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# Performance and Simulation of Adaptive Modulation Techniques of the WIMAX Network via AWGN Channel

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**ABSTRACT**

Worldwide Interoperability for Microwave Access (WiMAX) is a promising technology which can offer high speed voice, video and data service up to the customer end. WiMAX provides a line of sight (LOS) and none line of sight (NLOS) wireless connectivity. WiMAX Wireless communication technique uses orthogonal frequency division multiple access technique that has higher sensitivity to frequency offsets and noise pulses. Most of the modulation techniques use the perception of cyclic prefix (CP) by adding further bits at the transmitted information. in this paper, a performance analysis and simulation was done to measure the adaptive modulation techniques (BPSK, QPSK, 16-QAM and 64-QAM) in WiMAX network. These parameters are discussed on the premise of bit error rate and signal to noise ratio by varying cyclic prefix of the adaptive modulation techniques using the AWGN Channel model. The results shows that BPSK modulation technique over an AWGN channel is efficient and need less bandwidth compared to other modulation techniques.



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## INTRODUCTION

In this paper, a performance analysis is done regarding the adaptive modulation techniques (BPSK, QPSK, 16-QAM and 64-QAM) of a WiMAX network. These parameters are discussed on the basis of bit error rate and signal to noise ratio by varying cyclic prefix of the adaptive modulation techniques using the AWGN Channel model. WiMAX represents an IEEE metropolitan access standard (IEEE 802.16) that provides wireless broadband to fixed customer premises equipment (CPEs) and mobile terminals. The system offers a wide range of services including voice, video, data and multimedia. The full potential of the WiMAX network standard will be realized as the recent nomadic and mobile extensions are deployed (Singh, M. and Ahuja, K., 2010). WiMAX operation is currently active in a number of licensed bands at 2-4 GHz. Unlicensed operation (at significantly lower transmit power) is also transmitted at the top end of the 5 GHz band. In the licensed case, reliable non-line-of-sight (NLOS) operation can be achieved to mobile users over a number of kilometers. The performance of mobile WiMAX has been widely evaluated in the IEEE 802.16e standard that supports a number of advanced physical layer techniques, such as adaptive modulation and coding (AMC), multiple-input multiple-output (MIMO) transmission modes and scalable orthogonal frequency division multiple access (Wei, Z., 2009; Tarhini, C. and Chahed, T., 2007).

### *2. WIMAX Technology and Concept:*

The original idea of WiMAX is to supply users in rural areas with high speed communications as an alternative for fairly high-priced wired connections. WiMAX standard includes utilization of adaptive modulation and coding, that makes it potential to provide users with high connection speeds close to the BS (Base Station) and lower speeds once the radio channel isn't nearly as good. the main goal of WiMAX is to provide broadband facilities by using wireless communication (Andrews, J. G., Ghosh, A. and Muhamed, R., 2007). WiMAX can adopt techniques that support many modulation levels, like QPSK, 16 –QAM and 64 –QAM and so WiMAX systems are capable of covering large areas. WiMAX provides higher bandwidths as compared to global System for Mobile communication (GSM) and Universal Mobile telecommunication system (UMTS). It uses a 64-QAM modulation technique which provides channel bandwidth up to 10 mhz.

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### *3. Model Design and Implementation:*

A simple simulation model was designed, built and implemented using MATLAB software. Random codes were generated and assigned for (n) number of subscribers and the pilot data inserted to ensure the correction of phase noise and frequency offset in the receiver. An AWGN channel was added to the signal that passes through a channel with constant spectral density and a Gaussian distributed amplitude. The mean value and variance can be either scalars or vectors but if any of these is a scalar then the simulator applies the same value to each element or column of the output. By comparing the received signal with the original signal, the bit error rate can easily be calculated for each code that is sent with the data. Final conclusions were drawn from the results and a scheme was concluded to select the most suitable condition for a given situation.

## RESULT AND DISCUSSION

The results shown in this paper were focused on analyzing the behavior of the adaptive modulation techniques of a WiMAX network. Based on these modulation techniques the parameters such as Bit Error Rate (BER) and Signal to Noise Ratio (SNR) were studied. The figures below show the performance of BPSK, QPSK, 16QAM and 64QAM respectively on Additive White Gaussian Noise (AWGN). After several analyses it was found that as the number of bits per symbol is increasing the signal to noise ratio together with the bandwidth slightly increased as well for each given bit error rate, and when the bit per symbol reached $10^7$ the simulation discontinued because our highest modulation technique in regards to bit per symbol which is 64-QAM can take only $10^6$ as shown in table 1.

**Table 1:** Adaptive modulation under AWGN, comparison between SNR and Bit/Symbol When BER = $10^{-3}$

| Modulation | SNR | Bits/Symbol | Variance | Standard Deviation |
|---|---|---|---|---|
| BPSK | 7 | 1 | 0.0152 | 0.0025 |
| QPSK | 8 | 2 | 0.0152 | 0.0025 |
| 16-QAM | 10 | 4 | 0.0275 | 0.0064 |
| 64-QAM | 12 | 6 | 0.0238 | 0.0114 |

### *Probability of Error (PE):*

BPSK modulation which is the most robust of all the PSKs it takes the best level of noise or distortion to make the demodulator reach an incorrect decision. However, it's solely able to modulate at 1 bit/symbol and was unsuitable for high data-rate applications as shown in table 2 while BER = $10^{-1}$.

**Table 2:** Adaptive modulation under AWGN, comparison between SNR and Bit/Symbol When BER = $10^{-1}$

| Modulation | SNR | Bits/Symbol | Variance | Standard Deviation |
|---|---|---|---|---|
| BPSK | 2 | 1 | 0.0012 | 0.0322 |
| QPSK | 3 | 2 | 0.0012 | 0.0322 |
| 16-QAM | 17 | 4 | 0.0055 | 0.0739 |
| 64-QAM | 37 | 6 | 0.0237 | 0.1540 |

The Probability of Error is the assumption of the rate of the error that is introduced in the system because of noise and fading effects in the channel and also due to the cable losses at the transmitter and the receiver ends. The Probability of Error for PSK has been calculated using the following formula as shown in equation 1.

$$Pe \simeq erfc\left(\sqrt{\frac{Es}{No}}\sin\left(\frac{\pi}{M}\right)\right) \quad (1)$$

The probability of bit-error for QPSK is the same as for BPSK however, so as to attain a similar bit-error probability as BPSK, QPSK uses twice the power (since 2 bits are transmitted simultaneously). Also for QAM the error probability is given in equation 2.

$$Pe \simeq 2\left(1-\frac{1}{\sqrt{M}}\right)erfc\left(\sqrt{\frac{3Es}{2(M-1)No}}\right) \quad (2)$$

Fig. 1 shows the comparison of Probability of Error (PE) for the Adaptive Modulation techniques when the PE = $10^{-1}$.

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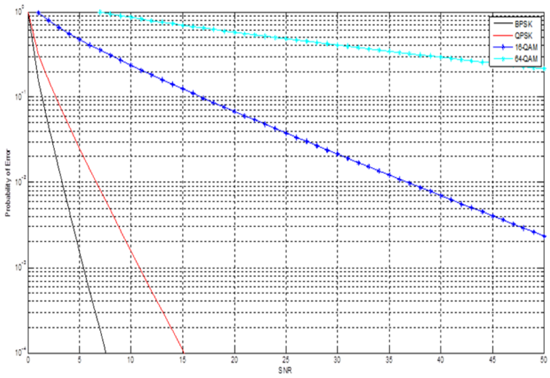


**Fig. 1:** Probability of Error (PE) for the Adaptive Modulation techniques.

16-QAM and 64-QAM modulation techniques as shown in the fig. 2 were able to modulate at 4 and 6 bits/symbol respectively. Like all modulation schemes, QAM conveys data by changing some aspect of a carrier signal, or the carrier wave, (usually a sinusoid) in response to a data signal. Fig. 2 shows the comparison of the bit-error rates of BPSK, QPSK 16-QAM and 64-QAM respectively. It is seen that higher- order modulations exhibit higher error-rates in exchange however they deliver a higher raw data-rate. Bounds on the error rates of various digital modulation schemes can be computed with application of the union bound to the signal constellation.

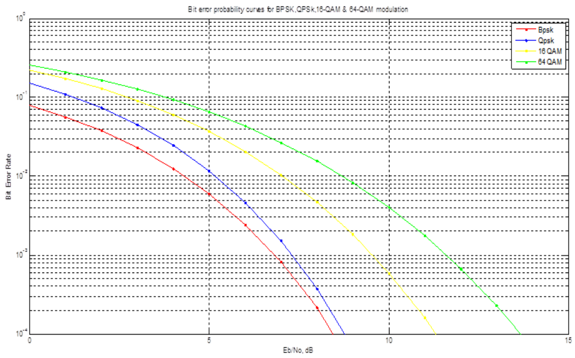


**Fig. 2:** Comparisons of modulation techniques for WIMAX via AWGN.

***Conclusion:***

The performance analysis and simulation of the adaptive modulation techniques can be used perceptively to boost diversity gain and multi-user performance. the fundamental idea of adaptive Modulation is to adapt different order modulations that enable sending more bits per symbol and therefore achieving higher throughputs or higher spectral efficiencies. In case of information measure utilization the 64QAM modulation needs higher bandwidth and offers a superb data rates as compared to others, whereas the QPSK and therefore the 16QAM techniques are within the middle of those two and need higher bandwidth and less power efficient than BPSK. However they needed lesser bandwidth and lower data rates than 64QAM. BPSK has the lowest BER whereas the 64-QAM incorporates a higher BER than the other modulation techniques.

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