A STUDY ON NOISE ESTIMATION IN WIMAX SYSTEM BY SIMULINK MODEL: A LITERATURE REVIEW

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***Abstract*— The experienced growth in the use of digital networks has led to the need for the design of new communication networks with higher capacity. Worldwide Interoperability for Microwave Access, known as WiMAX, is a wireless networking standard which aims for addressing interoperability across IEEE1 802.16 standard-based products. The message is to be transmitted through WIMAX system. Since interference and noise occurred in communication channel degrade the performance of any communication system. In this paper we represent the simulink model of WIMAX system. It consists of transmitter, channel and receiver. The noise is estimated and compare with existing WIMAX system.**

***Index Terms*— WIMAX, OFDM, Simulation, Noise Estimation, Simulink Model**

I. INTRODUCTION

The increased reliance on computer networking and the Internet has resulted in a wider demand for connectivity to be provided "any where, any time", leading to a rise in the requirements for higher capacity and high reliability broadband wireless telecommunication systems. Broadband availability brings high performance connectivity to over a billion users worldwide, thus developing new wireless broadband standards and technologies that will rapidly span wireless coverage. Wireless digital communications are an emerging field that has experienced an spectacular expansion during the last several years. Moreover, the huge uptake rate of mobile phone technology, WLAN (Wireless Local Area Network) and the exponential growth of Internet have resulted in an increased demand for new methods of obtaining high capacity wireless networks [1].

Worldwide Interoperability for Microwave Access, known as WiMAX, is a wireless networking standard which aims for addressing interoperability across IEEE1 802.16 standard-based products. WiMAX defines a WMAN2, a kind of a huge hot-spot that provides interoperable broadband wireless connectivity to fixed, portable, and nomadic users. It allows communications which have no direct visibility, coming up as an alternative connection for cable, DSL3, and T1/E1 systems, as well as a possible transport network for Wi-Fi4 hot-spots, thus becoming a solution to develop broadband industry platforms. Likewise, products based on WiMAX technology can be combined with other technologies to offer broadband access in many of the possible scenarios of utilization, WiMAX will substitute other broadband technologies competing in the same segment and will become an excellent solution for the deployment of the well-known last mile infrastructures in places where it is very difficult to get with other technologies, such as cable or DSL, and where the costs of deployment and maintenance of such technologies would not be profitable. In this way, WiMAX will connect rural areas in developing countries as well as underserved metropolitan areas. It can even be used to deliver backhaul for carrier structures, enterprise campus, and Wi-Fi hot-spots. WiMAX offers a good solution for these challenges because it provides a cost-effective, rapidly deployable solution. Additionally, WiMAX will represent a serious competitor to 3G (Third Generation) cellular systems as high speed mobile data applications will be achieved with the 802.16e specification. The IEEE 802.16 standard was firstly designed to address communications with direct visibility in the frequency band from 10 to 66 GHz. Due to the fact that non-line-of-sight transmissions are difficult when communicating at high frequencies, the amendment 802.16a was specified for working in a lower frequency band, between 2 and 11 GHz. The IEEE802.16d specification is a variation of the fixed standard (IEEE 802.16a) with the main advantage of optimizing the power consumption of the mobile devices. The last revision of this specification is better known as IEEE 802.16-2004 [3].On the other hand, the IEEE 802.16e standard is an amendment to the802.16-2004 base specification with the aim of targeting the mobile market by adding portability. WiMAX standard-based products are designed to work not only with IEEE 802.16-2004 but also with the IEEE802.16especification. While the802.16-2004 is primarily intended for stationary transmission, the 802.16e is oriented to both stationary and mobile deployments. Wireless access to data networks is expected to be an area of rapid growth for mobile communication systems. The huge uptake rate of mobile phone technologies, WLANs and the exponential growth that is experiencing the use of the Internet have resulted in an increased demand for new methods to obtain high capacity wireless networks. WiMAX may be seen as the fourth generation (4G) of mobile systems as the convergence of cellular telephony, computing, Internet access, and potentially many multimedia applications become a real fact.

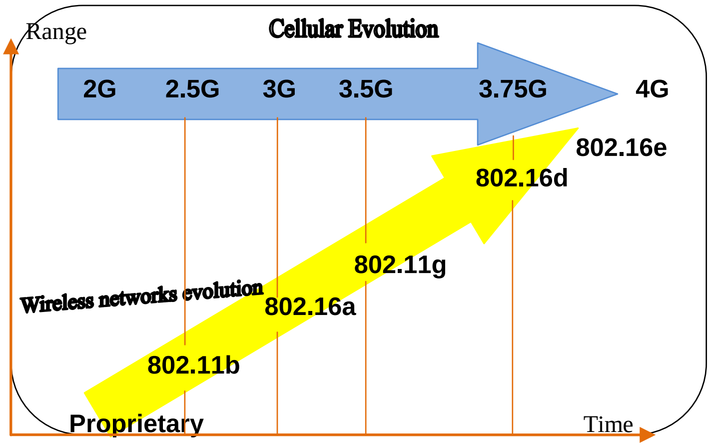

Fig 1. Convergence in wireless communications.

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The mentioned convergence between wireless and cellular networks is illustrated in Figure 1In any case, both WLAN and cellular mobile applications are being widely expanded to offer the demanded wireless access. However, they experience several difficulties for reaching a complete mobile broadband access, bounded by factors such as bandwidth, coverage area, and infrastructure costs. On one hand, Wi-Fi provides a high data rate, but only on a short range of distances and with a slow movement of the user. On the other hand, UMTS13 offers larger ranges and vehicular mobility, but instead, it provides lower data rates, and requires high investments for its deployment. WiMAX tries to balance this situation . As shown in Figure 1.1 - 2, it fills the gap between Wi-Fi and UMTS, thus providing vehicular mobility (included in IEEE 802.16e), and high service areas and data rates.

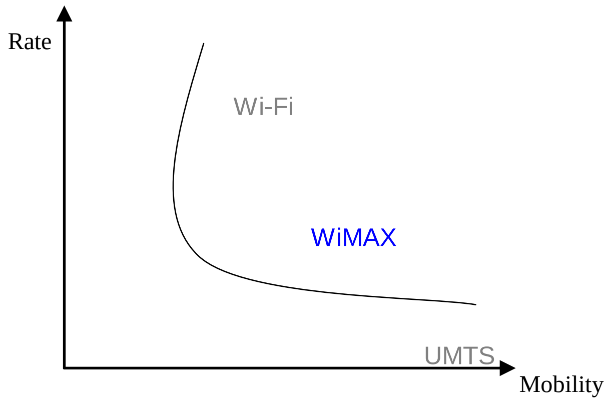

Fig 2. WiMAX fills the gap between Wi-Fi and UMTS.

Therefore, while WiMAX will complement Wi-Fi and UMTS in some of the possible scenarios where these systems are not sufficiently developed, i.e. they face several problems in the deployment and they do not offer enough capacity to serve all possible users, WiMAX will compete with Wi-Fi and UMTS also in other possible scenarios, where, in general, the costs in the deployment, maintenance, or just the supply of the service would not be profitable.

II. LITERATURE REVIEW

[1]In Nov 2007 Alim, O.A. ; Alexandria Univ., Cairo etal published a paper in IEEE WiMAX top level SIMULINK model with all system details has been implemented for simulation purpose. This paper has focused on channel estimation with different interpolation approaches for fixed/mobile OFDM system with parameters from WiMAX standards. The Doppler shift had a greater impact on the relative performance between the different channel estimators and interpolation approaches. One of the most interesting properties that were discovered is the big impact the interpolation method has over the estimating method in case of mobile case. The result from the simulation is that the low complexity LS method performs about the same for SNR as LMS which is more complex estimator, before Doppler shift but it has different behavior after that.
[2]In July 2009 Abdel Alim, O. ; Fac. of Eng., Beirut Arab Univ., Beirut, Lebanon et.al published a paper in Advances in Computational Tools for Engineering Applications, 2009. ACTEA '09. International Conference on Carrier Frequency Offset (CFO) estimation and correction is a critical issue in all OFDM receivers. For WiMAX Physical layer it is even more challenging to introduce a suitable CFO sub-system since WiMAX system supports complex features for future applications such as multiuser, multi-access and high mobility operation. This paper is concerned with low cost hardware implementation of CFO sub-system on field programmable gate array (FPGA) which fits in WiMAX system specifications. CFO algorithm and its basic building blocks description have been introduced. For FPGA implementation, an optimized CORDIC module has been used for estimation/correction steps. The design has been prototyped on an XC3S200A device in Spartan-3A Platform using ISE 10.1 all in one design suit from Xilinx. Synthesis results, floorplan mapping and testbench waveforms have been reported. Developing and validating the algorithm in VHDL and simulation phases have been explained. WiMAX transmitter/receiver system and CFO sub-system have been modeled and simulated in MATLAB/SIMULINK tools. Bit Error Rate (BER) versus signal to noise ratio graphs have been plotted for QAM and QPSK modulations.
[3]In July 2001 K.V. S. Hari, and etal at Stanford University, USA presented a paper on ground An important requirement for assessing technology for Broadband Fixed Wireless Applications is to have an accurate description of the wireless channel. Channel models are heavily dependent upon the radio architecture. For example, in first generation systems, a super-cell or "single-stick" architecture is used where the Base Station (BTS) and the subscriber station are in Line-of-Sight (LOS) condition and the system uses a single cell with no co-channel interference. For second generation systems a scalable multi-cell architecture with Non-Line-of-Sight (NLOS) conditions becomes necessary. In this document a set of propagation models applicable to the multi-cell architecture is presented. Typically, the scenario.

[4]In March 2005 Eugene Crozier etal from Wimax Forum presented the paper on NLOS. With a coverage area of up to 50 km, WiMax offers a new level of wireless data networking. Its non-LOS optimization makes it more powerful still. While many technologies currently available for fixed broadband wireless can only provide line-of-sight (LOS) coverage, the technology behind WiMax has been optimized to provide excellent non-line-of-sight (NLOS) coverage. WiMax's advanced technology provides the best of both worlds—large coverage distances of up to 50 kilometers under LOS conditions and typical cell radii of up to 5 miles/8 km under NLOS conditions.
[5]Onsy Abdel Alim etal from university of Egypt WiMAX (Worldwide Interoperability for Microwave Access) is a technology for wireless broadband and the core technique for the fourth-generation (4G) wireless mobile communications. However it still facing real challenge for low complexity and efficient system implementation. It supports non-line-of-sight environment with high data rate transmission and high mobility up to 125 Km/hr. WiMAX adopted OFDM/OFDMA in physical layer for fixed/mobile applications respectively. Integrated WiMAX model including Channel estimation and equalization are an active area for many recent researches. This paper presents a model for simulating OFDM WiMAX system in Simulink including channel estimation and equalization subsystems in MATLAB functions. Performance has been tested applying Additive White Gaussian Noise (AWGN) channel for fixed system and Doppler shifts due to changes in high and low relative velocity has been calculated and applied to the Simulink channel model for mobile system. Different iterative approaches for channel estimation and equalization have been modeled and evaluated. BER versus SNR curves at high and low Doppler shifts have been used for comparing these models.
[6] IEEE Computer Society presented This standard specifies the air interface of fixed broadband wireless access (BWA) systems supporting multimedia services. The medium access control layer (MAC) supports a primarily point-to-multipoint architecture, with an optional mesh topology. The MAC is structured to support multiple physical layer (PHY) specifications, each suited to a particular operational environment. For operational frequencies from 10-66 GHz, the PHY is based on single-carrier modulation. For frequencies below 11 GHz, where propagation without a direct line of sight must be accommodated, three alternatives are provided, using OFDM, OFDMA, and single-carrier modulation. This standard revises and consolidates IEEE Std 802.16-2001, IEEE Std 802.16aTM-2003, and IEEE Std 802.16cTM-2002.

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III. PROBLEM IDETIFICATION

WiMAX can provide at-home or mobile Internet access across whole cities or countries. In many cases this has resulted in competition in markets which typically only had access through an existing incumbent DSL (or similar) operator. Additionally, given the relatively low costs associated with the deployment of aWiMAX network (in comparison with 3G, HSDPA, xDSL, HFC or FTTx), it is now economically viable to provide last-mile broadband Internet access in remote locations. Orthogonal Frequency Division Multiplexing (OFDM) technique is widely adopted in wireless 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 micro-seconds which are longer than the guarding interval. Therefore, it is very challenging to maintain the system BER performance for non-line-of-sigh(NLOS) channels at high data rate transmission. In mobile WiMAX, mobility directly translates to Doppler Effect dynamics, which degrades the system performance. To combat the multipath and Doppler effects, wireless communications 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. When communicating over a wireless radio channel the received signal cannot be simply modeled as a copy of the transmitted signal corrupted by additive Gaussian noise. Instead, signal fading, while caused by the time-varying characteristics of the propagation environment, appears. In this way, short term fluctuations caused by signal scattering of objects in the propagation environment lead to a phenomenon known as multipath propagation. The time dispersion in a multipath environment causes the signal to undergo either flat or frequency-selective fading. Furthermore, the time dispersion is manifested by the spreading in time of the modulated symbols leading to inter-symbol interference (ISI). In order to avoid ISI in OFDM systems, the cyclic prefix time has to be chosen larger than the maximum delay spread of the channel.

IV. NEED OF OFDM IN WIMAX SYSTEM

Orthogonal Frequency Division Multiplexing (OFDM) technique is widely adopted in wireless 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 micro-seconds which are longer than the guarding interval. Therefore, it is very challenging to maintain the system BER performance for non-line-of-sigh(NLOS) channels at high data rate transmission. In mobile WiMAX, mobility directly translates to Doppler Effect dynamics, which degrades the system performance. To combat the multipath and Doppler effects, wireless communications 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.

V. SIMULINK MODEL OF WIMAX SYSTEM

MATLAB and Simulink are used for modeling the WiMAX OFDM physical layer. Simulink provides a very powerful extension to MATLAB for modeling and simulation of many types of systems especially communication systems. It provides set of ready block library. It is suitable for multi domain and dynamic system simulation using graphical user interface. Modeling the physical layer was in three stepsfirst implement the WiMAX transmitter second WiMAX receiver and at last end-to-end system with channel estimation and equalization model.

WiMAX transmitter model

The WiMAX standard provides specific instantiations of the physical layer data vectors (Input data, randomization, coding, and Interleaving) for different code rates (concatenated Reed Solomon and Convolutional Coding) and modulation schemes (M-QAM, QPSK). To ensure proper transmitter implementation, the transmitter has been modeled in accord with the standard for this specific configuration. the MATLAB Simulink model for transmitter. OFDM Symbol creation model. The input and output data vector is read in and written to MATLAB workspace after each major function block then it is compared to the standard test vector and it was identical. Additional functions are required for proper transmitter modeling but it was the same as in WLAN OFDM system such as Inverse Fast Fourier Transformed (IFFT) and cyclic prefix addition to the OFDM Symbol. All these additional elements have been modeled and added to ensure compatibility. MATLAB Simulink WiMAX Transmitter Model OFDM symbols creation

Doppler channel model

When a transmitter and a receiver are moving relative to one another the frequency of the received signal is higher than the source if they approach each others. When they are moving away from each other the received frequency decreases. This is called the Doppler Effect. The frequency change due to the Doppler Effect depends on the relative motion between the source and receiver, the angle of arrival of the incident wave,as well as the speed of propagation of the wave. The Doppler shift attains its maximum value when the incident ray is collinear with the direction of the receiver's motion. The steps that have been performed to implement the channel in our simulator started from the WiMAX specifications. A maximum speed of 125 km/hr is used here in the analysis as a high mobility value. The Doppler frequency *fdoppler* can be approximately computed as $f\text{doppler} = (v / c)\, f\text{carrier}$ (1)Where v is the velocity of the mobile terminal, c is the speedof light or electromagnetic wave in the air, and *fcarrier* is the carrier frequency of the signal transmission. The worst-case Doppler shift value from equation (1) for relative speed 125km/hr (~35 m/s) would be ~700 Hz for operation at the 6 GHz upper limit specified by the standard.

$f\text{doppler} = (35/3*108)*6*109 = 700$ Hz

In our simulation the "low value" a carrier frequency *fcarrier*of 3.5 GHz (a mid- point in the 2- 6 GHz frequency range)and a mobile speed v of 20 km/hour (6 m/second), the\Doppler frequency is ~ 70Hz, and the "high value" Doppler shift corresponding to the operation at 3.5 GHz for v of 120km/hour is ~ 400 Hz.

In the simulation, the channel has been modeled as a Multipath Rayleigh fading channel with additive white Gaussian noise (AWGN), at Simulink multipath fading box the calculated Doppler shift has been inserted.

WiMAX receiver model

The receiver implementation is an inversion of all the transmitter functions with addition of channel estimation and equalization parts. Several important receiver functions have a large impact on receiver performance. These include carrier tracking, frame synchronization and channel estimation. Of these, only the channel estimation functions were modeled in this simulation. First, a

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receiver model was constructed that reverses all of the elements of the transmitter, and its performance was validated using the AWGN channel. Second Multipath and Doppler shifts introduced into the channel model after implementation of receiver channel estimation and equalization functions. the initial receiver model incorporated into the context of an end-to-end simulation. First extract the data symbols from the OFDM waveform. Then we demodulated the QPSK waveform, Deinterleave, decode (first Viterbi, then Reed Solomon) and finally reverse the bit scrambling operation of the transmitter. Simulation performed using AWGN channel to predict initial accuracy and ensure accessibility. It was in agreement with the published results .

VI. EXPECTED OUTCOME

This paper introduces an end to end WiMAX System simulink model including channel estimation and equalization to facilitate evaluation of performance in fixed/mobile system. we will introduce the background of IEEE 802.16 standards packet format, channel estimation and equalization techniques.

VII. CONLUSION AND FUTURE SCOPE

WiMAX top level SIMULINK model with all system details has been implemented for simulation purpose. Channel estimation with different interpolation approaches for fixed/mobile OFDM system with parameters from WiMAX standards. The Doppler shift had a greater impact on the relative performance between the different channel estimators and interpolation approaches. One of the most interesting properties that were discovered is the big impact the interpolation method has over the estimating method in case of mobile case. In future the WiMax SNR can be better optimized by using presented simulink model.

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