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An Empirical Study and simulation analysis of MAC layer model using AWGN channel of WiMAX technology

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Abstract

The IEEE 802.16 specification defines WiMAX, a wireless broadband data transmission technology. It enables high-speed data transmission over a wide range and remains inexpensive. This is a point-to-multipoint wireless network technology that can also be used in other network applications such as wireless sensor networks. In this article, we will use MATLAB Simulink to analyze the MAC tier model on WiMAX. This MAC tier model can be used to evaluate WiMAX performance in multiple scenarios such as high data rates, modulation schemes, and channel conditions. The proposed simulation model has reduced simulation time and performance. In this analysis, various modulation techniques such as QPSK and QAM were used on the AWGN channel and the simulation results were compared by SNR and BER.

Keywords: WiMAX, LLC, MAC, quality of service, AWGN, IEEE 802.16, Matlab Simulink.

1. INTRODUCTION

Using IEEE 802.16 and IEEE 802.11e, WiMAX provides fixed, mobile, portable, and mobile wireless broadband without requiring a direct line of sight (LOS) to the base station. It allows for the

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establishment of connections, and also in charge of providing the globe with an alternative to wired internet, namely, broadband wireless access (BWA). IEEE Wireless MAN (IEEE 802.16) (Metropolitan Area Network) [12], is the standard for wireless networks. We investigated both licensed and unlicensed bandwidth of 266GHz used in fixed broadband wireless and mobile applications. It can provide internet connectivity up to 50km with a transmission rate of 75 Mbit/s. The IEEE 802.16 standard covers only the physical level and MAC (Media Access Control) level of the air interface, and does not change the upper layer. The IEEE802.16 standard suite (IEEE802.162004 and IEEE80216e2005) [3] outlines the four physical layers that can be used in combination with the MAC layer to create wireless broadband systems. To improve performance in a blind (NLOS) environment, the IEEE 802.16e air interface [56] uses Orthogonal Frequency Division Multiple Access (OFDMA). The IEEE divides the data link layer into two sub-layers. The terms "media access control" (MAC) and "logical link control" (LLC) are interchangeable (MAC). This form of wireless channel degradation can be addressed with MIMO (Multiple Input Multiple Output) technology [7].

The remainder of the paper is structured as follows: The WiMAX MAC Layer Simulink model blocks have been presented in section II. In part III, the modulation methods are explained, in section IV, the experimental simulation findings are presented, and in section V, the conclusion is presented.

2. WIMAX MAC LAYER SIMULATION MODEL

This paper shows a Matlab implementation of a WiMAX MAC layer simulation model. The operational phase of the model was designed using the Simulink version of Matlab 7.11.0 (R2010b), Simulink 7, and Communication Block Set 3. Independent autonomous MAC tiers, dynamic network topology adaptations, multi-hop networks, and dynamic network settings are all features of the MAC tier [8]. The sender, channel, and receiver are WiMAX-MAC layer models [6]. The WiMAX configuration (MACLAY and PHYLAY) is shown in Figure 1. The data that the MAC layer receives from the upper layer is called the service data unit (SUD). The data received from the channel is then input to OFDM demodulation. This includes removing cyclic prefixes, performing fast Fourier transforms, and decomposing OFDM frames.

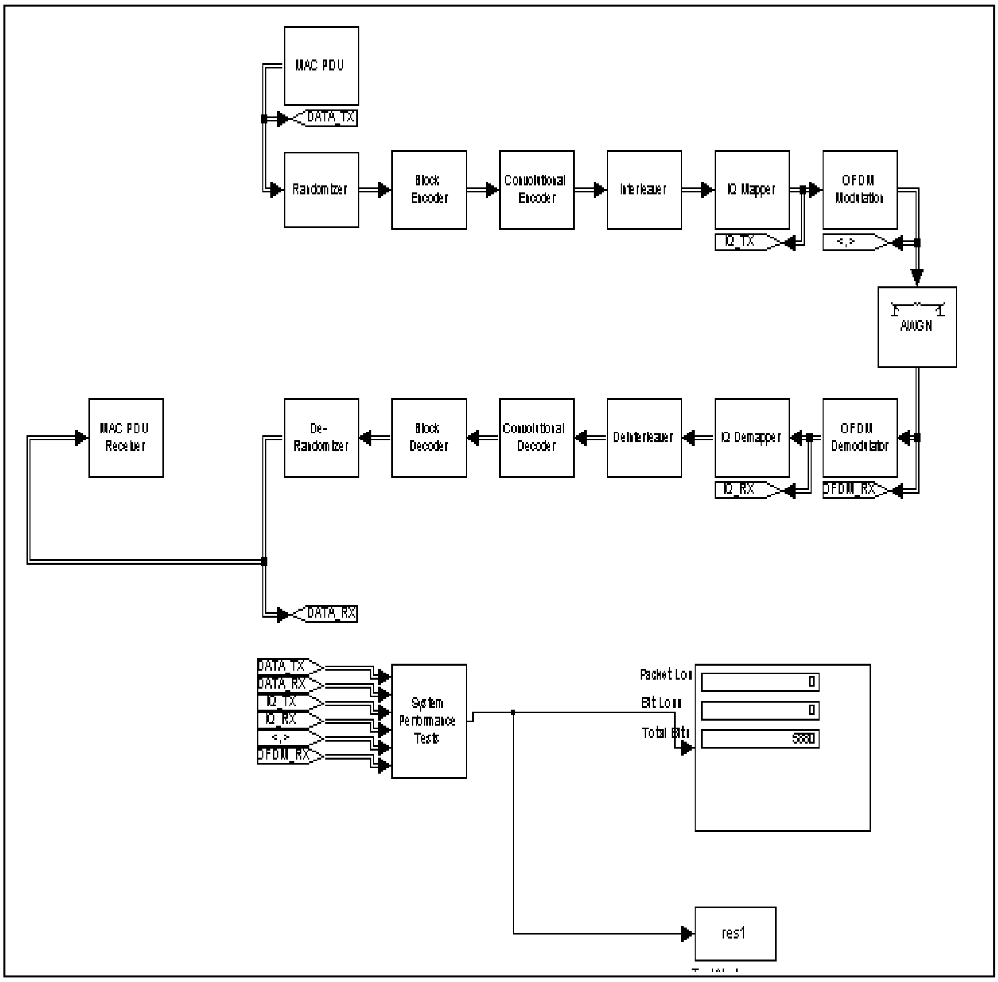

Fig. 1: WiMAX Model in Matlab Simulink

Table 1: Characteristics of WiMAX Simulation Model [6]

Standard	802.16e
Data Rate	70Mbps
Carrier Frequency	10GHz
Channel Size (Bandwidth)	1.5 MHz to 20 MHz
Modulation	QPSK, QAM
Topology	Mesh
Radio Technology	OFDM and OFDMA

2.1. MAC Layer of WIMA

The WiMAX MAC layer acts as a link between the upper transport layer and the physical layer. The convergence sub-layer is included in the IEEE802.162004 and IEEE802.16e2005 [3] MAC designs. It can be associated with various upper layer protocols such as ATM, IP and Ethernet. Packet header suppression is also supported to reduce MSDU overhead. The WiMAX MAC layer supports very high peak bit rates while providing quality of service comparable to ATMs. The Generic MAC Header (GMH) is placed before each MAC frame and contains the frame length, connection identifier (CID), CRC existence quality bits, sub-headers, secure keys, and encryption flags. ARQ (Automatic Repeat Request) [4] is also supported by WiMAX MAC to request a retransmission. MAC is further divided into three layers:

a. Convergence Sub-layer (CS),
b. Common Part Sub-layer (CPS),
c. Security Sub-layer (SS).

2.2. Quality of service

There are several applications for which the WiMAX MAC layer may be used, including voice and multimedia services. Non-real-time traffic, variable bit rate and greatest efficiency are all supported by the system. Multi-user and per-device connections are supported. Each connection has its own identification, which is used to control the quality of service. Traffic priority, burst and acceptable rate limits, ARQ type and delay limits, data unit type and size, and other QoS parameters are all part of this set of specifications.

2.3. OFDM

OFDM is based on the Multi-Carrier Modulation (MCM) transmission technology [4]. The MCM principle describes splitting one input bitstream into multiple parallel bitstreams, subsequently utilized to modulate various subcarriers. Each sub-carrier is separated from the others by a guard band to prevent them from overlapping. Bandpass filters are used on the receiver side to separate the spectra of different sub-carriers. OFDM is a spectrally efficient MCM technology that uses closely spaced orthogonal subcarriers with overlapping ranges. By executing FFT on the input stream, orthogonality is attained. A high data rate is achieved by merging numerous low data rate subcarriers into a single carrier. In multipath situations with short symbol durations, Inter-Symbol Interference (ISI), a common issue, may be minimised or eliminated, depending on the coherence time.

2.4. Communication Channel

Data is sent via a wireless channel with a specific bandwidth to obtain a greater data rate and preserve service quality. When delivering data over the air, it must contend with environmental challenges such as unexpected noise. Because of this, multipath delay spread, fading, path loss, Doppler spread and cochannel interference, among other things, are all factors that affect data transmissions. WiMAX technology has significant environmental impacts.

2.5. Additive White Gaussian Noise (AWGN)

There has been substantial modelling of the optical wireless channel, and the ideal modulation scheme for a particular channel is well established. This channel is called the AWGN (noise). This noise channel model works well for satellite and deep space communication, but not for terrestrial transmission because to multipath, terrain obstruction, and interference. AWGN is used to mimic channel noise. The mathematical statement r(t)=s(t)+ n is the same as in the received signal (t). This went through the AWGN channel, where s (t) represents the sent signal and n (t) means the background noise. The AWGN Channel block replaces a real or complex input signal with white Gaussian noise. The AWGN channel capacity equation 1 is if the average received power is P'[W] and the noise power spectral density is N0 [W/Hz].

$$c_{awgn} = W \log_2\left(1 + \frac{p'}{N_0 W}\right) {}^{Bit}/_{Hz}. \qquad (1)$$

Where $\frac{p'}{N_0 W}$ is the received signal-to-noise ratio (SNR)

Shannon–Hartley theorem equation 2 is used to calculate the channel capacity of an additive white Gaussian noise channel with a bandwidth of B Hz and a signal-to-noise ratio of S/N.

$$C = B \log\left(1 + \frac{S}{N}\right). \qquad (2)$$

2.6. Channel Coding

This enhances communication performance by altering signals and making them more resistant to interference, fading, and other channel defects. In order to encode a channel, randomization, FEC, and interleaving are all necessary steps.

3. MODULATION TECHNIQUES

Quadrature Amplitude Modulation (QAM) is a unique modulation method used by WiMAX that combines ASK and PSK (QAM). In QAM, a signal's amplitude and phase change at the same time. WiMAX networks provide a variety of QAM options, depending on the network's speed and range. For example, 64 QAM has a higher throughput, but it is limited in its range, whereas 16 QAM is more expansive, but it has less bandwidth. Quadrature Phase Shift Keying (QPSK) and Quadrature Amplitude Modulation (QAM) are WiMAX modulation methods.

3.1. Binary Phase Shift Keying (BPSK)

Because it uses two phases separated by 180o to represent binary digits, it's also known as two-level PSK (0, 1). This phase modulation is very effective and resistant to disturbances, especially in low data rate applications—the basic equation 3—because it can only alter one bit/symbol at a time.

$$s(t) = \begin{cases} A\cos(2\pi f_c t) & \text{for binary 1} \\ A\cos(2\pi f_c t + \pi) & \text{for binary 0} \\ A\cos(2\pi f_c t) & \text{for binary 1} \\ -A\cos(2\pi f_c t) & \text{for binary 0} \end{cases} \quad (3)$$

3.2. Quadrature Amplitude Modulation (QAM)

Wireless protocols use QAM modulation technology extensively. Two independent signals may be sent simultaneously using ASK and PSK, but one of them has to be 90 degrees offset from the other. The fundamental equation 4 is:

$$s(t) = d_1(t)\cos 2\pi f_c t + d_2(t)\sin 2\pi f_c t\,. \quad (4)$$

3.3. Quadrature Phase Shift Keying (QPSK)

This is also referred to as four-level PSK since each piece represents several bits. Each symbol has two bits and employs a phase shift of /2, which shifts the phase 90 degrees rather than 180 degrees. The fundamental equation is 5.

$$s(t) = \begin{cases} A\cos\left(2\pi f_c t + \frac{\pi}{4}\right) & \text{for binary 11} \\ A\cos\left(2\pi f_c t + \frac{3\pi}{4}\right) & \text{for binary 01} \\ A\cos\left(2\pi f_c t - \frac{3\pi}{4}\right) & \text{for binary 00} \\ A\cos\left(2\pi f_c t - \frac{\pi}{4}\right) & \text{for binary 10} \end{cases} \quad (5)$$

4. EXPERIMENTAL SIMULATION RESULTS

Emergency communications, military communications, 4G / 5G wide area coverage, and ultra-dense network scenarios can all benefit from mobile ad hoc networks [13]. Figure 1 shows a Simulink model of the WiMAX MAC layer (medium access control). This model uses AWGN (Additive White Gaussian Noise) and various modulation schemes such as QPSK (Quadrature Phase Shift Keying) and QAM (Quadrature Amplitude Modulation) (Quadrature Amplitude Modulation). Figures 2, 3, and 4 show the performance of the WiMAX MAC layer based on the simulation results. Table 2 shows the parameters used in this study.

Table 2: Performance of IEEE 802.16e MAC layers Parameters

Parameters	Value
Channel	AWGN
Modulation Techniques	QPSK and QAM
IFFT (Input port size)	256
CC Code Rate	1/2
Channel Size (Bandwidth)	10 MHz
Radio Technology	OFDM
RS Encoding (Codeword length N)	255
RS Encoding (Message length K)	239
Input Signal Power	0.01 ohm(Watts)
Simulation Mode	Normal
Simulation time	10 Sec
Trellis structure	poly2trellis(7, [171 133])
Generator polynomial input bit by PN- sequence	[1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1]

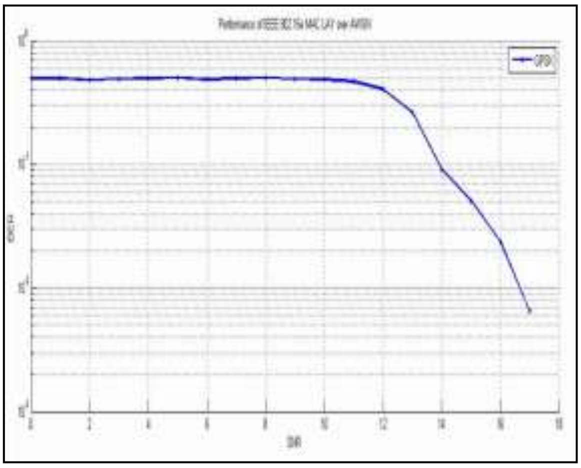

Fig.2: IEEE 802.16e MAC Layer Performance over AWGN with QPSK Modulation Scheme

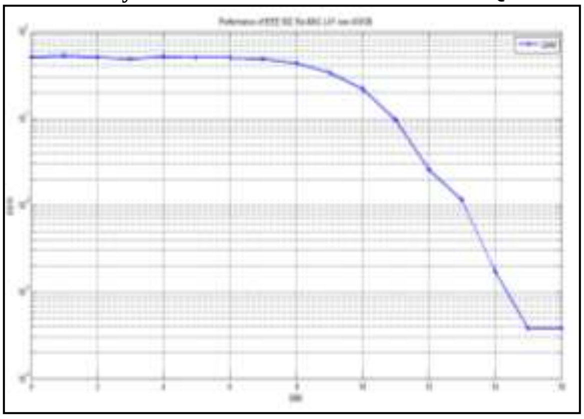

Fig.3: IEEE 802.16e MAC Layer Performance over AWGN with QAM Modulation Scheme

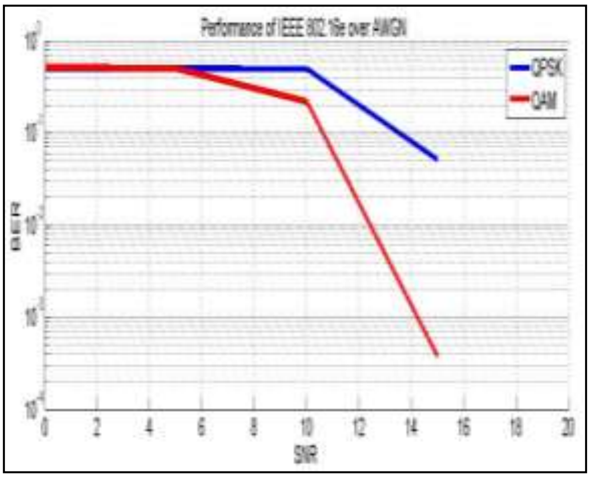

Fig.4: Performance of the MAC Layer over an AWGN Channel compared to QPSK Modulation and QAM

5. CONCLUSION

This study shows the performance of the MAC layer of an AWGN channel for various modulation schemes. BER vs. SNR is an important performance metric for wireless communication systems. The performance of the QAM system for BER is lower than the performance of the QPSK system at a particular SNR level for a particular signal power.

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