International Journal of Trend in Scientific Research and Development (IJTSRD)
Volume 8 Issue 4, Jul-Aug 2024 Available Online: www.ijtsrd.com e-ISSN: 2456 – 6470

Exploring the Different Preamble Detection Methods Using Wimax Technology with Additive White Gaussian Noise (AWGN) Channel

Rakesh Jain

Department of Computers Science Engineering,
Indore Institute of Science and Technology, Indore, Madhya Pradesh, India

ABSTRACT

This paper presents a comprehensive study of WiMAX-IEEE 802.16 standards and details a synchronization method for an OFDM communication system within a channel. In a multipath fading environment, the signal traverses through free space, exhibiting distinct characteristics in both the time and frequency domains. To achieve optimal spectral efficiency and bit error rate (BER) at the receiver, a precise synchronization model is essential. Synchronization requirements vary with the channel conditions, traffic patterns, and path loss components characteristic of different environments, such as urban and suburban areas. Timing synchronization identifies data burst arrivals and symbol boundaries, while frequency synchronization aligns the local oscillator with the carrier frequency. The prevalence of wireless communication systems globally underscores the relevance of this study. WiMAX operates at high data rates and, being a wireless technology, is susceptible to fading and attenuation due to noise, inter-symbol interference, and inter-carrier interference. This paper evaluates various preamble detection methods, including Schmidl and Cox maximum normalized correlation (SC), maximum normalized correlation using a geometric mean (GM), minimum mean squared error (MMSE), and maximum likelihood (ML). The analysis is conducted through an AWGN communication channel, employing QAM with OFDM modulation techniques. Performance is assessed based on sample versus detection values and MATLAB-R3013a simulations.

KEYWORDS: *AWGN, OFDM, Preamble detection, ISI, WiMAX, QAM*

How to cite this paper: Rakesh Jain "Exploring the Different Preamble Detection Methods Using Wimax Technology with Additive White Gaussian Noise (AWGN) Channel" Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456-6470, Volume-8 | Issue-4, August 2024, pp.486-491, URL: www.ijtsrd.com/papers/ijtsrd67177.pdf

IJTSRD67177

A. INTRODUCTION

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 [1, 2]. 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 [3-5]. WiMAX technology will support traffic based on transport technologies ranging for Ethernet, Internet protocol (IP), and asynchronous transfer mode (ATM), the forum will only certify the IP-related elements of the 802.16 products. A critical aspect of the research is the emphasis on synchronization to achieve high spectral efficiency and a low bit error rate (BER) at the receiver end. The need for accurate synchronization is underscored by its dependency on several factors, including channel conditions, traffic patterns, and path loss components specific to different environments, such as urban and suburban settings. Timing synchronization is pivotal for detecting the arrival of data bursts and determining symbol boundaries, whereas frequency synchronization is necessary for aligning the local oscillator with the carrier frequency [6].

The study conducts its analysis through an Additive White Gaussian Noise (AWGN) communication channel [7-10], utilizing Quadrature Amplitude Modulation (QAM) with Orthogonal Frequency-Division Multiplexing (OFDM) techniques [11-13]. The performance of the discussed methods is evaluated based on sample versus detection values, with results generated through MATLAB-R3013a simulations. MIMO-OFDM (Multiple Input Multiple Output - Orthogonal Frequency Division Multiplexing) technology has played a transformative role in conventional wireless communication systems. Its principles are increasingly being explored in emerging fields, including quantum dots cellular automata (QDCA) nanoelectronics. Quantum Dots Cellular Automata [14] is a promising technology in the realm of nanoelectronics [15]. Unlike traditional transistor-based electronics, QDCA relies on the position of electrons in quantum dots to represent binary states [16]. This approach can significantly reduce power consumption and increase processing speed, making it a key technology for future nanoscale devices.

B. PREAMBLE DETECTION METHODS

The widespread adoption of wireless communication systems globally highlights the importance of this study. WiMAX, known for its high data rates, faces challenges like signal fading and attenuation caused by noise, inter-symbol interference, and inter-carrier interference. To address these challenges, the paper explores several preamble detection methods, such as [4,5]:

- Schmidl and Cox Maximum Normalized Correlation (SC): A technique that uses correlation to detect preambles in the presence of noise.
- Maximum Normalized Correlation Using a Geometric Mean (GM): This method enhances the detection process by employing a geometric mean for normalization.
- Minimum Mean Squared Error (MMSE): A statistical approach aimed at minimizing the mean squared error in the detection process.
- Maximum Likelihood (ML): A method based on the principle of likelihood maximization to achieve optimal detection performance.

C. PREAMBLE DETECTION

Mobile WiMAX is a wireless protocol designed for broadband wireless access that employs Time Division Duplex (TDD) Orthogonal Frequency Division Multiple Access (OFDMA). The WiMAX frame structure initiates with a preamble symbol, which is crucial for establishing both the frame timing and the initial symbol timing necessary for mobile devices. In mobile WiMAX systems, the detection of the preamble symbol is typically achieved using a delay correlation detector. This method is integral to synchronization, which determines the start of the frame and the received signal. The process of synchronization measures the initial symbol timing, ensuring that the system is prepared to receive and process the incoming data accurately.

Synchronization in Mobile WiMAX [3] is facilitated by the preamble, which involves adding a specific stream of bits to the data. These bits, known to the receiver, do not carry actual data but serve to synchronize the receiver with the transmitter [7]. By increasing the length of the data with these known bits, the system ensures that the receiver can correctly identify the start of the frame and the timing of each symbol [10], thereby enhancing the overall reliability and efficiency of the communication process.

D. PACKET DETECTION USING CYCLIC PREFIX

In Orthogonal Frequency Division Multiplexing (OFDM) systems, packet detection is often achieved through auto-correlation using a Cyclic Prefix (CP) [13]. The Cyclic Prefix is a technique where a copy of the last few samples of an OFDM symbol is appended to the front of the symbol before transmission. This redundancy aids in mitigating inter-symbol interference and enhances the detection and synchronization processes.

Structure: Each OFDM symbol is extended by appending a copy of its last few samples (the CP) to its beginning.

Purpose: This extension helps in combating multi-path fading and allows the receiver to identify the start of the OFDM symbol by leveraging the repetitive structure introduced by the CP.

Packet Detection Process:

High Correlation: The Cyclic Prefix introduces a high correlation between the beginning and the end of the OFDM symbol. This property is exploited for packet detection. Delayed Correlation: By performing a delayed correlation between the first few samples of the OFDM symbol (corresponding to the CP) and the last few samples of the symbol, the receiver can effectively detect the start of the packet.

Auto-correlation Mechanism:

The receiver continuously performs an auto-correlation operation between incoming samples. When the correlation exceeds a certain threshold, it indicates the presence of the CP and hence, the start of an OFDM symbol. As the following advantages of bellow. Robust Detection: The method ensures robust detection even in the presence of noise and multi-path effects. Simplified Receiver Design: The use of CP simplifies the design of the receiver by providing an easy and efficient way to achieve synchronization.

E. SIMULATION PROCESS

In the Simulation process of the WiMAX-preamble detection model, there are some steps for implementation including data generation, data randomization, FEC encoder, interleaver, symbol mapper, IFFT modulator at the transmitter side. In medial section AWGN channel is used the simulation process of the WiMAX-preamble detection model involves multiple steps that encompass both the transmitter and receiver sides of the communication system. Here's a detailed exploration of each step [7]:

E.1 Transmitter Side

Data Generation:

Random data bits are generated, representing the information to be transmitted.

Data Randomization:

The generated data bits are randomized to reduce the occurrence of long sequences of identical bits, which helps in reducing signal peaks and improving transmission reliability.

FEC Encoder:

Forward Error Correction (FEC) encoding is applied to the randomized data. Techniques such as Convolutional Coding or Reed-Solomon coding are used to add redundancy, allowing the receiver to detect and correct errors.

Interleaver:

The encoded data is interleaved to spread out burst errors over multiple codewords. This process improves the robustness of the transmission by making error correction more effective.

Symbol Mapper:

The interleaved data is mapped onto symbols using modulation schemes like QAM (Quadrature Amplitude Modulation). Each group of bits is converted into a complex symbol representing a point in the constellation diagram.

IFFT Modulator:

An Inverse Fast Fourier Transform (IFFT) is applied to the mapped symbols to convert the frequency domain data into the time domain, forming the OFDM signal. This step includes adding a Cyclic Prefix (CP) to each OFDM symbol to combat inter-symbol interference.

Channel Model

E.2 AWGN Channel:

The transmitted OFDM signal passes through an Additive White Gaussian Noise (AWGN) channel. This channel model adds white noise to the signal, simulating real-world conditions where noise is always present in the communication medium.

E.3 Receiver Side

FFT Modulator:

At the receiver, the received OFDM signal undergoes a Fast Fourier Transform (FFT) to convert the time-domain signal back into the frequency domain. This step is crucial for demodulation and symbol recovery.

Symbol De-mapper:

The demodulated frequency domain symbols are then de-mapped back into their corresponding bits. This process involves determining the nearest constellation point for each received symbol and decoding the associated bits.

De-interleaver:

The de-mapped bits are de-interleaved to reverse the interleaving process performed at the transmitter. This step restores the original order of bits, which is necessary for effective error correction.

FEC Decoder:

The de-interleaved bits are fed into the FEC decoder to correct any errors that occurred during transmission. The decoder uses the redundancy added by the FEC encoder to detect and correct errors, ensuring data integrity.

Data De-randomizer:

The corrected bits are de-randomized to retrieve the original data sequence. This step reverses the randomization process applied at the transmitter.

Data Collection:

Finally, the de-randomized data is collected and analyzed. This output should match the original data generated at the transmitter side if the transmission and reception processes were successful.

F. SIMULATION RESULTS

The simulation process used cyclic prefix to minimize the Inter Symbol Interference (ISI) on the basis of modulation techniques through Matlab. The modulation techniques is used for simulation is Quadrature Amplitude Modulation (QAM) with consider AWGN channel and check the improve performance on the bases of different preamble techniques with the help of simulation toll Matlab R2013. With the help of above modulation techniques, channel and detection techniques, we got simulated results between “sample (Time in second) Represent” in X-axis verses “detection Value” Represent in Y-axis.

- **Preamble detection in SNR at 0dB and IFFT=128**

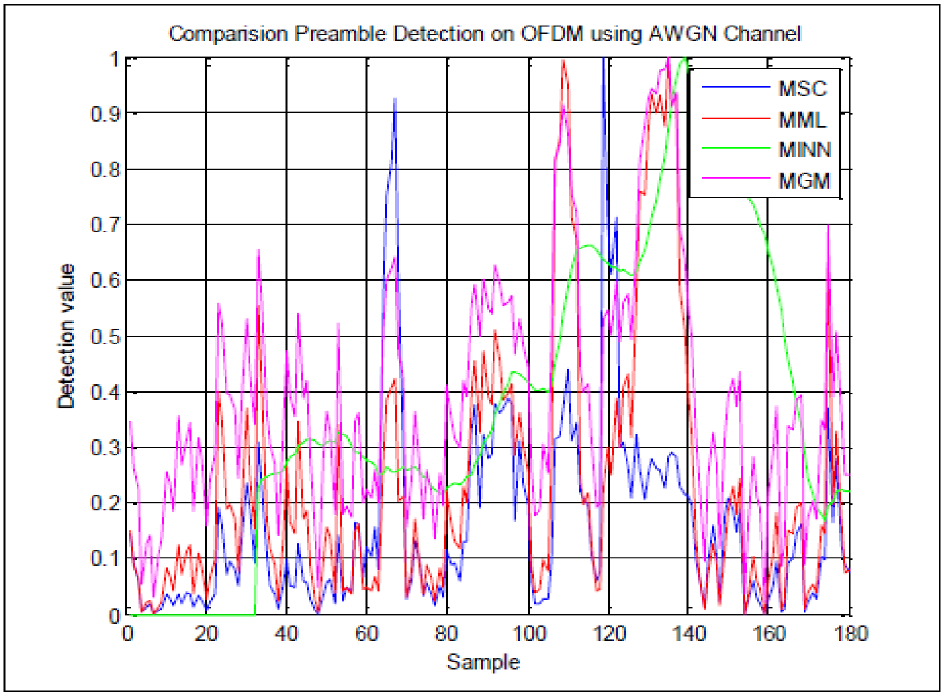

Fig.1: Correlation between different techniques at SNR=0db and IFFT=128

Table 1: Performance analysis of preamble detection at SNR=0db and IFFT=128

Preamble Technique	SNR/IFFT	Maximum Detection Value	Sample
MSC	0db/128	1.0	120
MML		1.0	110
MINN		1.0	140
MGM		1.0	135

- **Preamble detection in SNR at 15dB and IFFT=128**

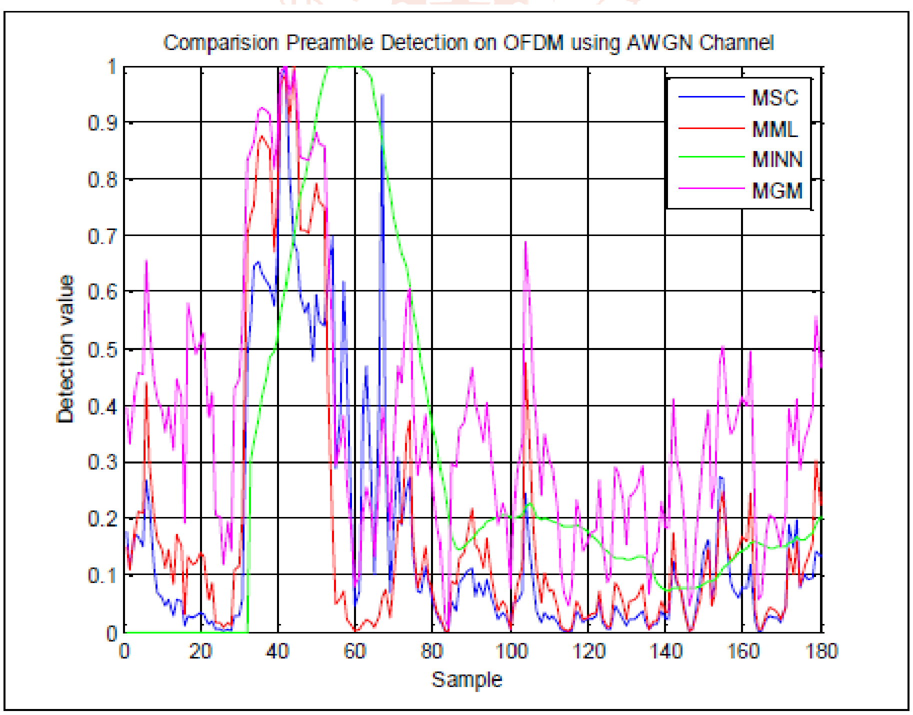

Fig.2: Correlation between different techniques at SNR=15db and IFFT=128

Table 2: Performance analysis of preamble detection at SNR=15db and IFFT=128

Preamble Technique	SNR/IFFT	Maximum Detection Value	Sample
MSC	15db/128	1.0	42
MML		1.0	42
MINN		1.0	50
MGM		1.0	42

CONCLUSION

WiMAX system is a promising technology which can offer high speed voice, video and data services at the customer's end. Due to the fact, WiMAX system has received immense interest globally for next generation wireless communication. An above result we analysis preamble technique (MSC, MML, MSC and MGM) at different SNR value (0dB and 15dB). In the SNR at 35dB have best performance is obtain in MML and MGM but some time both result suddenly down over performance on IFFT 256. 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] 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.

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

[3] Shreyaskumar Patel "Enhancing Image Quality in Wireless Transmission through Compression and De-noising Filters" Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456- 6470, Volume-5 | Issue-3, April 2021, pp.1318-1323, URL: www.ijtsrd.com/papers/ijtsrd41130.pdf

[4] Sachin M, Sindhushree S and Srikantarao S "Amendment of Energy Optimization & Modulations for IIOTs and Latest Generation of WiMAX Networks" International Journal of Pure and Applied Mathematics, Vol. 118(20), 2018

[5] 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.

[6] 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.

[7] Shreyaskumar Patel "Enhancing Image Quality in Compression and Fading Channels: A Wavelet-Based Approach with Db2 and De-noising Filters" Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456- 6470, Volume-8 | Issue-2, April 2024, pp.415-422, URL: www.ijtsrd.com/papers/ijtsrd64684.pdf

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

[9] 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.

[10] Patel, Shreyaskumar. (2023). Optimizing Wiring Harness Minimization through Integration of Internet of Vehicles (IOV) and Internet of Things (IoT) with ESP-32 Module: A Schematic Circuit Approach. International Journal of Recent Technology and Engineering (IJRTE). 8. 95-103. 10.5281/zenodo.12597639

[11] Dinanath Suryawanshi, Smita Patel and Rupesh dubey "Preamble Detection in Wimax 802.16e Using Reyligh Channel With OFDM System" International Journal Of Engineering Sciences & Management, Vol. 4(4), 2014.

[12] Schanan Gupta, Mukesh Patidar and Dr. Pragya Nema "Preamble Detection in Wimax 802.16e On OFDM With AWGN Channel" International Journal Of Engineering Sciences & Management, Vol. 5(2), 2015.

[13] Shreyaskumar Patel "Performance Analysis of Acoustic Echo Cancellation using Adaptive Filter Algorithms with Rician Fading Channel" Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456- 6470, Volume-6 | Issue-2, February 2022, pp.1541-1547, URL: www.ijtsrd.com/papers/ijtsrd49144.pdf

[14] Patidar, M., Jain, A., Patidar, K. et al. An ultra-dense and cost-efficient coplanar RAM cell design in quantum-dot cellular automata technology. J Supercomput 80, 6989–7027 (2024). https://doi.org/10.1007/s11227-023-05722-1

[15] Mukesh Patidar, Surendra Kumar Shukla, Vikas Tiwari, Giriraj Kumar Prajapati, Mukta Sahu, An efficient design and implementation of a reversible logic CCNOT (Toffoli) gate in QCA for nanotechnology, Materials Today: Proceedings, 2023. https://doi.org/10.1016/j.matpr.2023.03.373

[16] Dilip Kumar Sharma, Prachi Goyal, Mukesh Patidar, Mangukiya Hiteshkumar Bhupatbhai, Meena Rangari, An efficient design and demonstration of fault-effects in full-adder circuits based on quantum-dot computing circuits, Materials Today: Proceedings, 2023, https://doi.org/10.1016/j.matpr.2023.03.374