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The Effects of Randomization on Physical Layer Performance of Mobile WiMAX Under Different Communication Channels & Modulation Technique

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Abstract: IEEE 802.16e is a broadband wireless access network capable of delivering high data rates to fixed users as well as portable and mobile ones over long distances. It adopts Orthogonal Frequency Division Multiple Access (OFDMA) to improve multi-path performance in Non-Line-Of-Sight (NLOS) environments. Nowadays, performance evaluation of physical layer under varying channel condition is one of the research themes in Mobile WiMAX. However, most of the research work so far is limited to AWGN and ITU channels. In addition, Forward Error Correction, Reed Solomon Encoding and Bit Interleaver are very critical factor that may affect the overall performance. Therefore, in this work, research are carried out looking at the effect of forward error correction, bit interleaver and Reed Solomon encoding under different SUI channels and modulation technique. The simulation cover important parameter like BLER vs. SNR & BER vs. SNR for the effect of reed Solomon encoding,Interleaving & forward error correction on different SUI channel.

Key words:RS-CC,FEC, Interleaver, Block Error Rate & BER

INTRODUCTION

Along with the advance of communication technology, the need for ubiquitous access to the Internet is increasing today. Many technologies are being developed to support reliable, high-speed data communication environment for mobile users. One of the technology is Mobile WiMAX or the IEEE 802.16e (Dongmyoung *et al2009*). WiMAX (Worldwide Interoperability for Microwave Access) is a rapidly growing broadband wireless access technology based on IEEE 802.16-2004 and IEEE 802.16e-2005 air-interface standards that is anticipated to play a key role in future fixed and mobile broadband wireless services. The mobile WiMAX air interface utilizes Orthogonal Frequency Division Multiple Access (OFDMA) as the radio access method to improve multipath performance in non-line-of-sight environments. Scalable OFDMA (SOFDMA) is utilized in the IEEE 802.16e to support scalable channel bandwidths from 1.25 to 20 MHz (Sassan Ahmadi, 2009). Data streams to and from individual users are multiplexed to groups of sub channel on the uplink and downlink directions. By adopting scalable PHY architecture, mobile WiMAX is able to support a wide range of bandwidths. The scalability is implemented by varying the FFT size from 128 to 512, 1024 and 2048 (Table 1) to support channel bandwidths of 1.25 MHz, 5MHz, 10MHz and 20 MHz respectively. This paper analyses the performance of mobile WiMAX in terms of the BER, BLER as a function of signal-to-noise ratio (SNR).

The paper is structured as follows: Section II will describe mobile WiMAX PHY layer. Then SUI channel model and implementation are presented in Section III. Simulation results in section IV and discussion are provided in Section V and finally, Section VI offers the conclusion.

Mobile WiMAX Physical Layer:

The mobile WiMAX standard builds on the principles of OFDM by adopting a Scalable OFDMA-based PHY layer (SOFDMA). SOFDMA supports a wide range of operating bandwidths to flexibly address the need for various spectrum allocation and application requirements (Hussan Yaghoobi,2006). To guarantee a fixed OFDMA symbol duration, the FFT is amplified with the increase of operating bandwidth. The increase in FFT maintains a flat sub carrier frequency spacing of 10.94 kHz as shown in Table 1 and Table 2. As the basic resource unit is fixed, the impact of bandwidth scaling is minimized to the upper layers (Yang Xiao,2008).

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Table 1: Parameters for OFDMA PHY

Parameter	Value			
FFT size	128	512	1024	2048
Channel bandwidth (MHz)	1.25	5	10	20
Subcarrier frequency spacing (kHz)	10.94			
Useful symbol period	91.4			
Guard time	1/32,1/6,1/8,1/4			

For producing higher code rates, the channel coding stage includes randomization, convolutional coding and puncturing. Native code rate is ½ for convolutional coding. FEC technique typically use error correcting codes that can detect with high probability the error location. The forward error control (FEC) consists of a Reed-Solomon(RS) outer code and a rate-compatible Convolutional Code(CC) (J.G. Andews,*et al, 2007*).

Table 2: OFDMA parameters used in mobile WiMAX simulator

Parameter	Value	
channel bandwidth(MHz)	5	
Sampling frequency F_s(MHz)	5.6	
Sampling period $1/F_s$(μs)	0.18	
Subcarrier frequency spacing $f=F_s/N_{FFT}$(kHz)	10.94	
Useful symbol period $T_b=1/f$(μs)	91.4	
Guard Time $T_g=T_b/8$(μs)	11.4	
OFDMA symbol duration $T_s=T_b+T_g$		
	DL PUSC	UL PUSC
Number of used subcarrier(N_{used})	421	409
Number of pilot subcarriers	60	136
Number of data subcarriers	360	272
Number of subchannels	15	17
Number of users(N_{users})	3	3

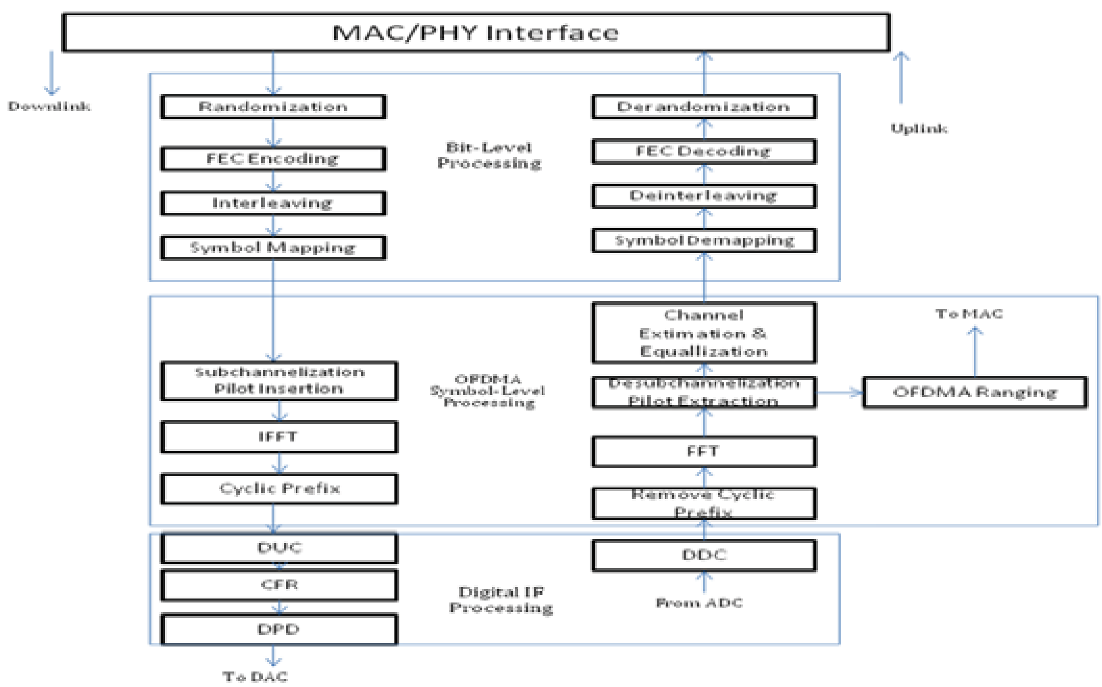

Fig. 1: Physical layer

A block interleaver is applied to interleave the encoded bits onto separated sub carriers. This minimizes the impact of burst errors. The modulation scheme used is QPSK, 16QAM or 64QAM. The modulated data is mapped by segmenting the sequence of modulated symbols into a sequence of slots. A guard interval is also inserted at this stage(IEEE std 2006).

Stanford University Interim(sui) Channel Models:

The model parameters were selected based upon some arithmetical models. The table III & IV show the parametric study of the six SUI channels (IEEE std 802.16 Etm-2004)(Daniel S Baum).

Table 3: Terrain type for SUI channel

Terrain Type	SUI Channels
C(Mostly flat terrain with light tree densities	SUI-1,SUI-2
B(Hilly terrain with light tree density or flat terrain with moderate to heavy tree density)	SUI-3,SUI-4
A(Hilly terrain with moderate-to-heavy tree density	SUI-5,SUI-6

We assume following parameters: 7km is the cell size. BTS antenna height is 30 m. Receive antenna height is 6m. BTS antenna beamwidth is 120 degree. Receive antenna beamwidth is Omni-directional polarization. 90% cell coverage with 99.9% reliability at each location covered.

Table 4: General characteristics of SUI channels

Doppler	Low delay spread	Moderate delay spread	High delay spread
Low	SUI-,2(High k-factor) SUI-3		SUI-5
High		SUI-4	SUI-6

Simulation Results:

In the following we present some simulation results. The system under consideration has parameters given in table V. To evaluate the performance, we used varying channel models such as SUI-1, SUI-2, SUI-3 and different modulation techniques. For experimentation purposes, simulation is done in Mat lab over hundred iterations with the parameters.

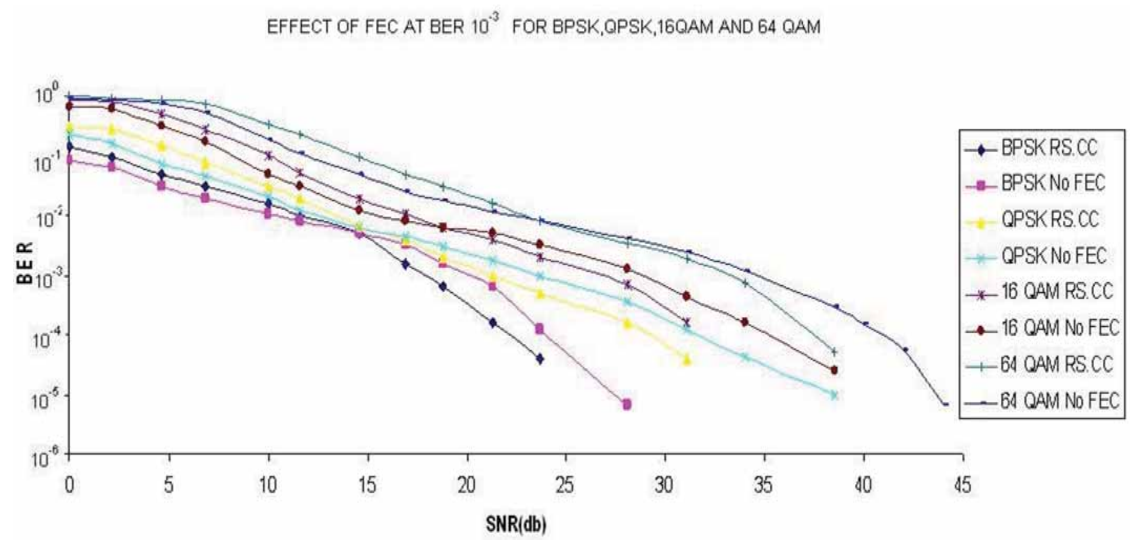

Fig. 2: BER vs. SNR plot for the effect of FEC for BPSK ½,QPSK ½,16-QAM ½ and 64 QAM ½ on channel SUI3

Figs 2 and 3 depicted the bir error rate (BER) and the block error rate(BLER) versus the signal to noise ratio to show the performance of RS-CC compared to No FEC for BPSK, QPSK, 16QAM and 64 QAM modulation on channel SUI-3. It can be seen from these figures that the BER performance improve by almost 8dB, 6dB, 5dB and 3dB respectively at BER level 10^{-3} and BLER performance improve by 10dB,7dB,6dB and 4 dB respectively at BLER level 10^{-2} for BPSK, QPSK, 16QAM and 64 QAM. It is observable from these figures that the system shows better performance with less SNR when lower modulation and coding technique is used.

Figs.4 & 5 depicted the bit error rate(BER) and block error rate (BLER) versus the signal to noise ratio. These figures show the performance improvement due to RS codec on different modulation and coding scheme on SUI-3 channel

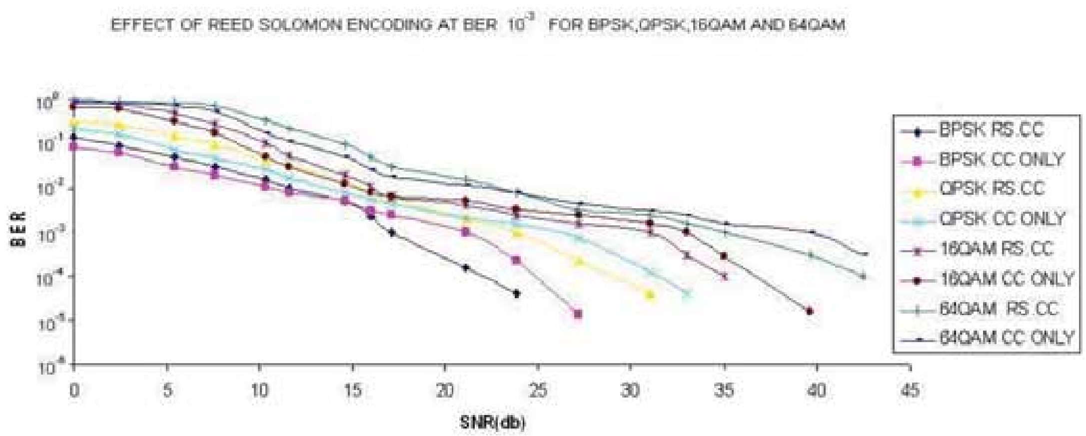

Fig. 3: BLER vs. SNR plot for the effect of FEC for BPSK ½,QPSK ½,16-QAM ½ and 64 QAM ½ on channel SUI3

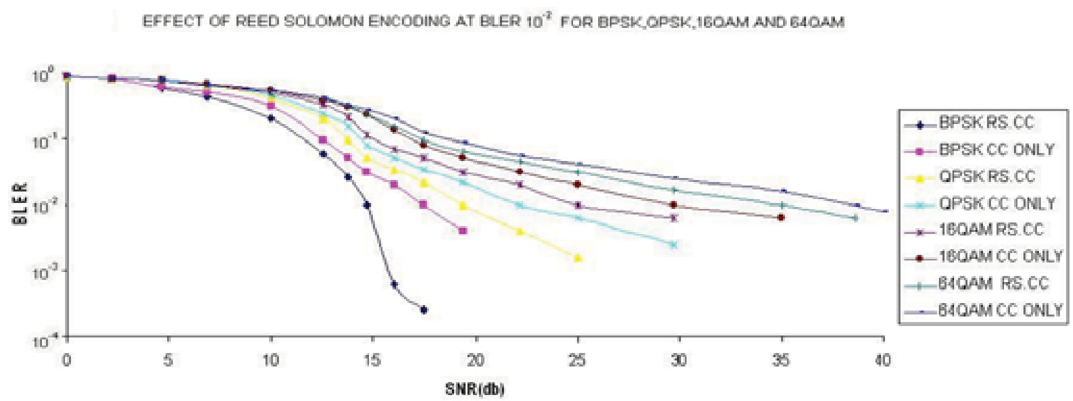

Fig. 4: BER vs. SNR plot for the effect of Reed Solomon Encoding for BPSK ½,QPSK ½,16-QAM ½ and 64 QAM ½ on channel SUI3

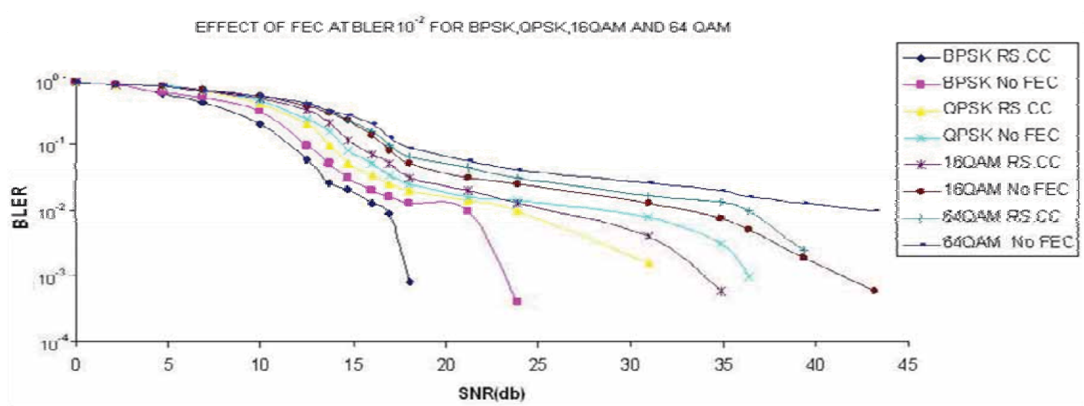

Fig 5: BLER vs. SNR plot for the effect of Reed Solomon Encoding for BPSK ½,QPSK ½,16-QAM ½ and 64 QAM ½ on channel SUI3

Figure 4 & 5 show BER performance improve by almost 3dB,5dB,6dB and 9dB at BER level 10^{-3} and the BLER performance improve by almost 2dB,3dB,5dB and 6dB respectively at BLER level 10^{-2} for BPSK,QPSK,16QAM and 64 QAM modulation technique on SUI-3

Figures 6 & 7 show the performance changes for the effect of bit interleaver on SUI-3 channel for different modulation technique. And the performance improve by almost 5dB,6dB,8dB and 10 dB at BER level $^{10-3}$ and 2dB,3dB,5dB and 6dB at BLER level 10^{-}

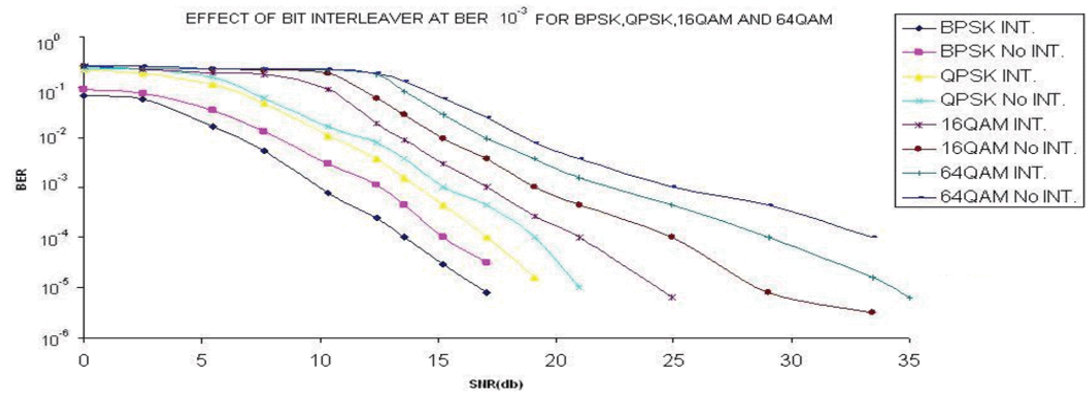

Fig 6: BER vs. SNR plot for the effect of bit interleaver for BPSK ½,QPSK ½,16-QAM ½ and 64 QAM ½ on channel SUI3

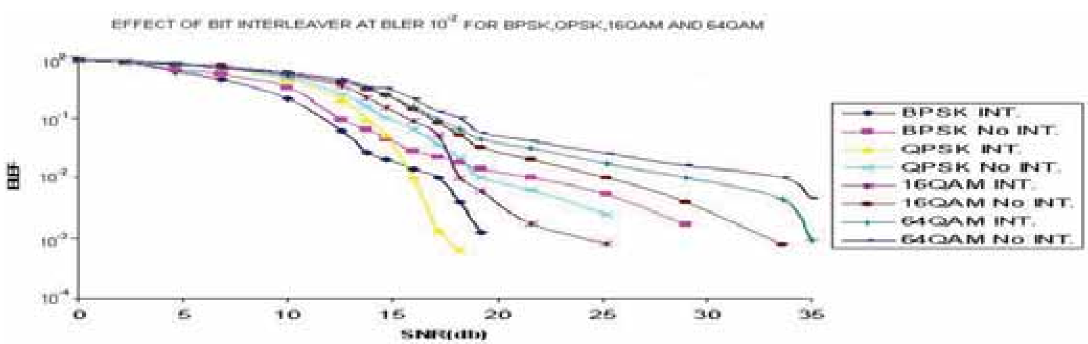

Fig. 7: BLER vs. SNR plot for the effect of bit interleaver for BPSK ½,QPSK ½,16-QAM ½ and 64 QAM ½ on channel SUI3

It is obvious from the figures that without the Reed Solomon encoder and the bit interleaver performance degradation will appear. All the figures and the tables give a scenario about the performances changes of mobile WiMAX physical layer under the different SUI wireless channel and modulation technique. Using AWGN and Raylight fading on SUI-3 the physical layer performance of mobile WiMAX is also acceptable compare to other channel like ITU and AWGN.

Discussion:

From the table X & XI gives the idea about the performance changes for the effect of bit interleaver on the different SUI channel and the different modulation technique. It is observable from the tables that the system shows better performance with less SNR when lower modulation and coding technique is used and the SUI-3 channel performance is better than SUI-1 and SUI-2 channel for mobile WiMAX physical layer.

Table 5: Simulation Parameter

Parameter	Value
Bandwidth(FFT)	10 MHz(1024)
Cyclic Prefix	1/8
Frame Duration(TDD)	5 ms
Symbol Time	102.90µs
Channel Models1	SUI-1,2,3

Table 6: Effect of bit FEC at BER $10^{-3}$for different channels

Channel	Effect of bit FEC at BER 10^{-3}							
	BPSK		*QPSK*		*16QAM*		*64QAM*	
	RS.CC	*No FEC*	*RS.CC*	*No FEC*	*RS.CC*	*No FEC*	*RS.CC*	*No FEC*
SUI-1	11.9	16.4	14	17.1	16	21.1	23	26.2
SUI-2	15.1	19.5	17	21.3	22	26.6	27	31.4
SUI-3	18.5	21.3	19	24.4	27	31.9	32	38.5

Table: 7 ffect of bit FEC at BLER 10^{-2} for different channels

Channel	Effect of FEC at BLER 10^{-2}							
	BPSK		*QPSK*		*16QAM*		*64QAM*	
	RS.CC	*No FEC*	*RS.CC*	*No FEC*	*RS.CC*	*No FEC*	*RS.CC*	*No FEC*
SUI-1	10	16.2	13.4	19.3	19	25.1	21	29.5
SUI-2	14	20.4	16.7	22.4	23	31.2	26	38.3
SUI-3	17	22.1	23.9	32.5	31	39.4	35	43.2

From the Table VI and VII we get the summary of performance improvement of the concatenated code for SUI-1, 2 and 3.

Table 8: Effect of Reed Solomon Encoding at BER 10^{-3} different channels

Channel	Effect of Reed Solomon encoding at BER 10^{-3}							
	BPSK		*QPSK*		*16QAM*		*64QAM*	
	RS.CC	*CC only*	*RS.CC*	*CC only*	*RS.CC*	*CC only*	*RS.CC*	*CC only*
SUI-1	11.4	13.3	14.2	17.1	20	24.2	27	30.3
SUI-2	14.5	18.6	19.1	23.3	28	31.5	30	34.5
SUI-3	17.1	21.1	23.8	27.2	31	34.3	35	39.6

Table 9: Effect of Reed Solomon Encoding at BLER 10^{-2} different channels

Channel	Effect of Reed Solomon encoding at BLER 10^{-2}							
	BPSK		*QPSK*		*16QAM*		*64QAM*	
	RS.CC	*CC only*	*RS.CC*	*CC only*	*RS.CC*	*CC only*	*RS.CC*	*CC only*
SUI-1	8.3	13.3	13.2	15.6	16	29.2	26	30.5
SUI-2	11.4	15.6	16.2	21.2	21	26.4	30	35.3
SUI-3	14.7	17.5	19.4	22.2	25	29.7	35	38.6

The SNR improvement due to RS Codec for different schemes and channel SUI-1, 2, 3 is tabulated in Table VIII and IX.

Table 10: Effect OF Bit Interleaver at BER 10^{-3}

Channel	Effect of Bit Interleave at BER 10^{-3}							
	BPSK		*QPSK*		*16QAM*		*64QAM*	
	Int.	*No Int.*	*Int.*	*No Int.*	*Int.*	*No Int.*	*Int.*	*No Int*
SUI-1	7.1	9.8	11.2	14.3	15	18.3	23	26.3
SUI-2	9.4	11.5	13.4	15.4	18	20.4	26	28.3
SUI-3	13.3	15.2	16.6	19.1	21	24.9	29	33.4

Table 11: Effect of Bit Interleaver at BLER 10^{-2}

Channel	Effect of Bit Interleave at BLER 10^{-2}							
	BPSK		*QPSK*		*16QAM*		*64QAM*	
	Int.	*No Int.*	*Int.*	*No Int.*	*Int.*	*No Int.*	*Int.*	*No Int*
SUI-1	11.3	14.5	9	11.2	11	15.8	22	26.2
SUI-2	14.3	16.1	12	14.5	14	21.7	27	29.4
SUI-3	18.4	21.6	16	19.1	19	25.2	29	34.9

Conclusion:

This paper has analysed the performance of mobile WIMAX physical layer for OFDMA on different channel condition assisted by Mobile IP(Internet protocol)for mobility management. Analysis demonstrated that performance of randomization for different the modulation and coding rate had a greater impact on the relative performance between the different channel conditions.

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