A Review on OFDM Based WiMAX System

Mohd. Abuzer Khan, Deepak Bicholia, Smita Patil

Abstract— In this paper, we present the review on the OFDM based WiMAX system and its various versions. Worldwide Interoperability for Microwave Access has a acronym WiMAX. It is a PTP & PMP wireless technology which is based on IEEE 802.16 standard. WiMAX is a wireless technology that supports high speed data service, video and voice at the customer side. WiMAX technology could be used to overcome the problems like less coverage area, low data rate and less security. WiMAX technology has various versions that are 802.16d (fixed WiMAX) and 802.16e (mobile WiMAX). OFDM is an amalgam of multiplexing and modulation. Through this review paper, the observation has been done of the different modulation techniques and different wireless channels. The outcome of this review will provide a basic idea about the amendment of the WiMAX system by using Orthogonal Frequency Division Multiplexing technology.

Keywords-WiMAX, OFDM, ICI, ISI, Doppler shift, Channel estimation, BER, SNR, Cyclic Prefix.

I. INTRODUCTION

WiMAX system is presently one of the fastest growing telecommunication system. WiMAX system is a wireless communication system which is a IEEE 802.16 standard. The WiMAX terminology or acronym is given by WiMAX forum in June-2001. The different versions of WiMAX system came in 2001 and its complete versions came in 2004. WiMAX system provide data rate Upto 70-100 Mbps. WiMAX support wireless MAN technology which delivers very high data rate to the wireless devices [1].

WiMAX technique having different–different variants but mainly its two version are:- (i) Fixed WiMAX system and (ii) Mobile WiMAX system. Fixed WiMAX system support OFDM with 128 FFT size only where as mobile WiMAX system supports OFDMA with 128, 512, 1024 FFT sizes that is why some time it is call as scalable system. WiMAX system provide high BW data, it support large coverage area with good QoS [2].

WiMAX can be deploy in 3G & 4G mobile cells with good amount of data rate. It is having two kind of services are:- (i) non-line of sight and (ii) line of sight. WiMAX supporting very high peak data rates. It has a scalable property by which it is able to scale according to its channel BW. The channel BW of WiMAX has a 5-10 MHz operating frequency. WiMAX supports lots of error correcting coding technique but one of them is FEC and also support modulation schemes. WiMAX technique supports TDD and FDD modes. WiMAX or its parameters can be use in OFDM system. It provides air interface also [3].

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OFDM is an amalgam of modulation and multiplexing. The OFDM firstly patent by Bell Labs in 1966. Then later on, L. Cimini gave a idea that OFDM can be used in mobile communication. ETSI deploy OFDM in DVB-T in the year 1997. Then OFDM consider for physical layer of Wi-Fi technology and then for its variant in 1999. The OFDM is based on the principle of orthogonality in which higher order data is converted or splits into the lower order data for achieving or maintaining the orthogonality between different symbols to mitigate or overcome the problem of inter-symbol- interference. OFDM uses the IFFT and FFT stages or blocks for making OFDM symbols and also for maintaining the orthogonality between the OFDM symbols and for successfully data transmission. But the biggest problem with the OFDM is, it's having very high PAPR.

The purpose of this review paper is to provide a review on the OFDM based WiMAX system. OFDM based WIMAX system transmit lower order data at a very high speed over the noisy channels. WiMAX with OFDM method increases the efficiency of the system and also mitigate the BER.

A. Main features of WiMAX system

- The carrier frequency is provided by the WiMAX system is <11 GHz.
- WiMAX system is developed or built on the OFDM technology for achieving higher efficiency and for low bit error rate.
- The data rate provided by the WiMAX system is between 70-100 Mbps.
- WiMAX supports three topologies are MT, PTP, PMP topologies.
- WiMAX providing Mobility, good QoS, Los-NLoS and high security services [4].

B. Differences between WiMAX vs. Wi-Fi

WiMAX and Wi-Fi is very similar to each other but having a very slightly difference between both of them are:- (i) WiMAX is IEEE 802.16 standard and (ii) Wi-Fi is IEEE 802.11 standard. WiMAX technology is having high speed and large coverage area as compare to Wi-Fi. WiMAX proving good amount of quality of services where as Wi-Fi doesn't provide QoS. WiMAX operates at 5-6 bps/Hz where Wi-Fi operates at 2.8 bps/Hz. WiMAX works on Full duplex mode where Wi-Fi works on Half duplex mode. WiMAX uses OFDM transmission technology where as Wi-Fi uses DSSS radio technology [5].

C. Various standards of 802.16(WiMAX)

The IEEE 802.16 standard is given to BWA; it is the working group of IEEE 802. Its main objective is to provide a high QoS and high data rate WMAN. WLAN Wi-Fi having a much lower range as compare to BWA networks. IEEE 802.16 broadly classified into two variants:- (i) IEEE 802.16(d)-2004 and (ii) IEEE 802.16(e)-2005. IEEE

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802.16(d) is defined for Fixed WiMAX and IEEE 802.16(e)-2005 is defined for Mobile WiMAX. The IEEE 802.16(d) and IEEE 802.16(e) is the advance versions of the IEEE 802.16. the IEEE 802.16(f) standard is defined for the MIB, and it was published in 2005.

The IEEE 802.16(g) standard is defined in the year 2006 and it is for MS. The IEEE 802.16(k) standard is for MAC Bridges and it is defined July 2006, IEEE 802.16(h) also built in the year 2006 but it is for ICM. IEEE 802.16(i) standard for MM it is built in 2006 and IEEE 802.16(j) is defined for the MMR & PAR and it is developed in 2006.

TABLE I. STANDARDS OF 802.16 [6]

Parameters	*802.16*	*802.16d*	*802.16e*
Date	Dec.-01	June-04	Dec. 05
Spectrum	11-65 GHz	3-12 GHz	1-5 GHz
Operation	LoS	LoS & NLoS	NLoS
Bit Rate	30-130 Mbps	Upto 70 Mbps	Upto 20 Mbps
Channel BW	25 MHz	15 MHz	10 MHz

II. LITERATURE REVIEW ON WiMAX

Mobile WiMAX system is for high data rate and also for BWA [7]. The WiMAX IEEE 802.16 standards provide wireless services and broadband services to business and consumers [8]. WiMAX technology is very useful and can be implemented in 3G and 4G wireless technology [9]. WiMAX provide or supports two kind of services Fixed and Mobile services. Fixed (IEEE 802.16(d)) for OFDM & Mobile (IEEE 802.16(e)) for OFDMA [9]. WiMAX provide high efficiency and long range at a low price [9]. SIMO scheme doesn't require a BW expansion or any kind of feedback from the Tx to the Rx which is similar to the MRC [5]. The probability of a CSDR of binary coherent & non-coherent signals through CNFC [8]. IEEE 802.16(d)-2004(fixed) technology provides for physical layer of OFDM-128 FFT size where IEEE 802.16(e)-2005(mobile) technology provide for scalable OFDMA-128, 256, 512,1024, etc, FFT sizes [9][10].

A. ISI

When the one symbol interferes with its subsequent symbol due to multipath propagation channels that is called ISI (Inter-Symbol-Interference) [11].

Nyquist was the person who solves the ISI problem, while having the low BW [12].

Mathematically Nyquist theorem or equation (1) [12] given by:-

$$h_{eff}(n\,T_s) = \begin{cases} K & n = 0 \\ 0 & n \neq 0 \end{cases} \qquad (1)$$

Where, T_s is the symbol period, n is an integer and K is a no-zero constant [12]. ISI has occur when signal BW is greater than the channel BW [12].

B. ICI

It is occur when a signal from one subcarrier causes or interfere its subsequent subcarrier than it is called ICI. Guard time is not used in real OFDM system because it only mitigate or eliminate or remove the ISI not the ICI, so for removing or mitigate the effect of both ISI and ICI we used cyclic prefix. The factor which effect the ICI are DS and CP [13].

C. About Cyclic shift

Cyclic prefix is a term which is adding or duplicating the last part of the N samples of the signal of the IFFT output which append them at the beginning of the signal to mitigate or overcome the problem of ICI and ISI. The CP is used because it changes the aperiodic signals to periodic signals which is providing easy DFT processing. CP should be longer than the longest channel impulse response because it mitigate or remove the ISI & ICI completely [8].

The length of the CP should be covering Max. length of the T_d. If the length of the CP is shortest it causes the ISI, so the length of the CP should be chosen that, it should between P_{loss} & T_d. The signal to noise loss is given by the equation (2) [8]:-

$$SNR_{loss} = -10\log_{10}\left(1 - \frac{T_g}{T_s}\right) \qquad (2)$$

Where, T_g the length of a CP, the transmitted signal can be written as equation (3) and equation (4):-

$$s(t) = \sum_{i=-\infty}^{+\infty} \sum_{k=1}^{N} C_{i,k} exp^{(j2\pi f_k (t - iT_s)).g(t - iT_s)} \qquad (3)$$

$$g(t) = \begin{cases} 1 & -T_g < t \leq T_b \\ 0 & t > -T_g, t > T_b \end{cases} \qquad (4)$$

Where $g(t)$ is pulse waveform of the symbol and

$$T_s = T_g + T_b \qquad (5)$$

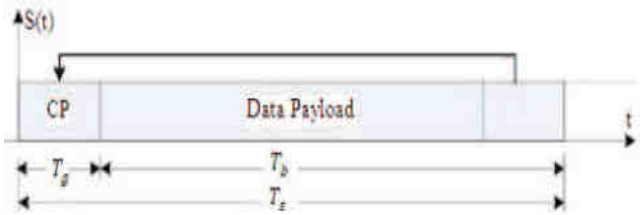

Fig. 1. Cyclic Prefix [3]

D. About Doppler effect

When the frequency changes due to the Doppler effect is called Doppler shift [13].

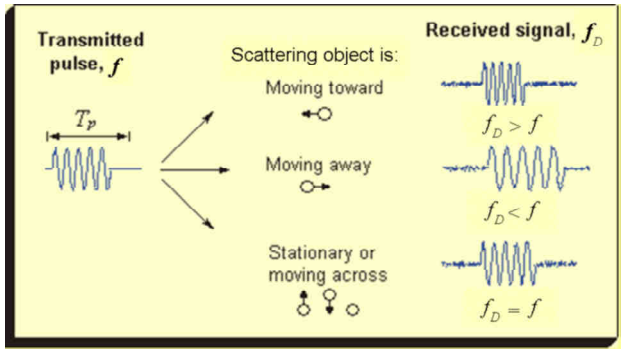

Fig. 2. Doppler Shift [14]

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When the frequency of the sound, waves, light or any other sources increases or decreases or vice versa and observer move away or towards the source or vice versa, this effect making a changes in the pitch which is noticeable this effect is called Doppler effect and it is given by the following equation (6) [14]:-

$$f' = \left(\frac{v}{v \pm v_s}\right) f \qquad (6)$$

It is evident from the formula that the detected frequency increases for objects moving towards the observer and decreases when the source moves away. This is known as the Doppler Effect [15].

III. PROPOSED OFDM BASED WIMAX SYSTEM MODEL

The i/p serial data is formatted into the word size required for transmission, e.g. 2 bits/word for QPSK, and converted into a parallel data stream. Then each data assign a one subcarrier frequency for the data transmission. The data on each symbol is then mapped to a phase angle based on the modulation method. After getting the required spectra is worked out, an IIFT transform is used to find the corresponding time waveform. CP then added to the start of each symbol to maintain the orthogonality [15].

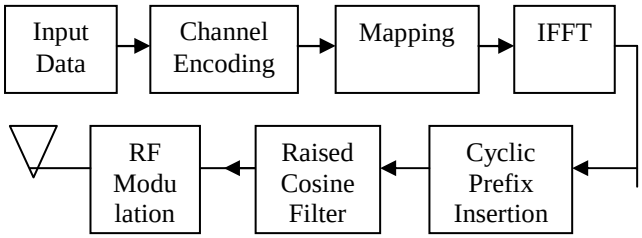

Fig. 3. OFDM Based WiMAX Tx [16]

Then the channels are applied to output data through which noise is add up to the data and that noise is AWGN noise which follows the Gaussian distribution and then this data is transmitted by the transmitter and give back to receiver part of the OFDM based WiMAX system [16].

The receiver part of the WiMAX based OFDM system works totally opposite to the transmitter side of the system as

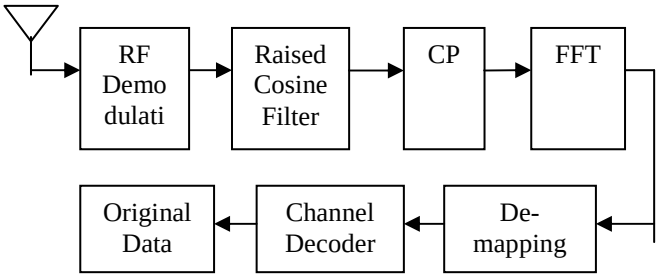

Fig. 4. OFDM Based WiMAX Rx [16]

the CP is removed, the FFT of each symbol is then taken to find the original transmitted spectra. The phase angle of each transmission carrier is then converted back to the output data by demodulating the received data. The received data are then combined back to the same data and finally we got the original data [16].

Performance analysis of BPSK, QPSK and 16-QAM modulation technique over AWGN channel using OFDM based WiMAX system is given by the Table 2 [17] which is given below :-

TABLE II. COMPARISON OF BER VS. SNR OVER AWGN CHANNEL [17]

SNR(dB)	*BPSK (BER)*	*QPSK (BER)*	*16 QAM (BER)*
0	0.8	0.22	0.2187
2	0.4	0.2	0.2073
4	0.002	0.0200	0.2744
6	0.0006	0.0065	0.1105
8	0.00001	0.0055	0.1020
10	10^{-5}	10^{-3}	0.0478
12	10^{-7}	10^{-4}	0.0196

From the given table it is clear that, the value of SNR is increasing, BER continuously decreasing in BPSK modulation technique.

Performance analysis of BPSK, QPSK and 16-QAM modulation technique over Rayleigh fading channel are given below:-

TABLE III. BER VS. SNR OVER RAYLEIGH CHANNEL [17]

SNR(dB)	*BPSK (BER)*	*QPSK (BER)*	*16-QAM(BER)*
0	0.1712	0.2746	0.2737
2	0.1344	0.2419	0.2404
4	0.1002	0.2062	0.2109
6	0.0738	0.1766	0.1876
8	0.0513	0.1505	0.1706
10	0.0379	0.1243	0. 1560
12	0.0260	0.1031	0.1453

From the Table 3 [17] the value of SNR is increases, BER is decreases in all three modulation technique. BER performance of BPSK is much better than QPSK and 16-QAM. Also QPSK is better than 16-QAM for higher SNR values.

IV. CONCLUSIONS

In this paper, we summarized the review of OFDM based WiMAX system. Firstly started with basic of WiMAX and its features. Then also we have given review of literature survey and discuss problems related to WiMAX system e.g. ICI, ISI and Doppler shift etc. Comparisons has been done of different modulation techniques over AWGN and Rayleigh Fading channel. We conclude that the BPSK has an overall better performance as compared to QPSK & 16-QAM techniques. That means lower order of modulation techniques is better to use in wireless communication system.

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