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A SURVEY ON QUALITY OF SERVICE IN OFDM BASED WIMAX SYSTEMS

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ABSTRACT

Worldwide Interoperability for Microwave Access often termed as WiMax is an effective OFDM based technique used for providing last mile connectivity to end users specifically in a wireless network. Wireless Fidelity is fundamentally limited by communication range and data rate which is overcome by WiMax systems. However due to the large coverage area of WiMax, it is susceptible to distortions created by the non-ideal nature of wireless channels. This results in Bit Error Rate degradation of the wireless system, thereby degrading the Quality of Service (QoS). This paper presents the basics of WiMax Systems, the main challenges faced by WiMax based systems and techniques or methodologies to overcome the challenges to enhance system performance.

Keywords: Worldwide Interoperability for Microwave Access(WiMAX, Orthogonal Frequency Division Multiplexing (OFDM), Bit Error Rate (BER), Probability of Error (Pe), Quality of Service (QoS).

I. INTRODUCTION

WiMax can be thought of a technology used for last mile connectivity in wireless networks. The major advantages that separate WiMax from WiFi are its range and data rate.

Table.1 Comparative Analysis of WiFi and WiMax

Parameter	WiFi	WiMax
Range	100m	40km
Coverage	Indoor	Indoor and Outdoor
Data Rate	Up to 54Mbps	10-100 Mbps
Device support	In hundreds	In Thousands
Channel Bandwidth	20MHz	1.25-20 MHz (Flexible)
Connection Orientation	Not connection oriented	Connection oriented

Thus it can be seen that WiMax can cater to a larger range of coverage with many more users at higher data rates which is customizable due to its flexible bandwidth. Channel bonding is also possible in case of WiMax which is a big advantage with increasing number of users. The block diagram of WiMax System is shown below:[16]

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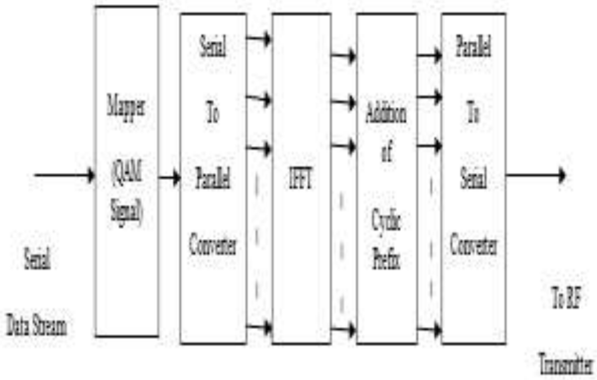

Fig.1 WiMax Transmitter

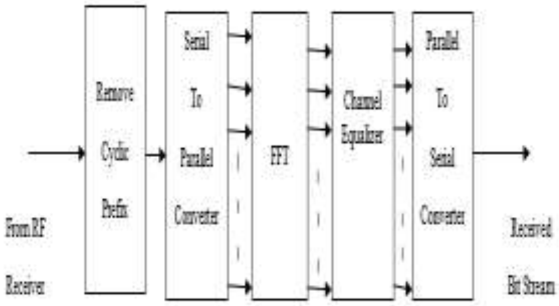

Fig.2 WiMax Receiver

The block diagram of WiMax can be subdivided into two categories i.e. the transmitter and the receiver. The basic technology for spectrum sharing used by WiMax is Orthogonal Frequency Division Multiplexing (OFDM). This is one of the fundamental reasons why WiMax can cater to larger number of users in th limited bandwidth range of 20MHz. The comparative analysis of spectrum of both FDM and OFDM is shown below.

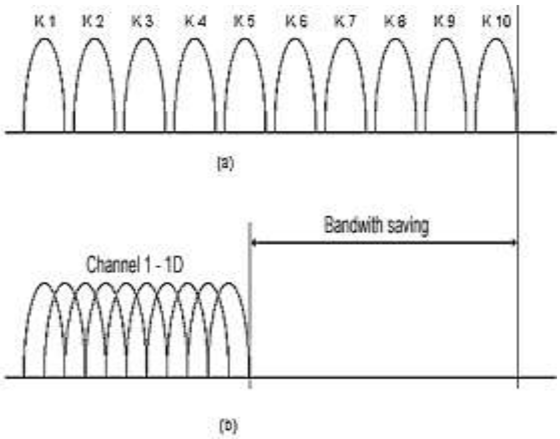

Fig.3 Comparative Spectra of FDM and OFDM

It can be clearly seen that due to orthogonality, the spectral efficiency of OFDM is more. There are various modulation tecchniques which can be used for modulationgthe orthogonal sub-carriers generated by the IFFT block. The WiMax system has a serial to parallel converter to convert the serial data stream to a parallel data

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stream so as to apply it to the IFFT block. Then a classical IQ (In phase Quadrature phase) modulation (BPSK, QPSK, M-QAM, etc) is sent over the sub-band. If it designed correctly, all the fast changing effects of the channel disappear as they are now occurring during the transmission of a single symbol and are thus treated as flat fading at the receiver. A large number of closely spaced orthogonal subcarriers are used to carry data. The data is divided into several parallel data streams or channels, one for each subcarrier [9]. Each subcarrier is modulated with a conventional modulation scheme such as Quadrature Amplitude Modulation (QAM) or Phase Shift Keying (PSK) at a low symbol rate. The total data rate is to be maintained similar to that of the conventional single carrier modulation scheme with the same bandwidth. A Cyclic Prefix is also added to circumvent the effects of channel distortions. The parallel data is further converted to serial form prior to transmission through the wireless channel. The signal is received at the receiving end and it is again converted from serial form to parallel form using a serial to parallel converter. The FFT block at the receiver is used to demodulate the signal. The parallel data is finally converted to serial form to route it to the data sink. The negative effects of the channel are nullified to a large extent using a channel equalizer whose functioning is given below.

II. NEED FOR CHANNEL EQUALIZATION

The major challenge with long range wireless communication systems such as WiMax is the fact that it encounters channel distortion due to the non-ideal characteristics of a wireless channel. This is shown in the figures below:

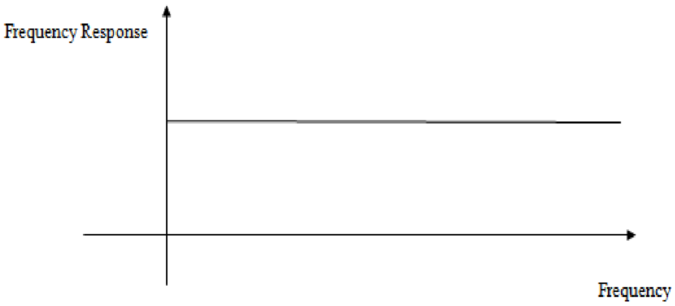

Fig.4 Frequency Response of an Ideal or Flat Wireless Channel

For the transmission to be distortion less, the channel should have a flat frequency response as shown in the figure above. [17] But practically, wireless channels are random and show non ideal characteristics. Such a channel's frequency response is shown in figure below:

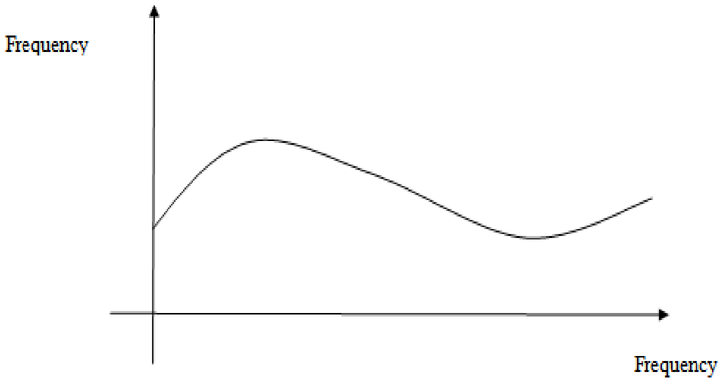

Fig.5 Frequency Response of a Non-Ideal or Practical Wireless Channel

Such a channel introduces distortions in the received signal thereby degrading the BER performance of the system. If we know the frequency response of the channel **H(z),** then we can design the frequency response of the equalizer as

$$E(z) = 1/H(z) \qquad (1)$$

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Since the wireless channels are realized as filters, hence equalizer structures also need to be realized as filters. One of the biggest challenges of realizing an equalizer is in designing an algorithm that would implement the equalizer transfer function. Different Equalizer structures can be used to implement a particular equalizer transfer function but each has its own pros and cons. Moreover, channel sounding mechanisms should be accurately designed so as to gauge the varying channel characteristics.

III. PREVIOUS WORK

While different research methodologies are being devised to improve the performance of WiMax systems, the main challenges remain to decrease the Bit Error Rate (BER) and Outage Probabilities of the WiMax systems. The following contemporary works focus on the same:

In [10] Sayali R et.al put forth the technique of Wavelet Packet Modulation to be incorporated in WIMAX based systems. The results which were obtained indicated the fact that the performance of the system in terms of BER was better compared to conventional WiMAX systems using OFDM in conjugation with cyclic prefix. The system was simulated for both AWGN and Rayleigh channel models. Simulations were run for different wavelet families and clearly exhibited the variations in BER performance.

In [11] Goran T. Djordjevic et.al explained a technique for the computation of the overall error ratio of WiMax system using mixed FSO/WiMAX link design. The approach shows that the error rate is a function of different channel characteristics such as frequency response, noise power spectral density (psd), auto correlation function (ACF) of the channel response etc. The effects of FSO and RF channel were explained in the results obtained comparatively. Quasi cyclic low-density parity-check (LDPC) codes were shown to have a significant improvement on the system performance in terms of errors and outage. Code words of varying lengths were tested to simulate the system.

In [12] Hardeep Kaur et.al demonstrated the Bit Error Rate (BER) performance of ITU-R and Cost- 207 channel model conditions for Typical Urban (TU) Area and Typical Rural Area (RA) based WiMax systems. A juxtaposed QPSK-QAM analysis is also made. The performance of the Pedestrian-A channel is found to be better than the Vehicular-B channel with the same modulation technique thereby leading to the inference that the system performance has improved. It has been shown that the Cost-201 channel model performs better for TU channel model compared to RA user scenario.

In [9] Lavish Kansal et al. put forth a comparative channel estimation technique using both the discrete Fourier transform (DFT) and the Discrete Wavelet Transform (DWT). The study computed the performance of the system over Rayleigh channel using divergent digital modulation levels along by diverse convolution code (CC) rate proposed for FFT-WiMAX and WHT-WiMAX. It was found from the simulation results that the WHT-WiMAX system performed better than the FFT-WiMAX based system.

The observations which can be made from the contemporary research works is the fact that most researchers are focusing on utilizing the channel response to reduce the BER of WiMax systems. Moreover, attaining a high signal to noise ratio reduces the chances of outage probability of the system which improves the Quality of Service (QoS) of WiMax systems. This is critically important as the WiMax systems have a large coverage area and the effects of multi-path communication, inter-symbol interference etc are pre dominant.

IV. PERFORMANCE METRICS

The performance metrics used for the evaluation of a WiMax based system are:

1) Bit Error Rate
2) Outage Probability

Bit error rate is defined as:

$$\mathbf{BER = EB/TB} \qquad \mathbf{(2)}$$

Where,
EB = Number of error bits
NB = Total number of bits transmitted

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The outage probability is a measure of the chances of the system to reach unacceptable service quality. It is mathematically defined as:

P(SINRK > VK) (3)

Here,
SINR represents the signal to noise plus interference ratio.
VK represents the threshold of Signal to noise ratio needed for acceptable quality of service (QoS).

Moreover the channel frequency response changes with time although being a function of frequency. This scenario is depicted in the figure below:

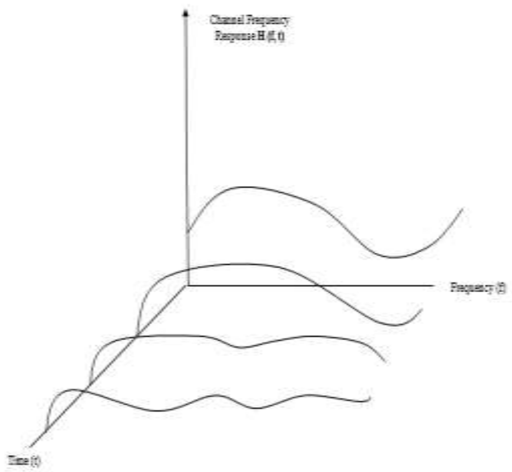

Fig.6 Time frequency response of channel response

It can be seen from figure 6 that practical wireless channels change over time. The frequency response no longer remains a function of frequency alone but becomes a function of time as well. Such a frequency response d designated as [17]

H = f (f, t)
If one takes snippets of the frequency response of the channel over time, one gets an image as figure 6. It is clear that the frequency response changes over time. Thus in case the channel is estimated using channel sounding every Trep

where Trep is the repletion interval for taking samples of the channel frequency response by the channel sounder, it will obtain different values for a practical wireless channel.

V. CONCLUSION

It can be concluded that WiMax systems are have a higher efficacy compared to other last mile connectivity mechanisms such as WiFi etc. The major challenge though is its susceptibility to channel distortions due to multipath propagation and non-ideal nature of wireless channels. The significant issues to be fixed are Bit Error Rate (BER) and outage probability. It has been shown that contemporary researchers are focusing on sing channel estimates to enhance WiMax system performance.

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