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PREAMBLE DETECTION IN WIMAX 802.16E USING REYLIGH CHANNEL WITH OFDM SYSTEM

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Abstract

WiMAX represents World Interoperability for Microwave Access is a major part of broadband wireless network having IEEE 803.16 standard provides innovative fixed as well as mobile platform for broadband internet access anywhere in anytime. WiMAX works on high data rate and it is a wireless technique so fading and attenuation in the signals is presence due to noise, inter symbol interference, inter carrier interference etc. OFDM modulation technique is used to work on multicarrier. OFDM works on orthogonality so presence of ISI is neglected. These methods are Schmidl and Cox maximum normalized correlation (SC), maximum normalized correlation using a geometric mean (GM), minimum mean squared error (MMSE), maximum likelihood (ML). Maximum Likelihood (ML) 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 paper analysis of preamble detection method with Reyligh fading channel, also used modulation techniques QPSK with OFDM. The performance has been concluded based Sample versus Detection value and output through MATLAB-R3013a Simulation.

I. INTRODUCTION

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 803.16e-3005 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 [14] as following, and Figure1 show in WiMAX network architecture based on IP.

a) Mobile Station (MS),
b) Access Service Network (ASN),
c) Connectivity Service Network (CSN).

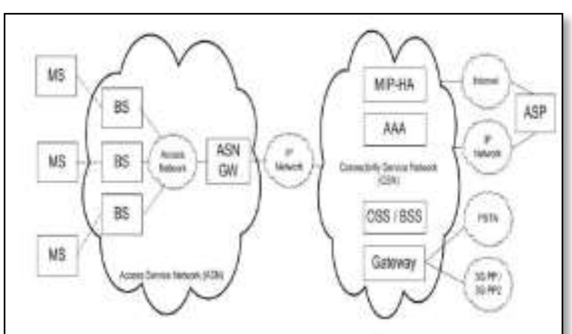

Fig. 1: WiMAX Network Architecture based on IP

II. OFDM SYSTEM

A typical OFDM transmission system is shown in Figure 2. At the transmitting end, first of all, input binary serial data stream is first processed by channel encoder, constellation mapping and serial to parallel (S/P) conversion. A single signal is divided into N parallel routes after N-point inverse fast Fourier transform (IFFT). Each orthogonal sub-carrier is modulated by one of the N data routes independently. By definition the N processed points constitute one OFDM symbol.

Next, convert modulated parallel data to serial sequence and then copy the last L samples of one symbol to the front as cyclic prefix (CP). At the receiving end, digital down conversion is carried out, demodulate receiving signals. At last, demodulated signals are fed into an analog to digital (A/D) converter, sample output and take timing estimation to find initial position of OFDM symbol.

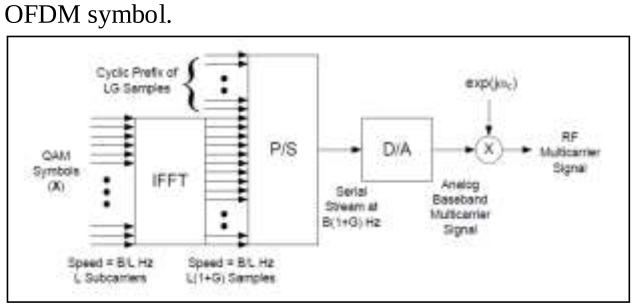

Fig. 2: Basic structure of OFDM system

The frequency of an OFDM signal can be expressed as:

$$fi = fc + i \cdot \Delta f \quad (1)$$

Where fc stands for carrier frequency, Δf is the smallest interval between different sub-carrier frequencies. Δf is given by:

$$\Delta f = \frac{1}{T} = \frac{1}{Nt_s} \quad (2)$$

III. QPSK MODULATION

This is also known as four-level PSK where each element represents more than one bit. Each symbol contains two bits and it uses the phase shift of π/3, means 90º instead of shifting the phase 180º.

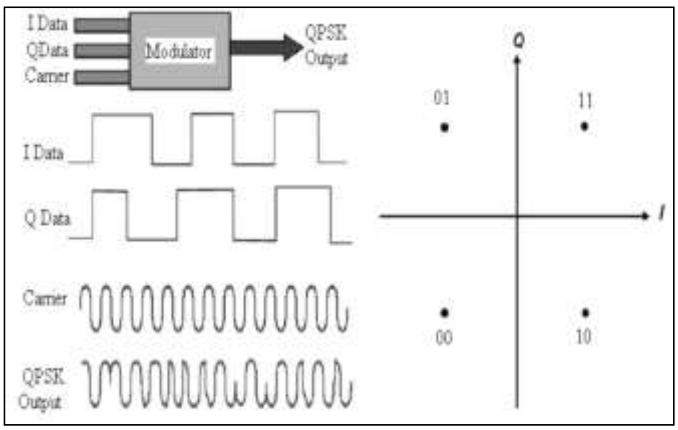

Fig. 3: QPSK Block Diagram and Constellation Diagram

In this mechanism, the constellation consists of four points but the decision is always made in two bits. This mechanism can ensure the efficient use of bandwidth and higher spectral efficiency. The principle equation (3) of QPSK Modulation of the technique is:

$$S(t) = \begin{cases} A\cos\left(2\pi f_c t + \frac{\pi}{4}\right), \; for\ binary\ 11 \\ A\cos\left(2\pi f_c t + \frac{4\pi}{4}\right), for\ binary\ 01 \\ A\cos\left(2\pi f_c t - \frac{4\pi}{4}\right), for\ binary\ 00 \\ A\cos\left(2\pi f_c t - \frac{\pi}{4}\right), for\ binary\ 10 \end{cases} \quad (3)$$

IV. MULTI PATH FADING

When an object comes on the way between a wireless transmitter and a receiver, it blocks the signal and creates several signal paths known as multi path. Even though the signal makes till the receiver but with variant time and it is hard to detect the actual signal. Multi path degrade the quality of the signal. Fast Fading**,** Slow Fading**,** Flat Fading (Non-Selective Fading) Frequency Selective Fading.

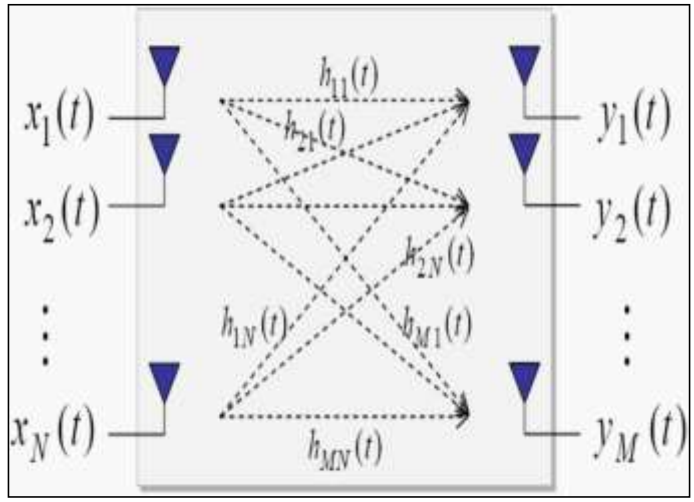

Fig. 4: Multipath (Multiple input and Output)

A. Rayleigh channel

The Rayleigh channel model assumes that at the sink a number of signals with varying amplitude and delay are received. The multipath components of the signal are reacted on still obstacles i.e. buildings, mountains, water surfaces and moving obstacles like vehicles and aircrafts.

Moving objects change their positions and hence the received multipath components reflected from these vary over time. The amount of Doppler shift depends on the velocity, the carrier frequency and the angle between moving direction and direction of the sender. The maximum Doppler shift is:

$$F_{D_{max}} = \frac{v.f_c}{C} \quad (4)$$

The Doppler shift depending on the angle between sender and receiver is:

$$f_D = f_{D_{max}}.\cos\alpha$$
$$= \frac{v.f_c}{C}.\cos\alpha \quad (5)$$

The In-Phase and the Quadrature part of each QAM symbol face statistically independent normal distributed variance. The sum of these variances is the sum of two zero-mean Gaussian distributions and called Rayleigh distributed:

$$f(x, \sigma) = \frac{x}{2\sigma} e^{\frac{x^2}{2\sigma^2}} \quad (6)$$

It is shows good performance in NLOS condition as it is based on OFDM which can handle delays caused in NLOS, perfectly.

V. MATHEMATICAL DESCRIPTION ON PREAMBLE SIGNAL MODEL

The Mobile WiMAX Preamble waveforms are defined in the frequency domain and can be represented by:

$$X_k\left(3m + s_k - \frac{N}{2} + N_{GL}\right) = W_k(m) \qquad (7)$$

For m = 0, ..., NPSC −1, where S_k = 0, 1, 3 represents the segment index, Wk is the unique sequence of • ± 1 's representing the preamble index k = 0, ..., 113. NGL represents the number of the guard subcarriers on the left (low frequency) side. *NPSC* is the number of subcarriers assigned for preambles in each segment. For the 10 MHz case N = 1034, NGL = 86, and NPSC = 384.

A. 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.

A.1 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:

$$M_{SC}(n) = \frac{|R_{yy}(n,L)|^2}{R_{yy}^2(n,0)} \qquad (8)$$

A.2 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 $R_{yy}(n, d)$:

$$M_{M,L}(n) = \frac{2|R_{yy}(n,L)|^2}{(R_{yy}(n,0) + R_{yy}(n+L,0))^2} \qquad (9)$$

A.3 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:

$$M_{Minn}(n) = \frac{1}{N_g+1}\sum_{k=0}^{N_g} M_{M,L}(n-k) \qquad (10)$$

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:

$$M_{Minn2}(n) = \frac{|R_{yy}(n,L) + R_{yy}(n+L,L)|^2}{\left(\frac{1}{2}R_{yy}(n,0) + \frac{1}{2}R_{yy}(n+L,0)\right)^2} \qquad (11)$$

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

A.4 Maximum Normalized Correlation using a Geometric Mean (GM)

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

$$M_{GM}(n) = \frac{|R_{yy}(n,L)|}{\sqrt{R_{yy}(n,0)R_{yy}(n+L,0)}} \qquad (12)$$

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.

VI. SIMULATION RESULT

The Preamble techniques (MSC, MML, MINN and MGM) was analysis in this paper with used in Reyligh channel with threshold value at the 64 for CP ¼ for the total number of symbol used is 256 and preamble starts from the 64th symbol.

Table 1: Used Simulation Parameter

S. No.	Parameter	Value
01	No. of symbol	2
02	Number of bits per symbol	8
03	Ncbps	384
04	M	4
05	NFFT	256
06	Channel	Rayleigh
07	Modulation	QPSK
08	Preamble Techniques	MSC, MML, MINN, MGM

In the figure 5, 6, 7, 8 and 9 shows the different-different SNR value cosider with all preamble detection methiod.

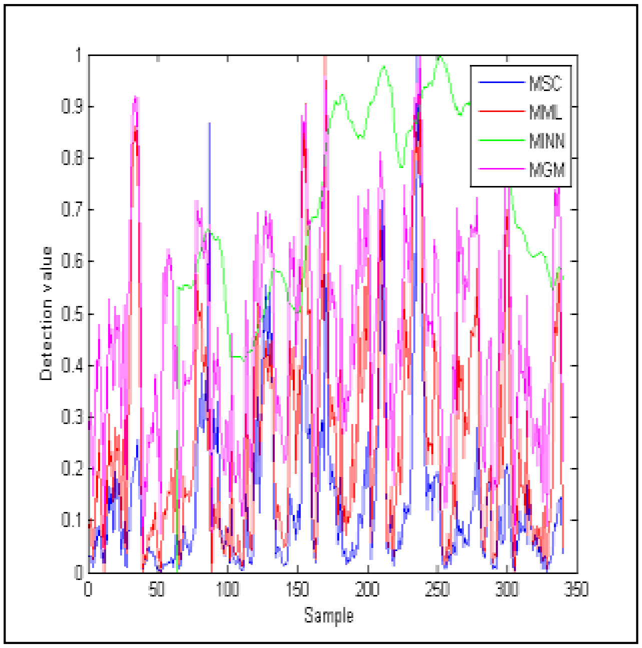

Fig. 5: Only Minn method provid single maxima in correleation vector which tell about synchronization SNR=10

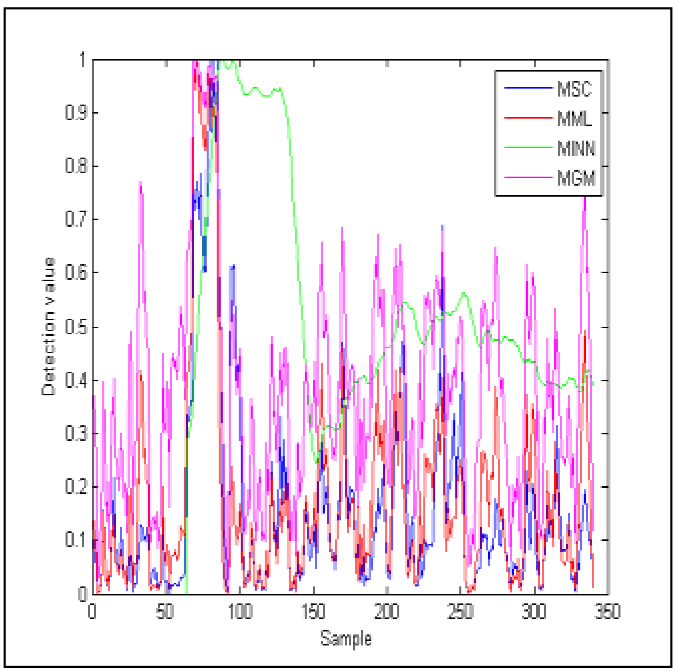

Fig. 6: Only Minn method provid single maxima in correleation vector which tell about synchronization SNR=15

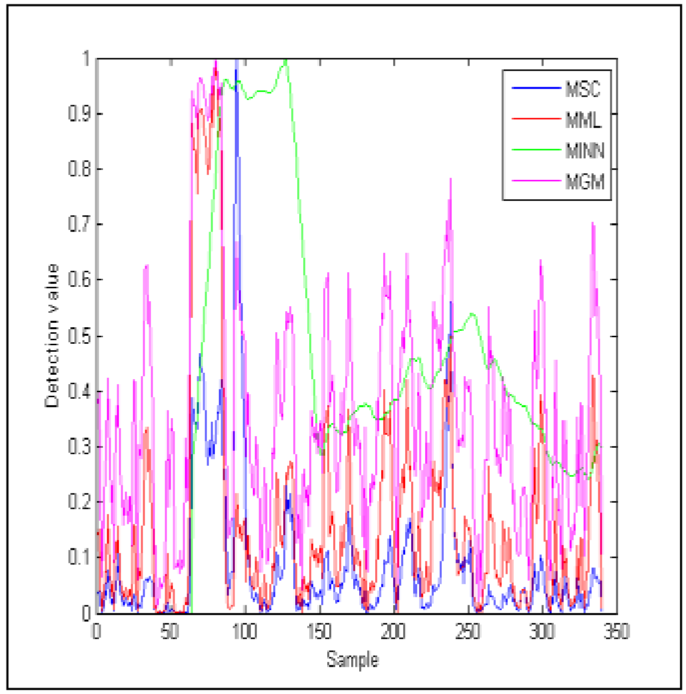

Fig. 7: Only Minn method provid single maxima in correleation vector which tell about synchronization SNR=20

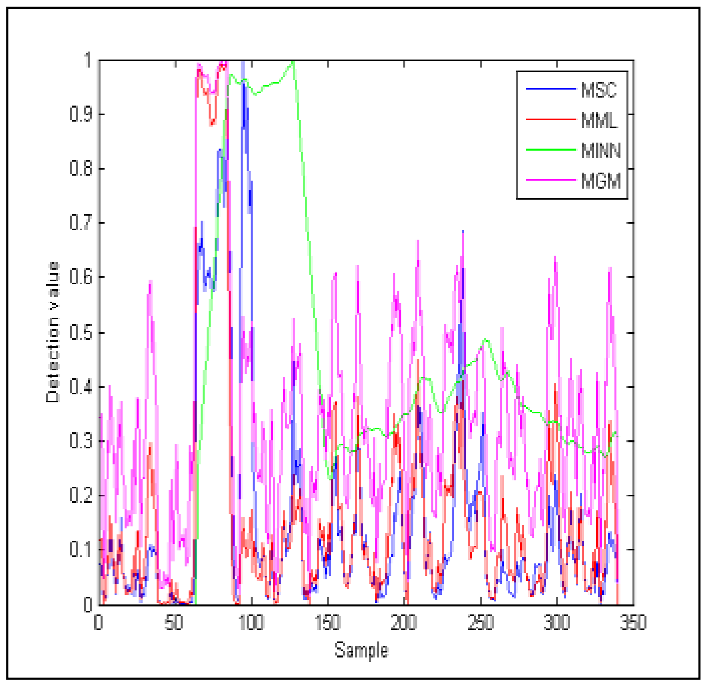

Fig. 8: Only Minn method provid single maxima in correleation vector which tell about synchronization SNR=25

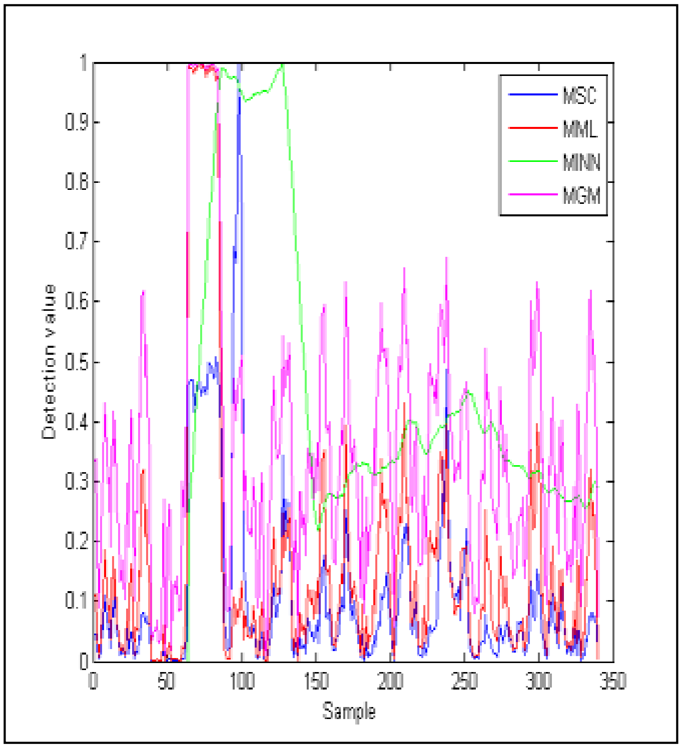

Fig. 9: Only Minn method provid single maxima in correleation vector which tell about synchronization SNR=30

Table: Preamble Simulation result analysis

SNR	Sample			
	MSC	MML	MINN	MGM
10	ND	ND	103	ND
15	ND	ND	70	ND
20	ND	ND	60	ND
25	ND	ND	60	58
30	ND	ND	58	58

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/MINN), maximum likelihood (ML). Different correlation lag is used and the different integer length is applied. MINN 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.

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