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REVIEW OF EFFECT OF EQUALIZATION ALGORITHM ON BER IN OFDM

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Abstract: *IEEE802.16e adopted OFDM in physical layer for mobile applications in NLOS environment. OFDM is very robust in frequency selective channel. The drawback of the OFDM technique is sensitivity of subcarriers in time selective channel. The high speed of the users or reflectors in the environment causes to reduce the orthoganility between subcarriers in OFDM which results in ICI and reduced performance. Equalizer at receiver side to improve the performance in time selective channel is allowed in Mobile WiMAX. Equalizer in wireless communication is adaptive traversal linear filter which is designed as channel compensator. The value of weight of equalizer is adjusted according to equalization algorithm. ZF and MMSE equalization algorithm are two most popular algorithms. The aim of this paper is the evaluation of 802.16e system using different channel equalizers at the receiver module.*

Keywords:- *OFDM, ICI, MMSE, ZF Equalization , BER.*

***Asst. Professor TIT&S Bhiwani**

INTRODUCTION

WiMAX is based on wireless metropolitan area networking (WMAN) standards developed by the IEEE 802.16 group and adopted by both IEEE and the ETSI HIPERMAN group. It provides very high data throughput over long distance in a point-to multipoint and line of sight (LOS) or non-line of sight (NLOS) environments. WiMAX can provide seamless wireless services up to 20 or 30 miles away from the base station. The IEEE 802.16 group subsequently produced 802.16a, which include NLOS applications in the 2GHz–11GHz band, using an orthogonal frequency division multiplexing (OFDM)- based physical layer. Further revisions resulted in a new standard in 2004, called IEEE 802.16- 2004, which replaced all prior versions and formed the basis for the first WiMAX solution. These early WiMAX solutions based on IEEE 802.16-2004 targeted fixed applications often it is referred to as fixed WiMAX [1]. IEEE group completed and approved IFEEE 802.16e-2005, a standard that added mobility support. The IEEE 802.16e-2005 forms the basics for the WiMAX solution for mobile applications and is often referred to as mobile WiMAX [2]. OFDM technique is widely adopted in those systems due to it's robustness against Multipath fading and simpler equalization scheme. In most of applications, for retaining the orthogonality of subcarriers and overcome intersymbol interference (ISI), a cyclic prefix (CP) is inserted instead of simply inserting guard interval. If the maximum delay of the Multipath channel does not exceed the CP length, the OFDM system would be ISI free by removing the guarding interval. For WiMAX systems, its delay spread is typically over several microseconds which are longer than the guarding interval. Therefore, it is very challenging to maintain the system BER performance for non-line-of-sight (NLOS) channels at high data rate transmission also for mobile WiMAX Doppler effect degrades system performance. Both, the equalizer or channel estimator can be applied to compensate for the attenuation and phase shift introduced by the channel. Equalization and channel estimation basically it is simple for OFDM systems but it needs careful consideration due to their implementation limitations to accomplish the trade-off between complexity and accuracy. This paper introduces an end to end WiMAX PHY layer system model including channel estimation and equalization approaches to facilitate evaluation and hardware implementation for fixed/mobile WiMAX system.

REVIEW OF RELATED LITERATURE

IEEE 802.16e standard is proposed as a standard of wireless interface for broadband wireless access (BWA) [3]. WiMAX is the commercialization of the IEEE 802.16 standards; it aims to provide business and consumer wireless broadband services on the scale of the Metropolitan Area Network (MAN) [4]. In fact, WiMAX is essentially a fourth generation wireless technology that enhances broadband wireless access. To meet the requirements of different types of access, the WiMAX Forum has two different system profiles: the first one is called fixed system profile based on IEEE 802.16-2004 OFDM PHY; the other second is called mobility system profile based on IEEE 802.16e-2005 scalable OFDMA PHY. WiMAX applications are engineered to deliver ubiquitous, high-throughput broadband wireless services at a low cost [5] [6]. Although mobile and fixed WiMAX technologies are both based on IEEE 802.16 standard, the 802.16e is not backwards compatible with 802.16-2004, because the physical (PHY OFDM-256) layer used in fixed WiMAX cannot meet the requirements of mobile applications which uses a scalable OFDMA-based physical layer and the FFT sizes can vary from 128 bits to 2,048 bits [7] [8].

A. Intersymbol Interference (ISI)

Multiple scattering by different structures like buildings and other obstacles in the vicinity of a mobile unit lead to severe multipath propagation, which makes the design of a mobile communication channel very challenging. While the vehicle moves in the multipath field, that scattering varies rapidly the amplitude and phase of the received signal.

Multipath fading may also be frequency selective, which is the complex fading envelope of the received signal at one frequency may be only partially correlated with the received envelope at a different frequency. This decorrelation is due to the difference in propagation time delays associated with the various scattered waves making up the total signal [9]. The spread in arrival times, known as delay spread causes transmitted data pulses to overlap, resulting in intersymbol interference (ISI). In a typical urban environment, a spread of several microseconds and greater can be occasionally expected. Thus, if the signal is delayed by more than one microsecond because of multipath, the symbol will be received in the next symbol period, causing a significant symbol error. The faster the data rate, the higher the chance that multi-path will cause Inter Symbol Interference (ISI) [10].

B. Intercarrier Interference (ICI)

One of the main OFDM advantages is its robustness against frequency-selective channels but any time-varying channel characteristic will degrade the performance and destroy the orthogonality of subcarrier waveforms. Without the orthogonality, when the arriving signals are downconverted to the baseband at the receiver, intercarrier interference (ICI) occurs because a signal from one subcarrier causes interference to others, mostly to neighboring subcarriers [11]. Anyway, there are many factors that cause the ICI, such as Doppler shift, local oscillator frequency offset, multipath fading and cyclic prefix.

C. Cyclic Prefix

The guard interval is not used in practical systems, because it can eliminate ISI but not intercarrier interference (ICI). ICI is crosstalk between different subcarriers that means they are no longer orthogonal. The loss of orthogonality may be due to the frequency offset, the phase mismatch, or excessive multipath interference [12]. Fortunately, ICI can be mitigated by introducing a cyclic prefix to the OFDM symbols. A cyclic prefix is a copy of the last part of the OFDM symbol that is prepended to the transmitted symbol [13]. This makes the transmitted signal periodic and always has an integer number of cycles within the FFT interval, which decreases transceiver complexity at the expense of additional overhead and increases SNR loss after arriving optimum value.

D. Doppler Shift

The Doppler shift is the change in frequency and wavelength of a wave for an observer moving relative to the source of the waves. In multipath fading channel, different Doppler shift on each of the multipath components lead to random frequency modulation as long as there is relative motion between the base station and the mobile, Doppler shift is given by ,

$$f_d = \frac{v}{\lambda}\cos\theta \qquad (1)$$

where: Equation 1 refers to the relation between the Doppler shift and the mobile velocity as well as the spatial angle between the direction of mobile motion and the wave arrival [14].

E. Equalization Technique

An Equalizer is a compensator for Channel Distortion. For communication channels in which the channel characteristics are unknown or time-varying, optimum transmit and receive filters cannot be designed directly. For such channels, an equalizer is needed to compensate for the interference created by the distortion in the channel [16]. Training and tracking are two modes of operation of an equalizer. For a time varying channel an adaptive equalizer is needed to track the channel variations. There are three types of equalization methods commonly used:

- Maximum Likelihood (ML) Sequence Detection - Optimal, but Impractical.
- Linear Equalization - Suboptimal, but simple.
- Non-Linear Equalization (DFE)- for severe ISI channels.
- Linear Equalizers are simple to implement and are highly effective in channels where is the ISI is not severe (like the wireline telephone channel). Most linear equalizers are implemented as a linear transversal filter [16], shown in figure1.4
- If Y (t) is the input to the equalizer, then the output of the equalizer is given by,

$$y_{Eq}(t) = \sum_{i=-M}^{M} W_i Y(t - iT) \qquad (2)$$

- Where, the number of equalizer taps is 2M +1 and T is the symbol duration Non Linear Equalizer: these equalizers care not only the nonlinearity of the amplifier but also the HPA memory and distortion introduced by channel and pulse shaping. The Volterra series [16] provides a general approach to model the nonlinear channel with memory composed of pulse shaping filter, channel and receive filter. The equalizer is added after the receive matched filter and before the OFDM receiver

Criterion for Optimization.

Two criteria are commonly used for optimizing the equalizer tap weights[16]:

- Peak Distortion Criterion - leading to the Zero-Forcing Equalizer.
- Mean Square Error (MSE) Criterion - leading to the LMMSE equalizer and the Gradient (LMS) algorithm.

Zero Forcing Equalizer:

It uses the Peak Distortion Criterion to evaluate the equalizer tap weights [16]

- The condition for zero-ISI is given by,

$$H_T(f)\, H_C(f)\, H_R(f)\, H_{Eq}(f) = H_{RC}(f) \qquad (3)$$

- By definition we have,

$$H_T(f)\, H_R(f) = H_{RC}(f) \qquad (4)$$

- So the value of $H_{Eq}(f)$ that compensates for the channel distortion $H_C(f)$ is given by,

$$H_{Eq}(f) = 1/H_C(f) \qquad (5)$$

- This equalizer is also called the inverse channel equalizer.
- The discrete time version of the above equation , with a sampling rate equal to the symbol-duration T, is given by,

$$1 = H_C(f)H_{Eq}(f) \qquad (6)$$

Or, in the discrete-time domain, we have

$$\sum_{i=-\infty}^{\infty} h(n-i) = p_{Eq}(n) = \begin{cases} 1 & if\ n = 0 \\ 0 & if\ n \neq 0 \end{cases} \qquad (7)$$

Where, h(n) is the (discrete-time) impulse response of the channel and $p_{Eq}(t)$ is the response after Equalization

LINEAR MINIMUM MEAN SQUARE ERROR (LMMSE) EQUALIZER

The Zero-Forcing Equalizer has a severe drawback due to its noise performance. The LMMSE filter overcomes this drawback by relaxing the zero-ISI condition and selecting the equalizer characteristic such that the combined power in the ISI and the additive noise at the equalizer output is minimized.

The following are assumed in the derivation of the LMMSE Equalizer.

- The input symbols are temporally uncorrelated, (i.e.), E {AnAn+j} = $\delta(j)$
- The input symbols are uncorrelated with noise

The quantity to be minimized the mean squared error (MSE) given by $E\{|A_n - \hat{A}_n|^2\}$ Where $\hat{A}_n$ is output of equalizer [16].

CONCLUSION

IEEE802.16e adopted OFDM in physical layer for mobile applications in NLOS environment. OFDM is very robust in frequency selective channel. The drawback of the OFDM technique is sensitivity of subcarriers in time selective channel. The high speed of the users or reflectors in the environment causes to reduce the orthoganility between subcarriers in OFDM which results in ICI and reduced performance. Equalizer at receiver side to improve the performance in time selective channel is allowed in Mobile WiMAX. Equalizer in wireless communication is adaptive traversal linear filter which is designed as channel compensator. The value of weight of equalizer is adjusted according to equalization algorithm. ZF and MMSE equalization algorithm are two most popular algorithms. MMSE based equalization has better performance than ZF based equalization. In MMSE based equalization N-by-N equalizer matrix is computed. The performance of system can be evaluated from BER and E_b / N_0 at different normalized doppler frequencies. For minimum BER of coded digital information, Equalization and decoding is required at receiver side.

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