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Simulation of WiMAX System Based on OFDM Model

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***Abstract*-** **The demand for mobile Internet and wireless multimedia applications are growing tremendously. The researchers came up with more advanced and efficient technology to satisfy the user requirements and to overcome the limitations of existing wireless technologies. To provide high speed internet access in the residential as well as small and medium sized enterprise sectors; Orthogonal Frequency Division Multiplexing (OFDM) based WiMAX (Worldwide Interoperability for Microwave Access) is the outcome in this direction which promises to solve the last mile access technology. WiMAX technology is based on the IEEE 802.16 specification of which IEEE 802.16-2004 and 802.16e amendment are Physical (PHY) layer specifications. In this paper, the performance of WiMAX based on OFDM is investigated. The performance of WiMAX2004 system is accessed by using computer simulations performed using MATLAB.**

Index Terms – **WiMAX IEEE802.16, OFDM (Orthogonal Frequency Division Multiplexing), and WiMAX2004 simulation.**

I. Introduction

IEEE 802.16 is a series of Wireless Broadband standards written by the Institute of Electrical and Electronics Engineers (IEEE) although the 802.16 family of standards is officially called WirelessMAN in IEEE, it has been commercialized under the name "WiMAX" (from "Worldwide Interoperability for Microwave Access") by the WiMAX Forum industry alliance. It specifies a frequency band in the range between 10 GHz to 66 GHz. Basically WiMAX is a wireless internet service that is capable of covering a wide geographical area by serving hundreds of users at a very low cost. It particularizes a metropolitan area networking protocol that not only provides a wireless alternative for cable, Digital Subscriber Line (DSL) and T1 level services for last mile broadband access but also provides a backhaul for 802.11 hotspots and due to its higher data rates WiMAX is also gaining interest in cellular sector as well. WiMAX uses radio microwave technology to provide wireless internet service to computers and other devices that are equipped with WiMAX compatible chips for e.g. PDA's, cell phones etc. It works more or less like cellular network technology, because WiMAX technology also involves the use of a base station to establish a wireless data communication link just as in the same way it is required in cellular networks like GSM and UMTS. The theoretical range of WiMAX is up to 30 miles and achieves data rates up to 75 Mbps, although at extremely long range that is greater than 30 miles the throughput is closer to the 1.5Mbps. WiMAX Operates in similar manner as Wi-Fi but with two very convincing differences as compared to Wi-Fi these are data rate and range

The typical WiMAX scenario involves a base station normally mounted on top of the building or at some place high where it can provide optimum coverage and a WiMAX receiver that can be in any form like for e.g. CPE, or a Chip installed in laptops or home PCs just like a Wi-Fi chip. Now there are two steps that make up the whole communication model in WiMAX, these steps are:
1. Data transmission from WiMAX Receiver (CPE or WiMAX Chip) to the WiMAX base station.
2. Data transmission from BS to backbone Internet

II. WiMAX – Physical Layer

The focal point of this thesis work is mainly on the WiMAX physical layer so in this point of view a brief description of WiMAX physical layer is presented. The WiMAX physical layer depends up OFDM – to reduce the amount of cross talk in the signal transmission it is a data multiplexing technique that distributes high bit rate data over a large number of precisely spaced smaller sub carriers with each sub carrier using a separate frequency for each carrier providing resistance against interference. Or in brief, the channel bandwidth is divided into multiple sub channels and information on each channel is transmitted using different frequencies

Problem

As higher data rates are used, the duration of one bit or symbol of information becomes smaller so it becomes difficult to recover the information sent due to impulse noise. The acceptability to interference from other continuous signal sources becomes greater and as a result ICI and ISI occur. At high data rates, the channel distortion to the data is very significant, and is somewhat impossible to recover the transmitted data. So a complex receiver structure is needed with expensive equalization and channel estimation algorithms to estimate the channel.

Aim

A higher level of spectral efficiency could have been achieved. It is still possible to recover the individual subcarrier signals despite their overlapping spectrums as long as orthogonality is maintained. This lead to decrease in ISI.

OFDM drastically simplifies the equalization problem by turning the frequency-selective channel into a flat channel. A simple one-tap equalizer is needed to estimate the channel and recover the data.

OFDM is a multiplexing technique that divides the bandwidth into multiple frequency sub carriers. OFDM also uses multiple sub-carriers but the sub-carriers are closely spaced to each other without causing interference, removing guard bands between adjacent sub-carriers. It divides the available spectrum into many carriers, called subcarriers, instead of using a single carrier channel and recovers the data.

OFDM technology is used by WiMAX for data transmissions because the huge benefits provided by this technique are far more than those provided by existing wireless data transmission techniques. Some of the important features of OFDM technology are:

Use of Multi-carriers – As we know that narrow band signals are less sensitive to ISI and frequency selective fading.

OFDM provides robustness against burst errors through the exploitation of frequency diversity schemes

OFDM achieves high spectral efficiency – As the FFT and IFFT operations ensure that the sub channels do not interfere with each other.

OFDM provides less complex equalization as compared to the equalization in single carrier systems.

OFDM provides effective robustness in multi-path environments.
However the OFDM physical layer is implemented differently in Fixed and Mobile versions of WIMAX. Fixed WiMAX uses 256 – FFT based OFDM physical layer where as the Mobile WiMAX uses a scalable OFDMA (SOFDMA) based physical layer and the FFT sizes in this case can vary from 128 bits up to 2048 bits. Here in the case of fixed WiMAX the number of sub-carriers is fixed and it is fixed to 256. Out of the 256 sub-carriers, 192 sub-carriers are used for carrying data, 8 are used for sub channel estimation and the rest of the carriers are used as guard band sub- carriers. However in this case the spacing between the sub-carriers is directly proportional to the channel bandwidth. It means that higher the channel bandwidth is the greater would be the subcarrier spacing which finally results in decrease of symbol time.

IEEE 802.16 structure

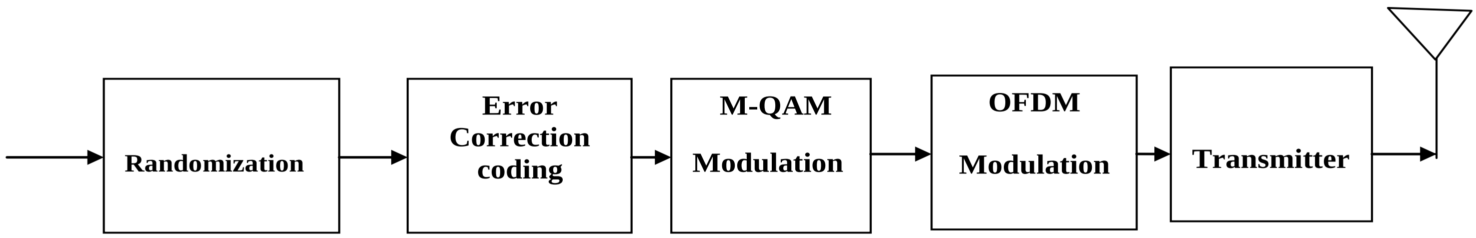

Fig. A. WiMAX transmitter block diagram

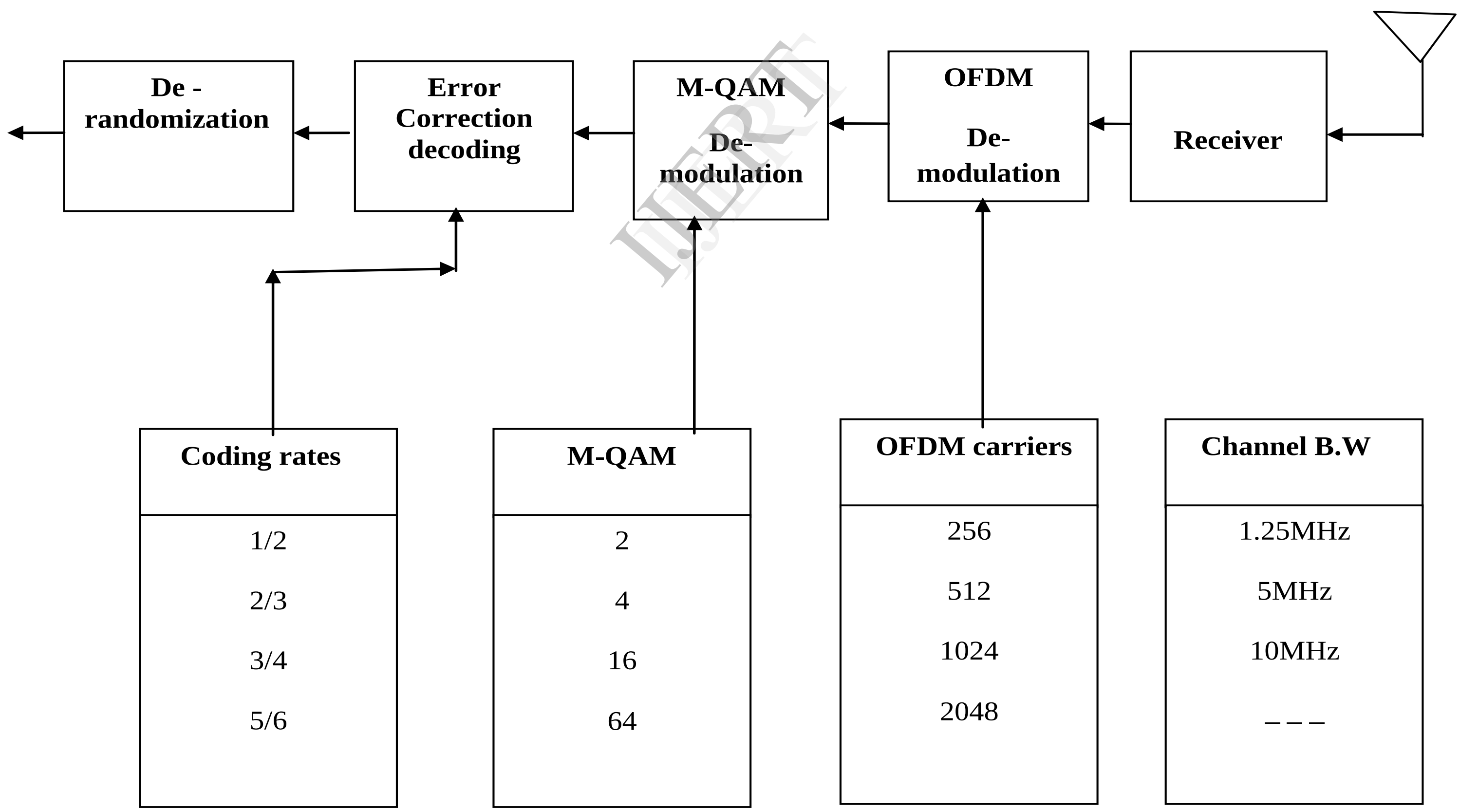

Fig. B. WiMAX receiver block diagram

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While in case of Mobile WiMAX the FFT size is scalable from 128 bits to 2048 bits, thus with the increase in the available bandwidth the FFT size also increases. In case of Mobile WiMAX the spacing between the sub carriers is set to 10.94 KHZ. This keeps the symbol time constant and thus produces a minimal impact of the scaling on the higher layers. This kind of sub-carrier spacing can support vehicular mobility at speed of 125 Km/h and supports delay spread value up to 20 µs. In order to enhance the range and performance of the Fixed WiMAX; a limited form of sub-channelization is allowed in the uplink (only). It helps in link budget improvements that can be used to enhance the range performance. Now in case of Mobile WiMAX the sub-channelization occurs in both directions (i.e. uplink and downlink). Hence different sub-channels are assigned to number of different users by using a specific type of an access mechanism and this particular access mechanism is called OFDMA. The establishment of the sub-channels is carried out in the following two different ways:

1. In the form of contiguous sub-carriers or
2. Sub-carriers distributed in a pseudo-randomly manner

It is worth noticing here that sub-carriers formed in contiguous manner, are useful in exploiting the multi-user diversity which provides significant gain in overall system capacity. That is the reason why contiguous sub-carriers are more applicable and suited for fixed and low mobility. On the other side if channels are distributed randomly across the frequency spectrum and more supportive for frequency diversity then they are well suited for mobile applications. Besides these key attributes that WiMAX physical layers perform there is another important function that physical layer performs and that is allocation of slots and framing for wireless communication channels. The slots that are created using the contiguous series assigned to a particular user are called "data region". These data regions are allotted to different users by various scheduling algorithms on basis of various channel conditions and some QoS demand parameters.

III. Simulation Result

In this section we have presented the simulation results

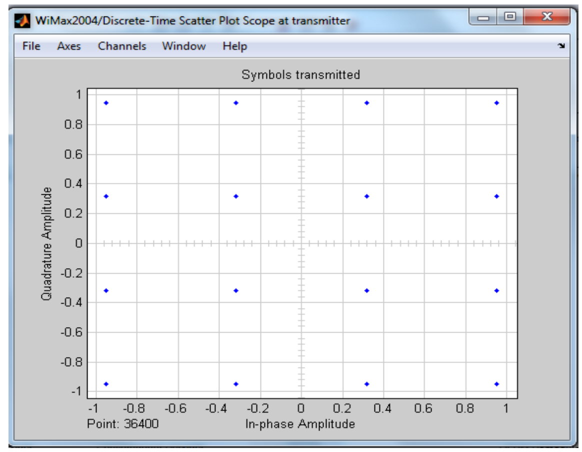

Fig.1. Discrete-Time scatter plot at QAM Modulator output.

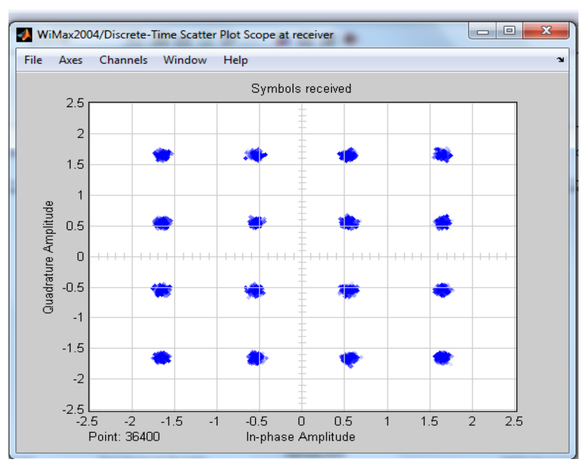

Fig.2. Discrete-Time scatter plot at QAM demodulator output

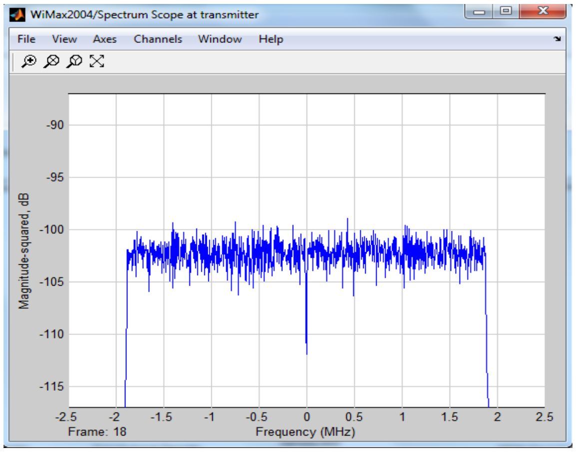

Fig.3. Spectrum at transmitter.

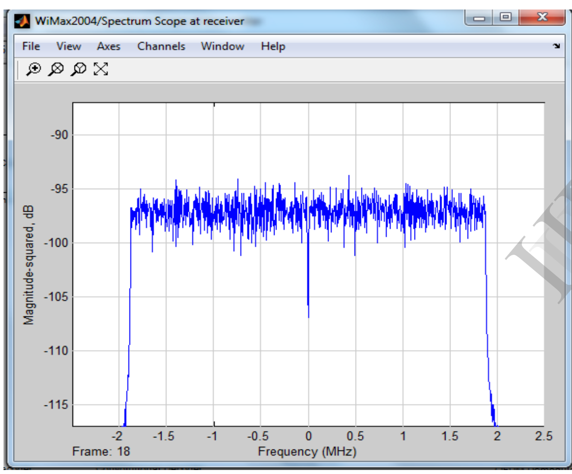

Fig.4. Spectrum at receiver.

IV. References

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