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A Polling Based Approach For Delay Analysis of WiMAX/IEEE 802.16 Systems

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Abstract: Worldwide Interoperability for Microwave Access (WiMAX) is a wireless communication which is based on IEEE 802.16 standard. Here a polling based queue model is implemented to analyse the delay of WiMAX physical layer using Orthogonal Frequency Division Multiplexing (OFDM) technique. The system involves three subscriber stations and single base station. If the subscriber stations got packets to transmit, bandwidth request message will be sent to the base station by replying the polling message. If resources are available base station will accept request, otherwise request will be rejected. Two states are considered here and for each state the delay for uplink and downlink is evaluated. WiMAX physical layer is implemented in MATLAB. This scenario is extended to Multi Input Multi Output (MIMO) WiMAX systems. Performance compared in terms of Bit Error Rate (BER) and packet arrival rate.

Keywords: Polling, WiMAX, delay, OFDM, MIMO

I. INTRODUCTION

The telecommunication networking system is changing rapidly so as to support next generation internet requirements. This requirement includes high data rate, large network coverage, quality of service capabilities and cheap maintenance cost. WiMAX network can be configured in Point to Multi Point (PMP) or mesh mode. Here a PMP mode is considered which involves a single base station serving multiple subscriber stations. The base station controls the channel usage and also allocates resources for subscriber stations in both the uplink and downlink direction.

The WiMAX system is reliable and will provide maximum throughput while covering long distance. This is achieved by using OFDM based systems. OFDM uses multiple carrier overlapping signals which provide high data rate and efficiency. Here a queuing model based on polling system is implemented. When subscriber station got packets to transmit bandwidth request is made depending on the which class of polling adopted, if resources are available base station reply for the request allowing subscriber station to initiate data transfer.

This paper is scheduled as follows section II includes the polling section III describes WiMAX physical layer and MIMO WiMAX section IV results and after that conclusion.

II. POLLING SYSTEM

Scheduling services are the data flow control function that decides when devices have to transmit and receive data on a communication system. Polling is the process of sending a request message for collecting information from a network device. By the receipt of polling message data transfer operation begins. Unicast polling involves data transfer between single sender and receiver. Multicast involves data transfer between single polling devices to several receiving devices. When a device receives multicast polling message the data transfer is initiated. Here a single base station serving three subscriber station criteria is considered. All subscriber stations are polled sequentially. When a packet arrive the subscriber station may be of any of these states: state: 1.The queue is empty. State: 2.The queue is non-empty [1]. The frame duration is assumed to be *Ts* and is divided into downlink frame T_{DL}, uplink frameT_{UL}, arrival instance of current frame is *t* and time for transmitting a packet *L*.

A. Delay analysis when queue is empty

When subscriber station is polled in current frame its data transfer can be initiated in current frame itself. The packet waits for the current frame to be over for *(Ts-t)*.The subscriber station makes a bandwidth request in the next frame and in the subsequent frame data can be transmitted. The number of substations be *n* and *i* be the current substation.

The expected waiting time is given by

$$E(X_i) = E(T_S - t) + T_S + T_{DL} + jL$$

$$= \frac{(n-i+1)T_p}{2} + T_S + T_{DL} + jL \qquad (1)$$

B. Delay analysis when queue is non-empty

When subscriber station is polled in the current frame bandwidth for the first N_{NQ} enqueued packets can only be reserved in the next frame. Another N_{NQ} frames are required to send these packets.
The waiting time is given by

$$E(X_i) = E(T_S - t) + T_S + N_{NQ}T_S + t_{DL} + jL$$

$$= \frac{(n-i+1)T_P}{2} + \left(E\left[N_{NQ}\right] + 1\right)T_S + T_{DL} + jL \qquad (2)$$

III. System Description

The fixed and mobile WiMAX physical layer implementations are different. For fixed WiMAX implementation IEEE 802.16 standard uses a 256 point FFT based OFDM layer. Two modulation techniques Quadrature Amplitude Modulation (QAM) and Binary Phase shift techniques are used for performance evaluation. OFDM fixed WiMAX implementation parameters are given in table 1.

Table 1 OFDM parameters used in fixed WiMAX

Parameters	Fixed WiMAX OFDM
FFT size	256
Number of data subcarriers	192
Number of pilot sub carriers	8
Number of guard bands	56

The WiMAX system includes transmitter and receiver part. The input data generated from a random source is randomized to improve robustness and coding efficiency. Randomization is implemented with change in position of bits and state of the bits using Pseudo Random Binary Sequence Generator (PRBS). The data is transmitted as blocks and so Forward Error Correction (FEC) is used to generate code words. It consists of outer Reed Solomon encoding and inner convolutional encoding. At the receiver side Viterbi algorithm is used to decode the encoded sequence. The size of the interleaving block depends on the number of coded bits per encoded block size. The interleaving is performed using two step permutation processes. The first permutation ensures that adjacent coded bits are mapped onto non adjacent subcarriers. The second permutation ensures that adjacent bits are mapped alternatively onto less or most significant bits of the constellation thereby avoiding long runs low reliable bits. Interleaved data is mapped onto subcarriers by using modulation techniques BPSK and QAM. The data is converted to OFDM symbol by taking IFFT and cyclic prefix and guard bands are added to avoid inter-symbol interference and inter carrier interference. The signal is transmitted through the Additive White Gaussian Noise (AWGN) Channel. At the receiver side counter operations performed to retrieve the original data bits.

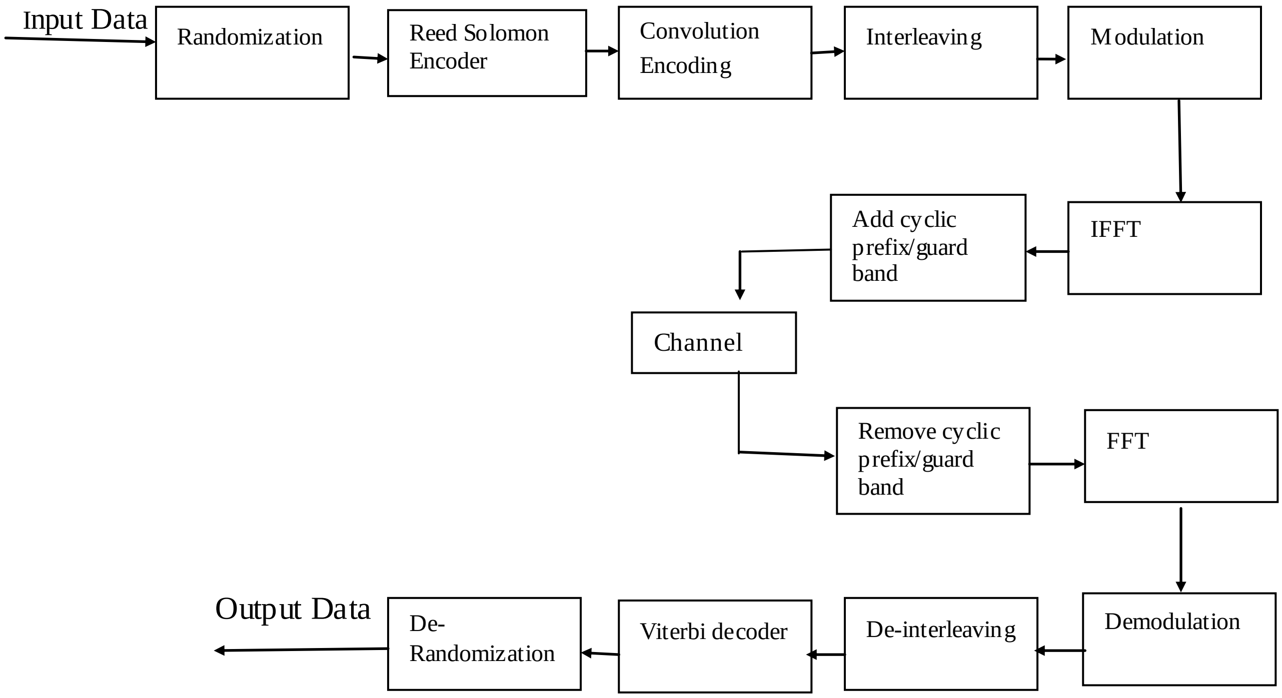

Figure 3 WiMAX Physical Layer

A. WiMAX with MIMO systems

MIMO system is a wireless technology that uses multiple transmitters and multiple receivers. It provides diversity gain to reduce signal fading and capacity gain to improve signal to noise ratio of the system. It also improves spectral efficiency. So MIMO when incorporated with WiMAX provides better Bit Error Rate (BER) and Signal to Noise Ratio (SNR).Here MIMO with Space Time Block Code (STBC) encoder and decoder is introduced.

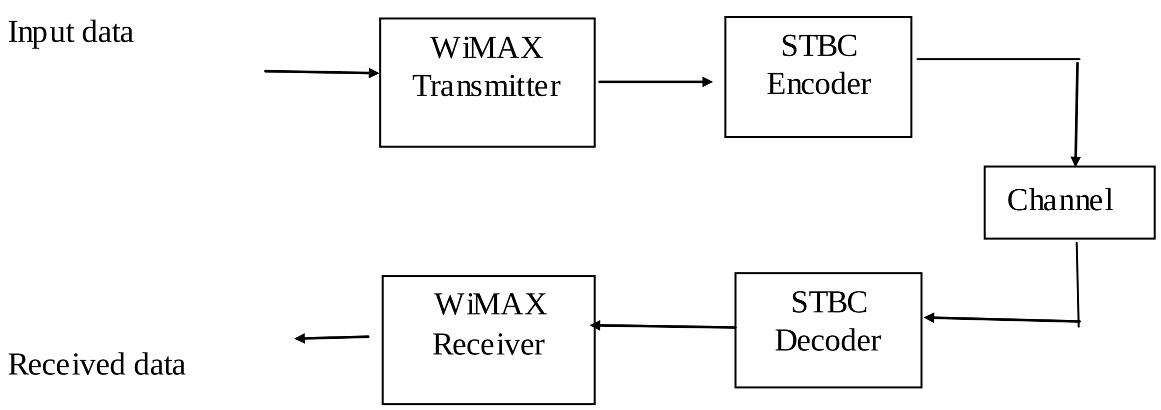

Figure 3.1 WiMAX with MIMO Block Diagram

IV. RESULTS AND DISCUSSION

The simulation for 802.16 physical layer is done in MATLAB. Both the WiMAX and MIMO WiMAX system performance is evaluated in terms of parameters like Signal to Noise Ratio (SNR) and packet arrival and delay occurred. Fig 4.1 shows the SNR versus BER plot of user in empty queue and Fig 4.2 show the SNR versus BER plot of user in nonempty queue. The packet rates versus delay also evaluated for the empty and nonempty queue which is 8.795 and 22.1421 respectively and are shown in Fig 4.3 and 4.4.A comparison of WiMAX and MIMO WiMAX is shown in Fig 4.5

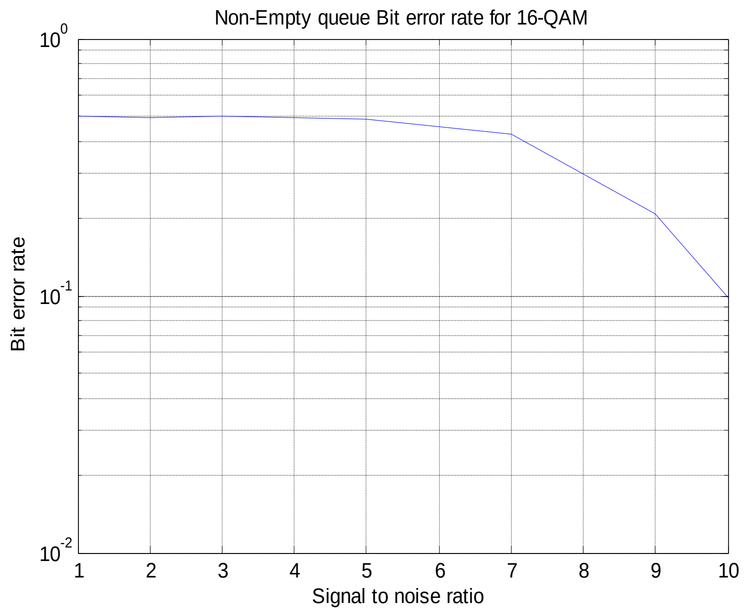

Figure 4.1 User in Non-Empty queue

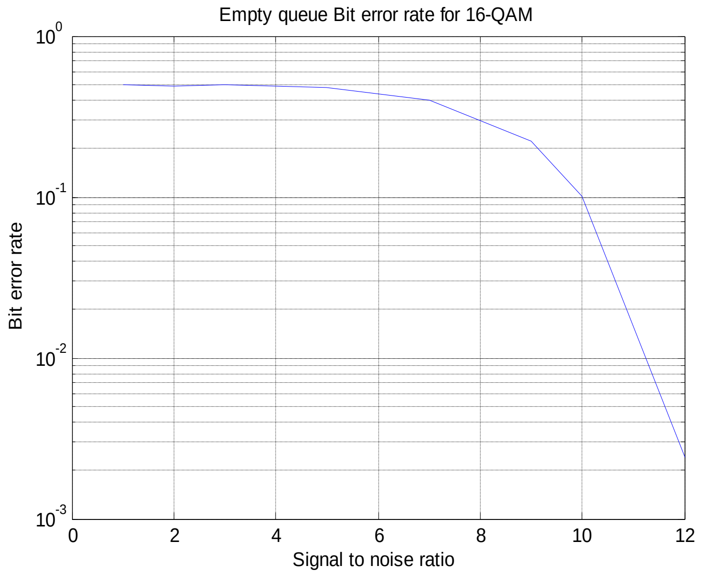

Figure 4.2 User in Empty queue

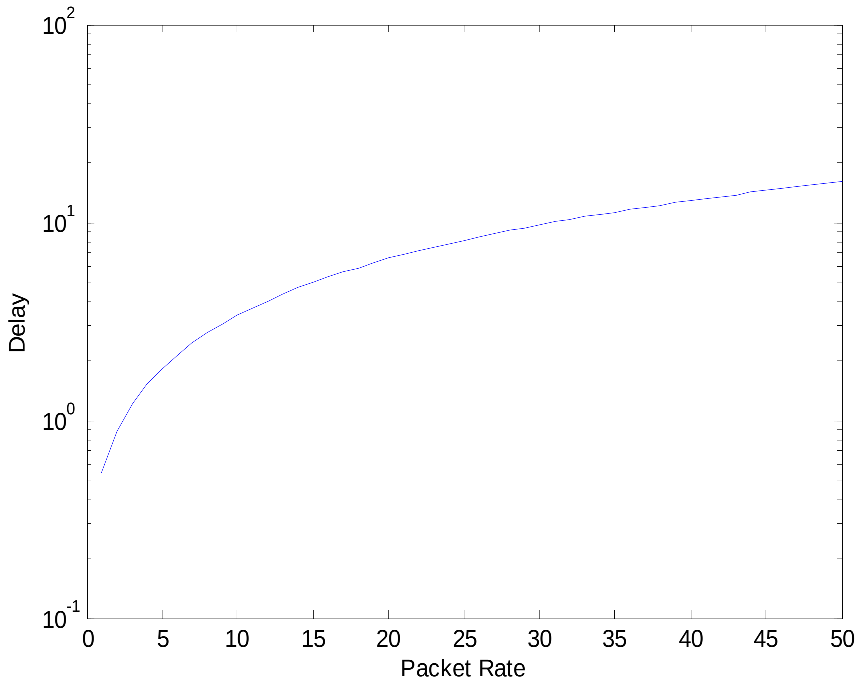

Figure 4.3 Non Empty queue Packet rate versus Delay

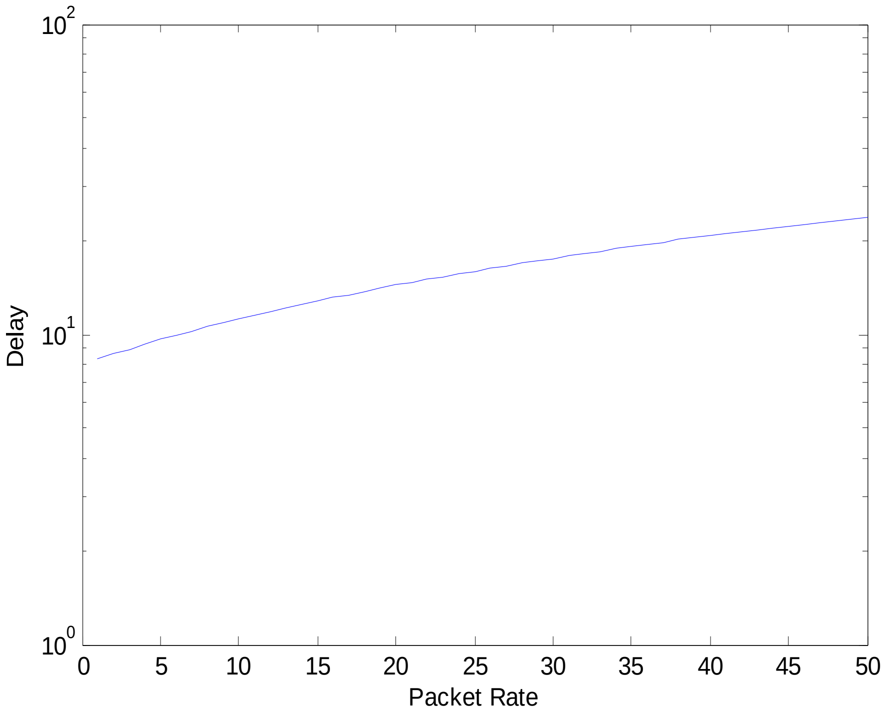

Figure 4.4 Empty queue Packet rate versus Delay

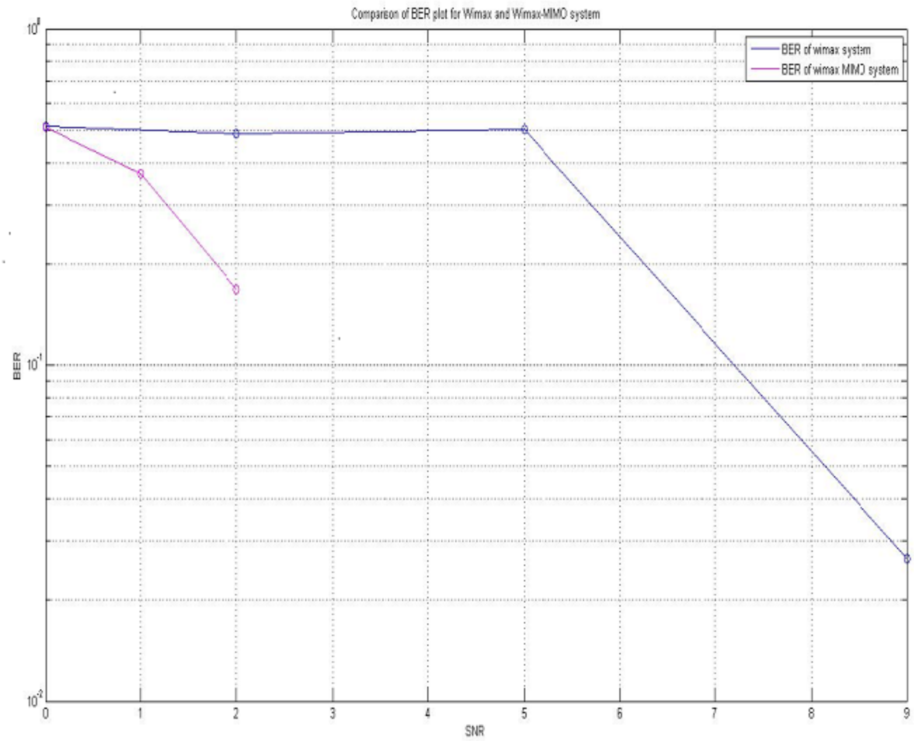

Figure 4.5 Comparison of WiMAX with MIMO WiMAX

V. CONCLUSION

A polling based queue approach for WiMAX delay analysis implemented here. The physical layer of WiMAX and MIMO WiMAX performance is evaluated in terms of bit error rate and delay. The performance evaluation can be extended to calculation of parameters like Mean Square Error (MSE) and throughput.

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