INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & MANAGEMENT

PREAMBLE DETECTION IN WIMAX 802.16E ON OFDM WITH AWGN CHANNEL

Schanan Gupta[1], Mukesh Patidar[2], Dr. Pragya Nema[3]
Department of Electronics and Communication Engineering
Lakshmi Narain College of Technology, Indore (M.P.) India
sachin170284@gmail.com

Abstract

WiMAX acronym meaning "Worldwide Interoperability for Microwave Access". It is an IP based Wireless Broadband Access Technology utilizing IEEE 802.16e-2005 standard as the air interface. Range of WiMAX is 15 Kms for Rural area (LOS) and 4 Kms for Urban area. User can expect to have broadband access speeds ranging from 256 Kbps to 2 Mbps. WiMAX will provide broadband connectivity anywhere, anytime, for any device and on any network. Examples include: High speed internet access where it is currently unavailable. Substantially increase data speeds for applications like Online Gaming, Video Conferencing and Streaming Video. The WiMAX technology incorporates much better and more flexible security support than the Wi-Fi standard. All user traffic is encrypted before being routed through the Network. In this paper implement different convolution methods for detection of preamble. These methods comparative analysis is done by apply different lag factor and integration length. These methods are SC (Schmidl and Cox maximum normalized correlation), maximum normalized correlation using a GM (geometric mean), MMSE (minimum mean squared error), ML (maximum likelihood). ML (Maximum Likelihood) method is better than the other is shown by the results. In correlation methods varying the value of correlation lag and find out what is the effect on detection technique. In this preamble detection method we used different communication channel like AWGN and Reyligh fading channel, also used digital modulation techniques QAM (Quadrature amplitude modulation) with OFDM (Orthogonal frequency division modulation). The performance has been concluded based Sample versus Detection value and output through MATLAB-R3013a Simulation tool.

Keyword- WiMAX (Worldwide Interoperability for Microwave Access), Preamble Detection, OFDM (Orthogonal frequency division modulation), AWGN (Additive white Gaussian Noise) etc.

I. INTRODUCTION

The growing demand for mobile Internet and wireless multimedia applications such as Internet browsing, interactive gaming, mobile TV, video and audio streaming has motivated development of broadband wireless access technologies in recent years. As a result, the 3rd Generation Partnership Project (3GPP) initiated the work on the long-term evolution (LTE) in late 2004. LTE will ensure 3GPPs competitive edge over other cellular technologies. The evolved UMTS terrestrial radio access network (E-UTRAN) substantially improves end-user throughputs, sector capacity and reduces user-plane and control-plane latencies, bringing significantly improved user experience with full mobility. The IEEE 802.16 group was formed in 1998 to develop an air interface standard for wireless broadband. The group's initial focus was the development of a LOS-based point-to-multipoint wireless broadband system for operation in the 10GHz-66GHz millimeter wave band. The resulting standard-the original 802.16 standard, completed in December 2001-was based on a single carrier physical (PHY) layer with a burst time division multiplexed (TDM) MAC layer.

The IEEE 802.16 group subsequently produced 802.16a, an amendment to the standard, to include NLOS applications in the 3GHz-11GHz band, using an orthogonal frequency division multiplexing (OFDM)-based physical layer. Additional to the MAC layer, such as support for orthogonal frequency division multiple access (OFDMA), were also included. 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, and we will refer to these as fixed WiMAX. In December 2005, the IEEE group completed and approved IEEE 802.16e-2005 an amendment to the IEEE 802.16e-2004 standard that added mobility support. The IEEE 802.16e-2005 forms the basis for the WiMAX solution for nomadic and mobile applications and is often referred to as mobile WiMAX.

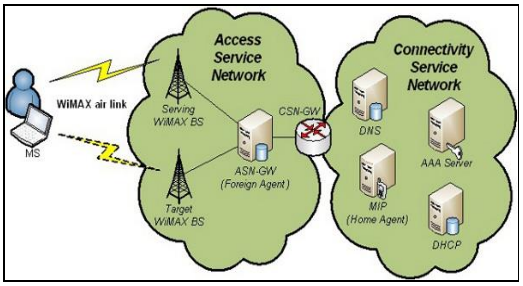

Fig. 1: WiMAX Network Architecture based on IP [5]

WiMAX architecture comprises of several components but the basic two components are BS and SS (Subscriber Station). Other components are MS, ASN, CSN and CSN-GW etc. The WiMAX Forum's Network Working Group (NWG) has developed a network reference model according to the IEEE 802.16e-2005 air interface to make sure the objectives of WiMAX are achieved. To support fixed, nomadic and mobile WiMAX network, the network reference model can be logically divided into three parts as following, and Figure1 show in WiMAX network architecture based on IP. Mobile Station (MS), Access Service Network (ASN), Connectivity Service Network (CSN).

II. SYNCHRONIZATION DETECTION METHODS

A major problem in data communications arises from the inter symbol interference (ISI) created by a frequency selective channel. ISI is a form of distortion of a signal in which one symbol interferes with subsequent symbols. This is an unwanted phenomenon since the previous symbols have similar eject as noise, thus making the communication less reliable. When the signals are transmitted through a band limited channel, wire or wireless, the channel characteristic is usually non-ideal, i.e., the amplitude response is not constant for the pass band and the phase response is not a linear function of frequency. A sequence of the pulses transmitted through the channel will then be distorted and may not be clearly distinguishable at the receiver.
Synchronization is used to find out the starting of the frame and received signal. Initial symbol timing is measured by the synchronization. Proper synchronization is useful for preparing the system that data is starting. Synchronization is done by the preamble. Normally synchronization is by adding stream of bits into the data. These bits increase the length of the data. These bits are known by the receiver.

In digital communication systems, the detection circuit in the receiver decides the presence and the absence of a transmitted signal. This decision is usually based on comparing the received signal voltage with a predefined threshold. If the received signal voltage is greater than the threshold then the presence of the signal is confirmed. The signal that is transmitted is composed of three parts - preamble, header and payload. The preamble part mainly contains a SYNC field that provide information to enable the receiver to perform the necessary synchronization procedures, followed by a Start Frame Delimiter (SFD) field to indicate the end of the SYNC field and start of the data part. The header part usually contains signaling information like the modulation technique used at the transmitter, the time required to transmit the payload and CRC. The payload contains the actual data to be decoded. The problem statement here is to develop an algorithm for preamble detection for the given input settings.

III. FRAMEWORK DESCRIPTION OF PREAMBLE DETECTION METHOD

The process in which the synchronization is achieved consists of the following steps Figure 2. The description of the above steps for correlation and matching the sequence is given below.

a. Packet Detection using Cyclic Prefix,
b. Preamble Detection in Time Domain,
c. Preamble Detection in Frequency Domain.

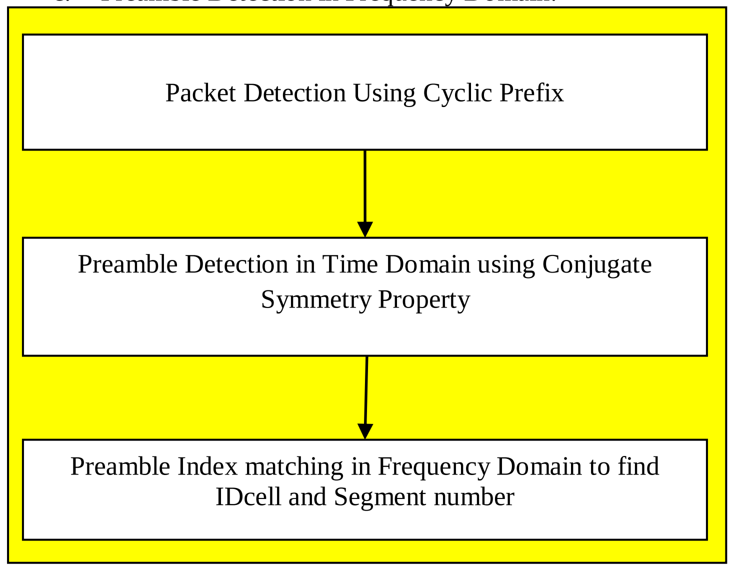

Fig. 2: Steps in Preamble detection

IV. OPTIMIZATION CRITERION (DETECTION)

Several types of optimization detection metrics have been developed: maximum correlation (MC), maximum normalized correlation (MNC), Schmidl and Cox maximum normalized correlation (SC), maximum normalized correlation using a geometric mean (GM), minimum mean squared error (MMSE), maximum likelihood (ML), and maximum normalized time reversed correlation (MTRC). The first six are functions of the same statistics, the correlation at lags equal to the Preamble's repetition period of the signal.
The delayed correlation is the autocorrelation of the received waveform evaluated at a specific lag d:

$$R_{yy}(n,d) = \frac{1}{M}\sum_{m=0}^{M-1} y(n+m)y^*(n+m+d) \qquad (1)$$

The power estimate is given by:

$$R_{yy}(n,0) = \frac{1}{M}\sum_{m=0}^{M-1}|y(n+m)|^2 \qquad (2)$$

Here d represents the correlation lag, and is fixed. The value of the lag is determined by the repetition period of the signal. The delay correlate computational burden is minimized by using an iterative moving average implementation:

$$R_{yy}(n+1,d) = R_{yy}(n,d) + y^*(n+d)y(n+d+M) - y^*(n)y(n+M) \qquad (3)$$

Where N is the FFT size, Ng is the cyclic Prefix length, and M is the correlation integration length.

IV-A: Schmidl and Cox maximum normalized correlation (SC)

The simplest detection metric is the un-normalized maximum correlation metric. This approach is problematic for determining a threshold that will work well under a varied channel conditions. A normalized version of this idea was developed by Schmidl and Cox:

$$M_{SC}(n) = \frac{|R_{yy}(n,L)|^2}{R_{yy}^2(n,0)} \quad (4)$$

VI-B. Maximum Likelihood (ML)

Maximum likelihood methods is modified by MINN using the Schmidl metrics denominator to average all the signal samples used in the calculation of $Ryy(n, d)$:

$$M_{M,L}(n) = \frac{2|R_{yy}(n,L)|^2}{(R_{yy}(n,0)+R_{yy}(n+L,0))^2} \quad (5)$$

VI-C. Minimum Mean Squared Error (MMSE)

Minimum mean squared error method is modified by MINN and also added a length $Ng + 1$ smoothing filter to remove the plateau, reducing the variance of the timing estimates.

$$M_{Minn}(n) = \frac{1}{N_g+1}\sum_{k=0}^{N_g} M_{M,L}(n-k) \quad (6)$$

At high SNR this has a clearly defined peak, Figure 4. MINN describes another metric that takes advantage of additional redundancy present in preambles that have 4, 8, and 16 repeated sections. In the next section it will be clear that this concept, with 3 sections, applies to WiMAX preambles. Applying MINN's second metric for a preamble with 3 repeated sections the resulting metric is given by:

$$M_{Minn2}(n) = \frac{|R_{yy}(n,L)+R_{yy}(n+L,L)|^2}{\left(\frac{1}{2}R_{yy}(n,0)+\frac{1}{2}R_{yy}(n+L,0)\right)^2} \quad (7)$$

Where $M = L = \left\lfloor \frac{N}{3} \right\rfloor$

VI-.D Maximum Normalized Correlation using a Geometric Mean

Another approach to normalize the metric uses the geometric mean of two delayed power estimates to normalize the metric:

$$M_{GM}(n) = \frac{|R_{yy}(n,L)|}{\sqrt{R_{yy}(n,0)R_{yy}(n+L,0)}} \quad (8)$$

The square root can be avoided by squaring the metric. This metric performs well at higher SNR. At low SNR the performance falls off. The minimum mean squared error (MMSE) criterion has been shown to be equivalent to the MINN metric. Maximum likelihood (ML) techniques based on the CP have been developed. The ML detector is essentially the MMSE metric with a threshold that is a function of the SNR.

V. AWGN CHANNEL

The AWGN channel model is a simple but basic concept for modeling channel effects on electromagnetic signals in communication systems. The simplest channel model in wireless commutations is the well known Additive White Gaussian Noise (AWGN) model. The mathematical expression of the AWGN channel as follows in Figure 3, The AWGN channel adds white noise $n(t)$ to the signal $x(t)$:

$$y(t) = x(t) + n(t) \quad (9)$$

The noise has a constant spectral density and the amplitudes are normal distributed with variance $\sigma^2 = N_0/2$. N0 is the single-sided noise spectral density. White Noise is existent in all communication systems independent of their propagation and induced by many sources like thermal noise in electronic circuits, terrestrial noise, and cosmic noise.

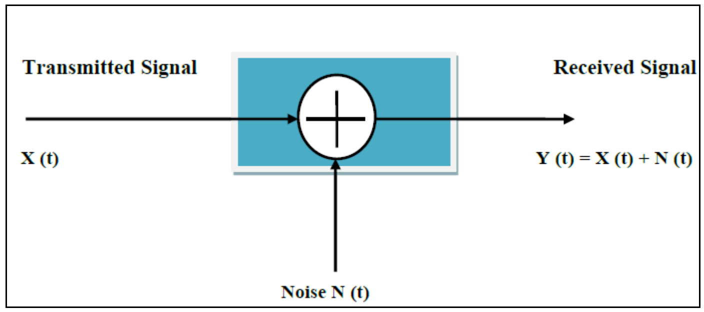

Fig. 3: AWGN channel [6]

Hence the AWGN channel model is essential but not sufficient to model terrestrial propagation effects. The terrestrial propagation faces further effects like multipath, slow and deep fading, which can affect the channel severe. To consider these, other channel models have to be used additionally. The Rayleigh and the Rician channel model are common representatives of these and described below.

If the average received power is $P'[W]$ and the noise power spectral density is N_0 [W/Hz], the AWGN channel capacity is:

$$c_{awgn} = W\log_2\left(1 + \frac{P'}{N_0 W}\right) \text{ Bit/Hz} \quad (10)$$

Where P'/NoW is the received signal-to-noise ratio (SNR). When the SNR is large (SNR >> 0 dB), the capacity C≈ W $\log_2 P'/N_0W$ is logarithmic in power and approximately linear in bandwidth. This is called the bandwidth-limited regime. When the SNR is small (SNR << 0 dB), the capacity C≈ W $\log_3$ e is linear in power but insensitive to bandwidth. This is called the power-limited regime.

VI. SIMULATION RESULTS

During our simulation we used cyclic prefix at transmitter side to minimize the Inter Symbol Interference (ISI) on the basis of following modulation (Quadrature Phase Shift Keying, Quadrature Amplitude Modulation) techniques through Matlab 2013a simulation toll. With the help of above modulation techniques we got the analysis parameters like the Sample (Time in second) Represent in X-axis, Detection Value Represent in Y-axis, also we have used AWGN and multipath fading channel.--

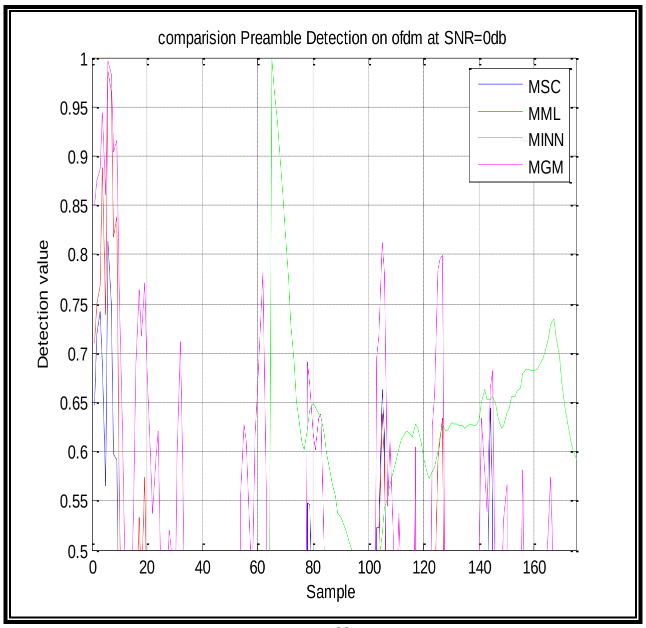

Fig.4: Correlation between Different signals at SNR=0 dB

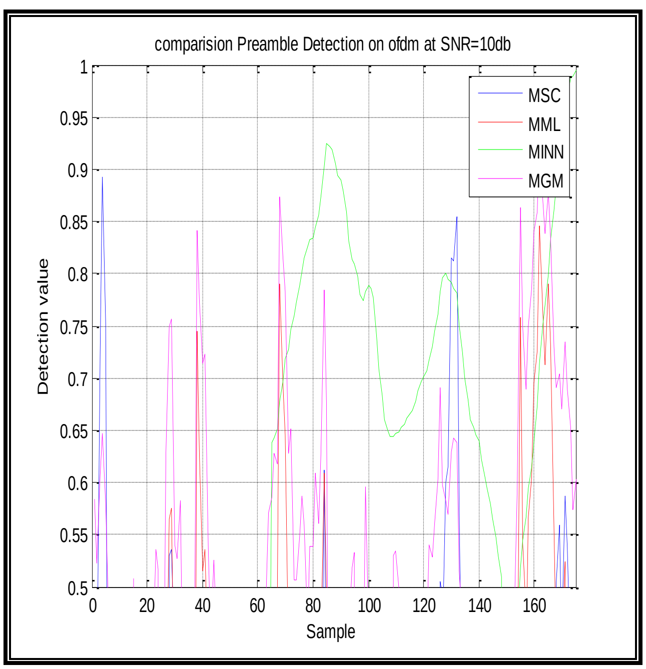

Fig. 5: Correlation between Different signals at SNR=10 dB

-- In this correlation of preamble detection (maximum normalized correlation (MNC or MINN), Schmidl and Cox maximum normalized correlation (SC or MSC), maximum normalized correlation using a geometric mean (GM or MGM), maximum likelihood (ML or MML) method are comparison on OFDM using AWGN Channel. In this model we have used QAM (Quadrature Amplitude Modulation) in modulation technique, and required SNR value is 0dB in figure 4 and the performance done by used MATLAB R2013a version.

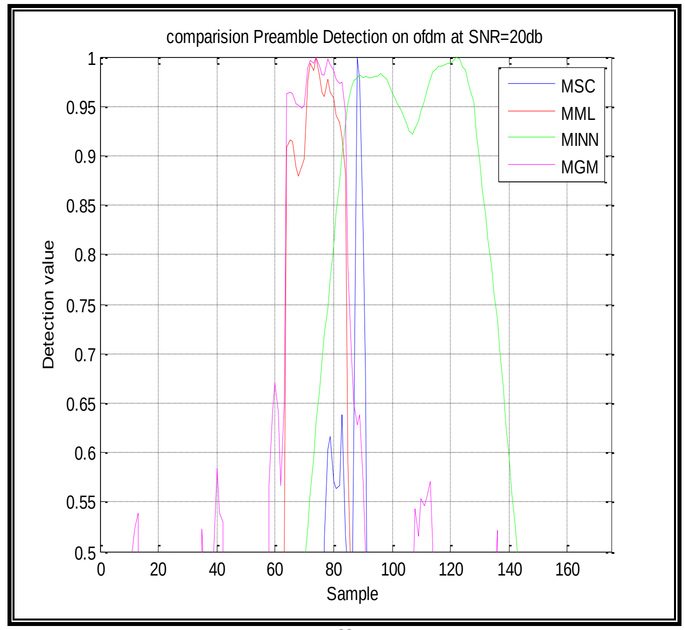

Fig. 6: Correlation between Different signals at SNR=20 dB

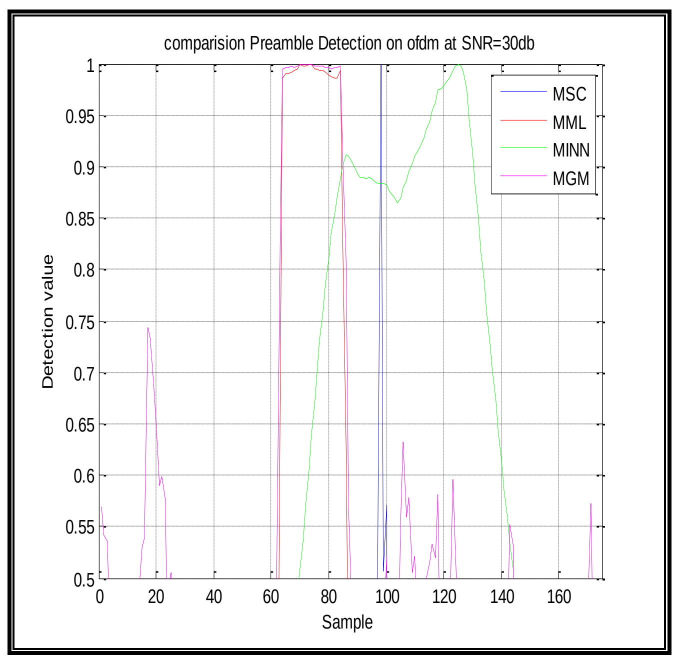

Fig.7: Correlation between Different signals at SNR=30 dB

VII. CONCLUSION

In this thesis Preamble detection of WiMAX is compared using four methods Schmidl and Cox maximum normalized correlation (SC), maximum normalized correlation using a geometric mean (GM), minimum mean squared error (MMSE), maximum likelihood (ML). Different correlation lag is used and the different integer length is applied. MMSE method starts the detection of the preamble correctly but the detection period is large rather than other methods. SC gives the sharp peak but it peak cannot takes exact position for preamble detection it detects after the redundancy occurred. MGM and ML detect exactly for the preamble detection but MML has lesser width than the MGM so ML is better method for preamble detection rather than the GM. ML is the preferred method for the preamble detection But in the MINN techniques has batter than all techniques because its performance is smoothly down and rise at all point so that MINN is batter techniques.

An figure 4,5,6 and 7 result we analysis all preamble technique (MSC, MML, MINN and MGM) at different SNR value (0dB, 10dB, 20dB and 30dB). In the SNR at 30dB have best performance is obtain in MML and MGM but some time both result suddenly down over performance of detection value. But in the MINN techniques has batter than all techniques because its performance is smoothly down and rise at all point so that MINN is batter techniques.

REFERENCES

[1] Dahiru Sani Shuabu, Sharifah Kamilah, Norsheila Faisal and Yakubu S. Baguda **"Simulation and Performance Analysis of Partial Usage Subchannels in WiMAX IEEE802.16e"** International Journal of Recent Trends in Engineering, Vol 2, No. 5, page no 126-129 November 2009.

[2] Miray Kas, Burcu Yargicoglu, Ibrahim Korpeoglu, and Ezhan Karasan **"A Survey on Scheduling in IEEE 802.16 Mesh Mode"** IEEE Communications Surveys & Tutorials, VOL. 12, NO. 2, Second Quarter 2010 page no 205-221.

[3] Md. Ashraful Islam, Md. Zahid Hasan **"Performance Evaluation of Wimax Physical Layer under Adaptive Modulation Techniques and Communication Channels"** (IJCSIS) International Journal of Computer Science and Information Security, Vol. 5, No.1, 2009.

[4] Rakhi Thakur and Kavita Khare **"Synchronization and Preamble Concept for Frame Detection in OFDM"** International Journal of Modeling and Optimization, Vol. 3, No. 1, February 2013.

[5] Shigenori Kinjo **"An MMSE Channel estimation algorithm based on the conjugate gradient method for OFDM systems"** (ITC-CSCC 2008).

[6] Muhammad Nadeem Khan, Sabir Ghauri, **"The WiMAX 802.16e Physical Layer Model",** University of the West of England, United Kingdom.

[7] Upen Dalal **"Wireless Communication"** Oxford University Press, fourth impression 2011. Pp 365-413, pp 591-631.

[8] Sumeeth Nagaraj, Sheehan Khan and Christian Schlegel **"On Preamble Detection in Packet-Based Wireless Networks"** 2006 IEEE Ninth International Symposium on Spread Spectrum Techniques and Applications.

[9] Mithun Sarode **"Preamble Detection Of IEEE 802.16"** proceedings of international conference on nanoscience, engineering & advanced computing (ICNEAC-2011).

[10] Chakchai So-In,Raj Jain and Abdel-Karim Tamimi, **"Scheduling in IEEE 802.16e Mobile WiMAX Networks: Key Issues and a Survey"** IEEE Journal on Selected Areas in Communications, VOL. 27, NO. 2, February 2009 page no 156-171.

[11] L. J. Cimini, **"Analysis and simulation of a digital mobile channel using orthogonal frequency division multiplexing"** IEEE Trans. Commun., vol. 33, no. 7, pp. 665–675, Jul. 1985.

[12] P. H. Moose, **"A technique for orthogonal frequency division multiplexing freuency offset correction"** IEEE Trans. Commun., vol. 42, no. 10, pp. 2908–2924, 1994.

[13] H. MINN, V. K. Bhargava, and K. B. Letaief, **"A robust timing and frequency synchronization for OFDM systems"** IEEE Trans. Wireless Commun., vol. 2, no. 4, pp. 822–838, Jul. 2003.

[14] T. M. Schmidl and D. C. Cox, **"Robust frequency and timing synchronization for OFDM"** IEEE Trans. Commun., vol. 45, no. 12, pp. 1613–1621, Dec. 1997.

[15] R. Negi, **"Blind OFDM symbol synchronization in ISI channels"** IEEE Trans. Commun., vol. 50, no. 9, pp. 1525–1534, Sep. 2002.

[16] Kun-Chien Hung and David W. Lin **"Joint Detection of Integral Carrier Frequency Offset and Preamble Index in OFDMA WiMAX Downlink Synchronization"** IEEE Communications publication in the WCNC 2007. Page no 1961-1966.