated. Three different modulation mode allocation algorithms were compared. Further studies on the application of interleave and OSTBC modulation and coding is conducted. K. SeshadriSastry discussed an OFDM-CDMA system with adaptive modulation schemes for future generation wireless networks are discussed [3]. Results presented there show that adaptive systems can perform better than fixed modulation based systems both in terms of BER and spectral efficiency.

In this paper Adaptive modulation is performed by multiplexing methods and combination of OFDM. Adaptive modulation improves the BER and throughput. This work is conducted in MATLAB version R2012a using Simulink.

Methodology

With an overview of the OFDM system, it is valuable to discuss the mathematical definition of the modulation system. It is important to understand that the carriers generated by the IFFT chip are mutually orthogonal. This is true from the very basic definition of an IFFT signal. This will allow understanding how the signal is generated and how receiver must operate. Mathematically, each carrier can be described as a complex wave:

$$S_c(t) = A_t(t)e^{-j(\omega_c(t)+\emptyset_c(t))} \quad (1)$$

The real signal is the real part of S_c (t). Ac (t) and φ_c (t), the amplitude and phase of the carrier can vary on a symbol by symbol basis. The values of the parameters are constant over the symbol duration period t. OFDM consists of many carriers. Thus the complex signal

Sc(t) are represented by:

$$S_c(t) = \frac{1}{N}\sum_{n=0}^{N-1} A_N(t)\, e^{-j(\omega_n(t)+\emptyset_n(t))} \quad (2)$$

Where $\omega_n = \omega_o + n\Delta\omega$

This is of course a continuous signal. If we consider the waveforms of each component of the signal over one symbol period, then the variables Ac (t) and φc (t) take on Fixed values, which depend on the frequency of that particular carrier, and so can be rewritten:

$$\emptyset_n(t) = \emptyset_n \text{ and } A_n(t) = A_n$$

If the signal is sampled using a sampling frequency of 1/T, then the resulting signal is represented by:

$$S_c(kT) = \frac{1}{N}\sum_{n=0}^{N-1} A_n e^{[j(\omega_o+n\Delta\omega)kT+\emptyset_n} \quad (3)$$

At this point, in equation 3 it has restricted the time over which analyzes the signal to N samples. It is convenient to sample over the period of one data symbol. Thus the relationship: t=NT. By simplifying the equation 3, without a loss of generality by letting ω_0=0, then the signal becomes:

$$S_s(kT) = \frac{1}{N}\sum_{n=0}^{N-1} A_n\, e^{j\emptyset_n} e^{j(n\Delta\omega)kT} \quad (4)$$

$$g(kT) = \frac{1}{N}\sum_{n=0}^{N-1} G\left(\frac{n}{NT}\right)e^{\frac{2\pi}{N}kn} \quad (5)$$

In Equation 3.4 the function $A_n\, e^{j\emptyset n}$ is no more than a definition of the signal in the sampled frequency domain and s (kT) is the time domain representation. Eqns.4 and 5 are equivalent if:

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$$\Delta f = \frac{\Delta\omega}{2\pi} = \frac{1}{NT} = \frac{1}{\tau} \qquad (6)$$

This is the same condition that was required for orthogonally thus one consequence of maintaining orthogonally is that the OFDM signal can be defined by using Fourier transform procedures.

Adaptive Modulation of OFDM is done using SNR variation in adaptive modulation transmission will be disabled when the channel is in deep fade. This mode is introduced because the signal quality is too bad to guarantee a required transmission. Data will be transmitted if the channel quality improved.

Mode Modulation Thresholds [4].

1 BPSK SNR≤15.6 dB
2 FSK 15.6 dB<SNR≤18.6 dB
3 16QAM 18.6 dB<SNR≤21.5 dB
4 32QAM 21.5 dB<SNR≤24.6 dB
5 64QAM SNR>24.6 dB

Results and Discussion

Result Shows the Adaptive Modulation of 4 cases out of six different Modulations. It is observed that as SNR increases Throughput (Mbps) increases and also the sharpness of Constellation diagram increased it indicates BER is reduced.

Figure 1(a) shows the constellation diagram for BPSK with SNR 1dB here only two symbols are used for representation of message signal, right side of axis is for logic symbol zero and Left side is for logic symbol 1. So BPSK has more area for the detector to demodulate the messages so can be used even if receiver is far away from antenna (low SNR).

In figure 1(b) QPSK divides constellation graph to four parts because it is having 4 symbol messages hence area present for demodulation is less than that of BPSK but Throughput is more compare to QPSK but must be operated in higher SNR or else more symbols will end up with error.

Similarly 64QAM in figure 5.3c&d message are represented by 16 symbol so constellation are divided into 16 parts operates in higher SNR (near receiver antenna) and gives good throughput.

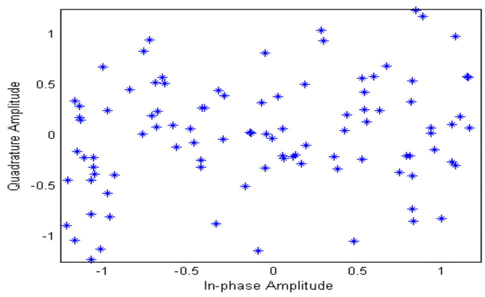

Figure 1a. WiMax BPSK Constellation diagram for SNR 1dB

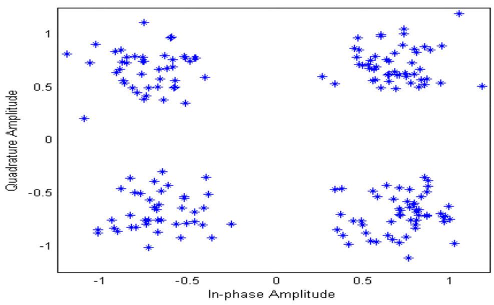

Figure 1b. WiMax QPSK CD SNR15dB and Rate ID 3Mbps

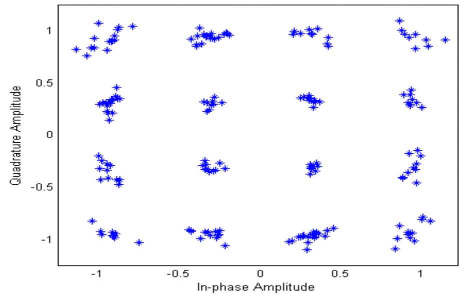

Figure1c. WiMax 64QAM3/4 Constellation Diagram SNR 30dB Rate ID 4Mbps

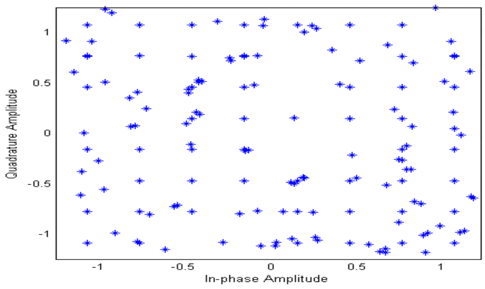

Figure1d. WiMax64 QAM 2/3ConstellationDiagramSNR 35dB Rate ID 5Mbps

Power spectral density

Power spectral density is the very important term represents the operation bandwidth in communication system. The spectrum of a time-series or signal is a positive real function of a frequency variable associated with a stationary stochastic, or a deterministic function of time, which has dimensions of power per hertz (Hz), or energy per hertz.Figure 2 shows the energy spectrum at the transmitter , figure 3 shows the PSD for different distance from antenna initially for low SNR received power is around -80dB and also it is very difficult to identify the BW of the spectrum as SNR is increased the power received improves and so bandwidth. See figure 3e the received power is -80dB and BW match with that of transmitted end.

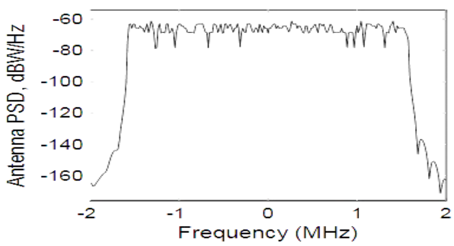

Figure 2. PSD at transmitter end

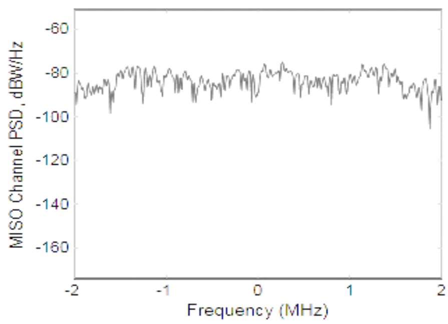

Figure 3a. PSD Reciver side 5dB SNR

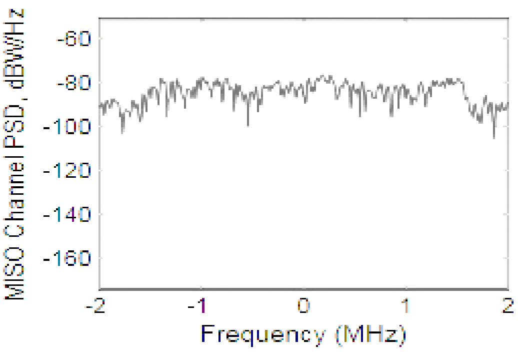

Figure 3b. PSD Reciver side 10dB SNR

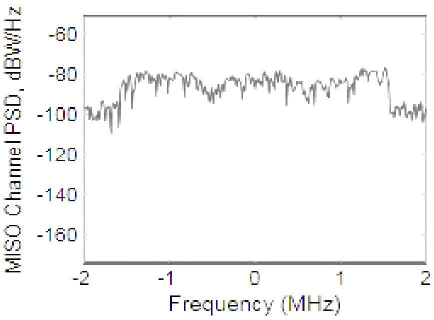

Figure 3c. PSD Receiver side 15dB

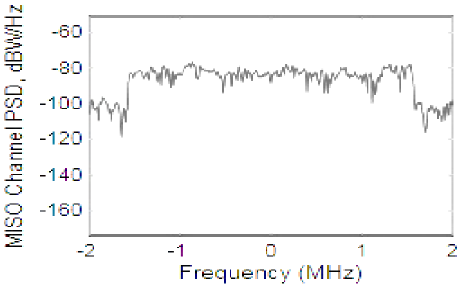

Figure 3d. PSD Receiver side 20dB

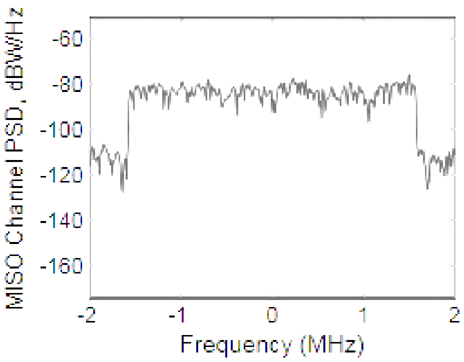

Figure 3e. PSD Receiver side 30dB SNR

BER Performance

Bit error ratio (BER) is the number of bit errors divided by the total number of transferred bits during a studied time interval. BER is a unitless performance measure, Figure 4 shows the BER vs. SNR plot for different modulation scheme. There is the gradual Variation in BER in case of Adaptive modulation as shown in figure 4(b). as SNR is increased throughput increases. The performance can be further improved by speeding up the switching methods and using adaptive MIMO antennas.

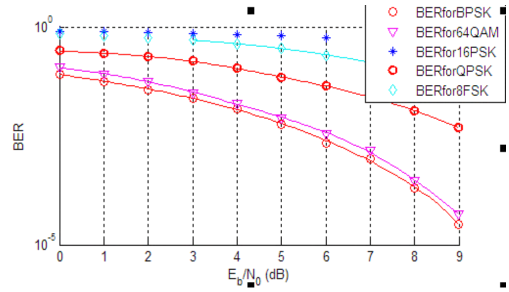

Figure 4a. BER of different modulation scheme without adaptation

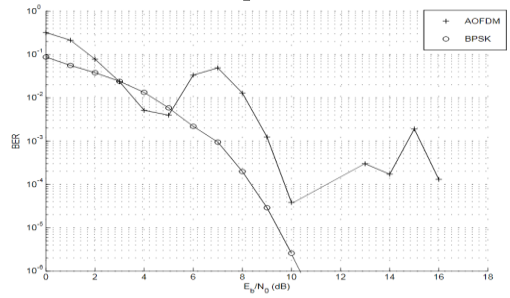

Figure 4b. BER of Adaptive and non-adaptive modulation

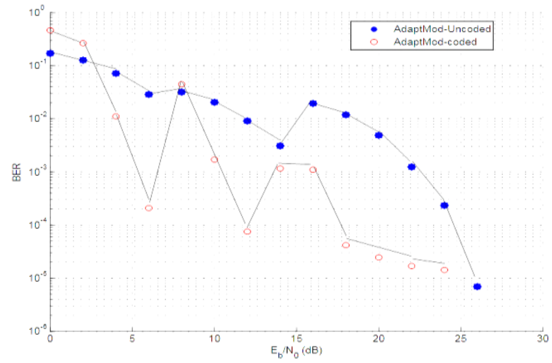

Figure 4c. BER performance of Adaptive OFDM with and without coding

Figure 4(c) shows the importance of forward error correction coding and interleaving. Blue color dot shows the non-coded adaptive OFDM it performance poorly right from 3dB to 30dB. In Adaptive OFDM modulation the performance varies with respect to SNR but overall BER is always less than that of non-Adaptive.

Conclusion

From this paper it is found that Adaptation of digital modulation and coding gives the good result of BER with respect to non-adaptive methods, Throughput can be increased by high SNR and hence increases spectral efficiency. Because of the use of OFDM for modulation mobility is also increased. This paper implements the physical layer of IEEE 802.16e which was designed by IEEE standards for mobile WiMax in 2004, literature gives the hint of adaptation of antennas MIMO and also in power allocation.

There is lots of scope in future for improving the speed of adaptive algorithm by using

- Neural network,
- Fuzzy logic
- Genetic algorithm for these modulation coding
- Using smart antennas and power allocation algorithm like beam-forming can improve the existing systems.

Reference

[1]. M.A.Mohamed, F.W.Zaki, R.H.Mosbeh“Simulation of WiMAX Physical Layer: IEEE 802.16e”IJCSNS, VOL.10.NO.11, November 2010.

[2]. J.Faezah1, and K.Sabira2 “Adaptive Modulation for OFDM Systems” International Journal of Communication Networks and Information Security (IJCNIS) Vol. 1, No. 2, August 2009.
[3]. K.SeshadriSastry, “SNR Estimation for QAM signals Using Fuzzy Logic Interface”. International Journal of Engineering Science and Technology Vol. 2(6), 2010, 2384-2392
[4]. Atta-ur-rahman, IjazMansoorQureshi, M.ZeeshanMuzaffar “Adaptive Coding and Modulation for OFDM Systems using Product Codes and Fuzzy Rule Base System” International Journal of Computer Applications (0975 – 8887) Volume 35– No.4, December 2011.
[5]. Thomas Hunziker, “Adaptive OFDM Transmission for Broadband Fixed Wireless Access System” Dirk Dahlhaus Communication Technology Laboratory, Swiss Federal Institute of Technology (ETH) ETH Zentrum, Sternwartstr. 7, 8092 Zurich, Switzerland.
[6]. Seshadri K. Sastry “Adaptive Modulation for OFDM System Using Fuzzy Logic Interface”. EIILM university, Sikkim 2007.
[7]. Chia-Chang Hu and Shih-Chang Lee, Hu and Lee “Adaptive low-rank channel estimation for multiband OFDM ultra-wideband communications” EURASIP Journal on Advances in Signal Processing 2011, 2011:64.
[8]. Ki-Hwan Eom, Kyo-Hwan Hyun, Kyung-Kwon Jung “The Performance Improvement of BASK System for Giga-Bit MODEM Using the Fuzzy”, Int. J. Communications, Network and System Sciences, 2010, 3, 441-445.
[9]. Vineeta, Asst. Prof. J. K. Thathagar, Asst. Prof. V. K. Patel, Prof. A. R. Charania, “Performance Evaluation of WiMAX System OFDM Physical Layer for Flat-Fading and Multipath-Fading Channel Environments” International Journal of Engineering Research and Applications (IJERA) Vol. 2, Issue 3, May-Jun 2012, pp.1426-1432.
[10]. Mohammed AboudKadhim and Widad Ismail “Implementation of WIMAX IEEE 802.16e Baseband Transceiver on Multi-Core Software Defined Radio Platform”, International Journal of Computer Theory and Engineering, Vol. 2, No. 5, October, 2010 1793-8201.
[11]. K.Harikrishna, T. Rama Rao, Vladimir A. Labay “FPGA Implementation of FFT Algorithm for IEEE 802.16e”, International Journal of Computer Theory and Engineering, Vol. 3, No. 2, April 2011 ISSN: 1793-8201.
[12]. “WIMAX, New Developments” Textbook by DrMsUpena D Dalal and Dr Y P Kosta, published December 2009 India.