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Performance evolution of turbo coded MIMO-WiMAX system over different channels and different modulation

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***Abstract— The wireless communication is highly affected with the channel behavior. The uses of Multiple-Input Multiple-Output system and FEC code are most common in wireless standard for provide the fast and reliable communication. In this project Space-Time Block Coding (STBC) for Multiple-Input Multiple-Output (MIMO) set-up is used in wireless channels. In the special version of STBC called Alamouti code is used for exploiting the performance of MIMO in Adaptive modulation. The further improvement in error rate has been achieved using turbo code. The simulation of the system has been analyzed for* different modulation schemes. The comparative result has been given in this paper.**

Keywords— MIMO, OFDM, STBC, WiMAX, BER, etc.

I. INTRODUCTION

Wireless communications are an emerging field that has experienced a significant development over the last several years [1]. The availability of broadband networks offers high performance connectivity to over a billion of internet users around the world. Development of new wireless broadband standards and technologies is essential to increase wireless coverage rapidly. The demand for mobile data services and broadband network connectivity continues to increase. Conventional high-speed broadband services are based on wired-access technologies such as digital subscriber line (DSL). However this service is difficult to deploy in remote rural areas and it lacks support for terminal mobility. Mobile Broadband Wireless Access can be used as an alternative in such problematic situations in order to obtain a flexible and cost-effective solution [2].

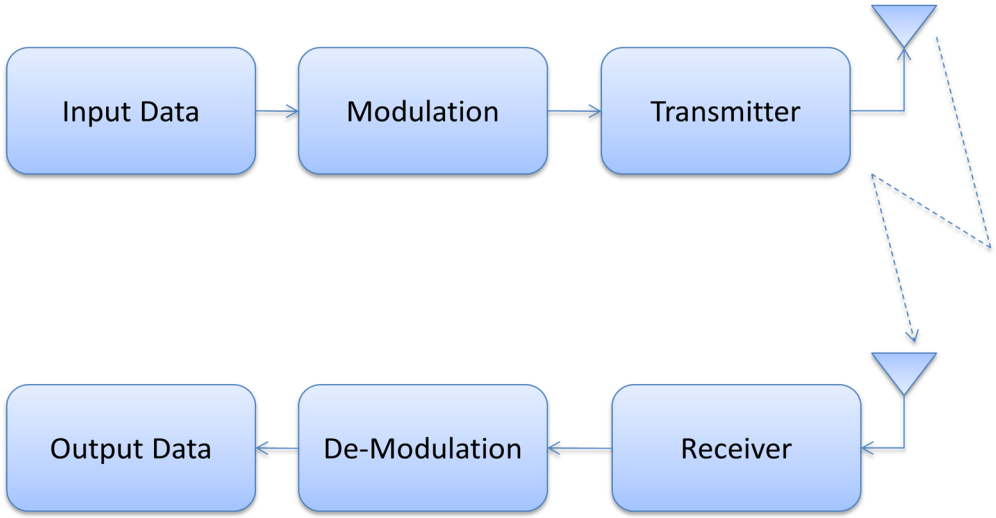

Fig:1 Wireless communication system

With high-speed broadband wireless service increasingly in demand, there have been two main emerging mobile broadband technologies: third generation partnership project (3GPP) Long-Term Evolution (LTE) [1-4] and mobile Worldwide Interoperability for Microwave Access (WiMAX) [5-6]. In both mobile-broadband wireless systems, the orthogonal frequency-division multiplexing (OFDM)-based frequency division multiple-access (OFDMA) technology is employed to schedule multiple mobile stations in a frame where each mobile station is assigned a subset of the sub-carriers for schedule, and each sub-carrier is scheduled exclusively

to each mobile station. Since multiple mobile stations are scheduled in one frame, a base-station transmits frame control information first at the beginning of each frame. The frame control information tells each mobile station in a cell whether it is scheduled in the current frame and how each mobile station decodes the data scheduled by a base station. The control channel message is short (in the range of 32 ~ 71 bits in comparison with data channel message, and a convolutional code is employed in 3GPP LTE and WiMAX. The control channel is critical to decoding the data channel, and hence is protected via using low code-rate. The average throughput requirement of control channel decoder is not comparable to that of data channel decoder. The throughput for control channel dictates the amount of buffering in OFDMA modem because of delay in decoding control message. Modem cannot process data scheduled for each mobile station till the end of control channel decoding. WiMAX is the upcoming wireless system which uses 802.16 IEEE standards. By using WiMAX technology we can overcome the limitations of the existing wireless communication like short coverage area, low data rate and lack of security. In our thesis, we have tried to improve the performance of WIMAX using adaptive modulation technique over MIMO system.

II. MULTIPLE INPUT MULTIPLE OUTPUT (MIMO) SYSTEM MODEL

Multi-antenna systems can be classified into three main categories. Multiple antennas at the transmitter side are usually applicable for beam forming. In Transmitter or receiver side multiple antennas for realizing different diversity. For the third class includes systems with multiple transmitter and receiver antennas realizing spatial multiplexing (often referred as MIMO by itself).

In radio communications MIMO means multiple antennas both on transmitter and receiver side of a specific radio server. The case of spatial multiplexing different data symbols are transmitted on the radio link by different antennas on the same frequency within the same time interval. The Multipath propagation is assumed in order to ensure the correct operation of spatial multiplexing and since MIMO is performing better in terms of channel capacity in a rich scatter multipath environment than in case of environment with LOS. It is achieves this by higher spectral efficiency (more bits per second per hertz of bandwidth) and link reliability or diversity (reduced the effect of fading). The properties of MIMO is an important part of modern wireless communication such as IEEE 802.16

The main feature of MIMO systems is space-time processing. Space-Time Codes (STCs) are the codes designed for the use in MIMO system. Space-Time Block Codes signals are coded in both temporal and spatial domains. The different types of STCs, the orthogonal Space-Time Block Codes (STBCs) possess a number of advantages over other types of STCs and are considered in this book.

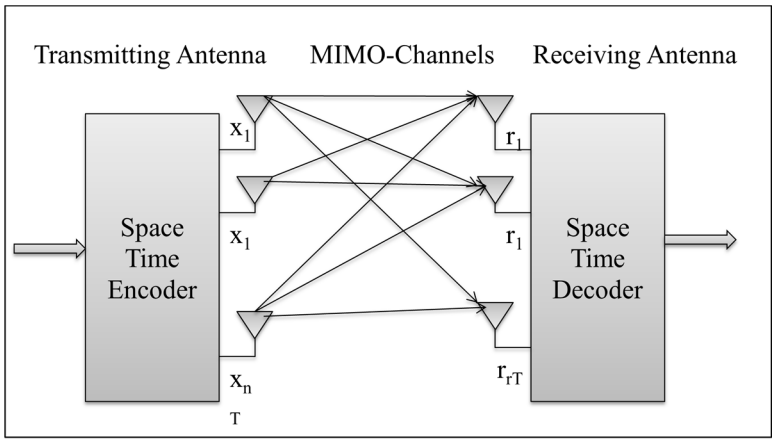

Fig. 2 MIMO system

III. WIMAX SYSTEM

Broadband Wireless Access (BWA) has emerged as a promising solution for last mile access technology to provide high speed internet access in the residential as well as small and medium sized enterprise sectors. As discussed above section, cable and digital subscriber line (DSL) technologies are providing broadband service. But due to the practical difficulties many urban and suburban locations may not be served by DSL connectivity as it can only reach about three miles from the central office switch. On Broadband wireless Access, because of wireless nature, it can be faster to deploy, easier to scale and more flexible, thereby giving it

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the potential lto serve customers not served or not satisfied by their wired broadband alternatives. IEEE 802.16 standard for Broadband wireless Access (BWA) and its associated industry consortium, WiMAX (Worldwide Interoperability for Microwave Access) forum promise to offer high data rate over large areas to a large number of users where broadband is unavailable

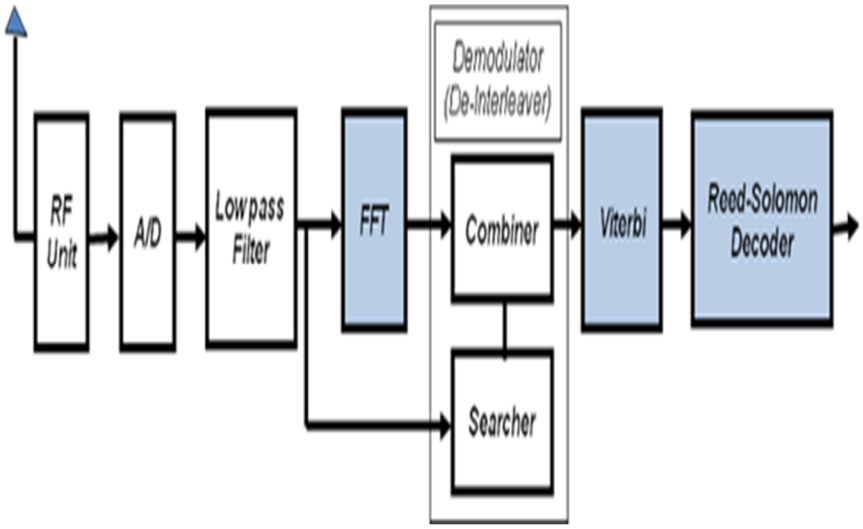

Fig. 3 WIMAX System

IV. QUADRATURE PHASE SHIFT KEYING (QPSK)

This is also known as four-level PSK where each element represents more than one bit. In the each symbol contains two bits and it uses the phase shift of π/2, which means 90º instead of shifting the phase 180º. The principle equation 5 is.

$$s(t) = \begin{cases} A\cos\left(2\pi f_c t + \frac{\pi}{4}\right) & \text{for binary 11} \\ A\cos\left(2\pi f_c t + \frac{3\pi}{4}\right) & \text{for binary 01} \\ A\cos\left(2\pi f_c t - \frac{3\pi}{4}\right) & \text{for binary 00} \\ A\cos\left(2\pi f_c t - \frac{\pi}{4}\right) & \text{for binary 10} \end{cases} \quad (1)$$

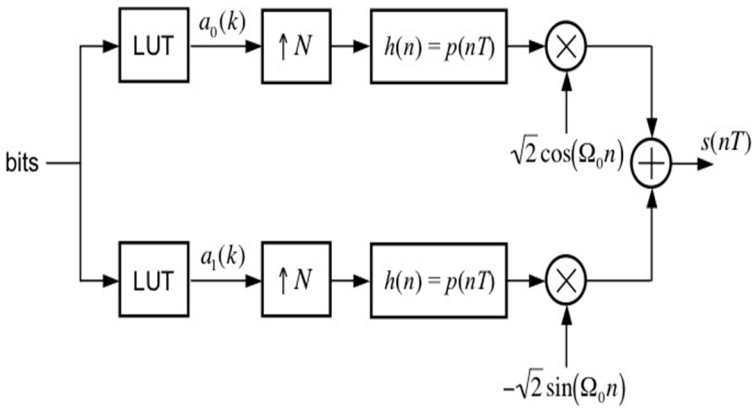

Fig. 5 QPSK System

The constellation consists of four points but the decision is always made in two bits. This mechanism can ensure the efficient use of bandwidth and higher spectral efficiency.

V. BINARY PHASE SHIFT KEYING (BPSK)

This is also known as two-level PSK as it uses two phases separated by 180º to represent binary digits (0, 1). This kind of phase modulation is very effective and robust against noises especially in low data rate applications as it can modulate only one bits/symbol. The principle equation 3 is.

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

Quadrature Amplitude Modulation (QAM)

The QAM is popular modulation technique used in various wireless standards communication. It combined with ASK and PSK which has two different signals sent concurrently on the same carrier frequency but one should be shifted by 90º with respect to the other signal. The principle equation 4 is.

$$s(t) = d_1(t)\cos 2\pi f_c t + d_2(t)\sin 2\pi f_c t \qquad (3)$$

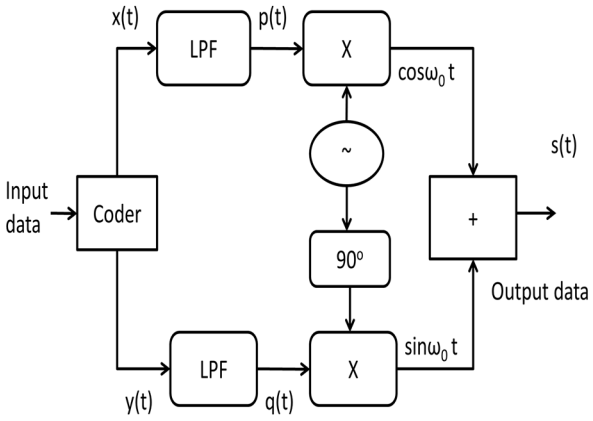

Fig. 4 QAM System

VI. BIT ERROR RATE CALCULATION

The BER of an uncoded system is obtained by averaging the BER of each subcarrier. Under the assumption of gray QAM mapping, it is known that the BER and symbol error rate (SER) are related as BER $\approx \frac{SER}{Q}$. To estimate the BER, we consider an error event with a correct vector, s, and an error vector s′ which satisfies $E_S\{S\,S^*\} = E'_s\{S'\,S'^*\} = I$ where denotes conjugate transposition, Es stands for the expected value . In this part of section, we will use H to represent the actual channel matrix if spatial multiplexing is used, and the effective channel matrix if STBC is used.

$$\square\square\square BER \approx \frac{SER}{Q} \approx \frac{E_H}{q}\left\{E_s\{\sum_{s\neq s'} P_r[s \to s' \mid H, s, s']\}\right\}$$

$$\geq \frac{E_H}{q}\left\{E_s\{\sum_{|s-s'|=D_{min}} P_r[s \to s' \mid H.s, s']\}\right\} \square$$

VII. RESULTS AND DISCUSSION

There are various simulation has been carried out for Wimax system. The various results are as follows, The BER performance graphs for the simulated WiMAX physical layer and MIMO-OFDM with the implementation of channel coding under modulation schemes over Rayleigh and Rician multipath fading channels.

A. Case: 1

1) Channel : Rician

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2) FEC code : Turbo code
3) Modulation technique : QPSK

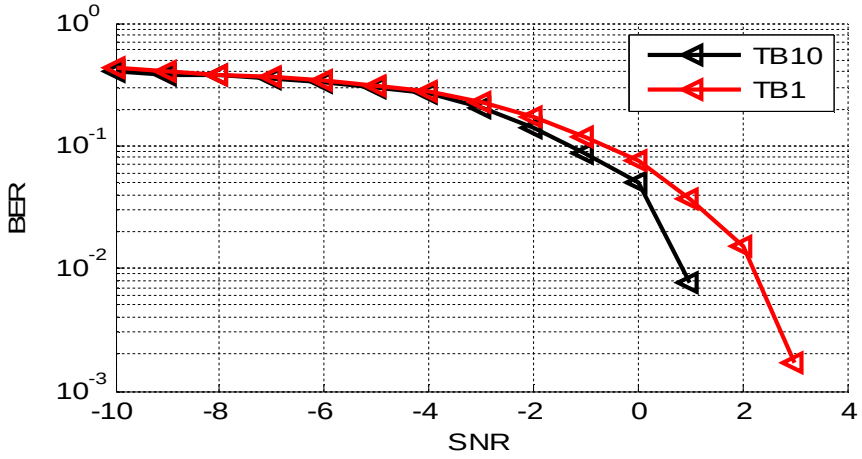

Fig. 6 BER performance of WiMAX for Rican channel

From the above graph it is clear that turbo 10 iteration showing better as compare to single iteration. Now going for the different modulation,

B. Case: 2

1) Channel : Rician
2) FEC code : Turbo code
3) Modulation technique : QAM-8

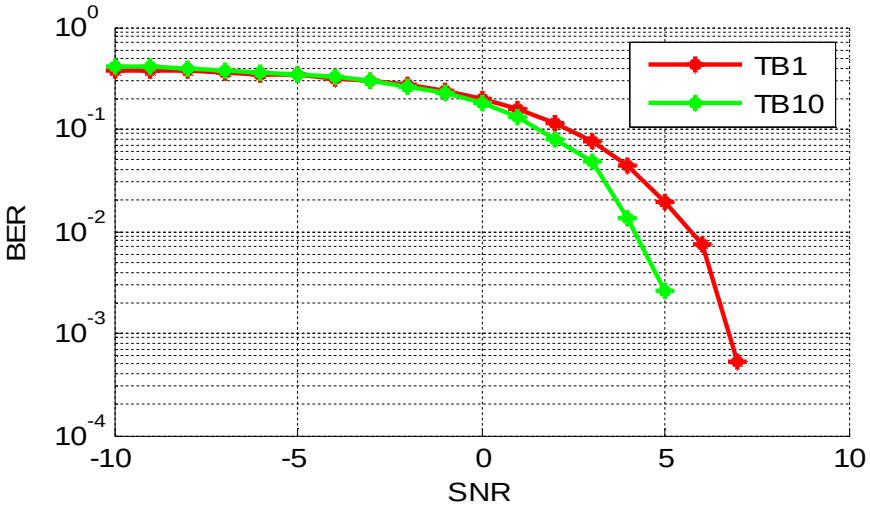

Fig. 7 BER performance of WiMAX-QAM for Rician channel

From the above graph it is clear that turbo 10 iteration showing also better as compare to single iteration for QAM8. Now we change the channel environment,

C. Case: 3

1) Channel : Rayleigh channel
2) Channel equalizer : MLSE
3) FEC code : Turbo code

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4) Modulation technique : QPSK

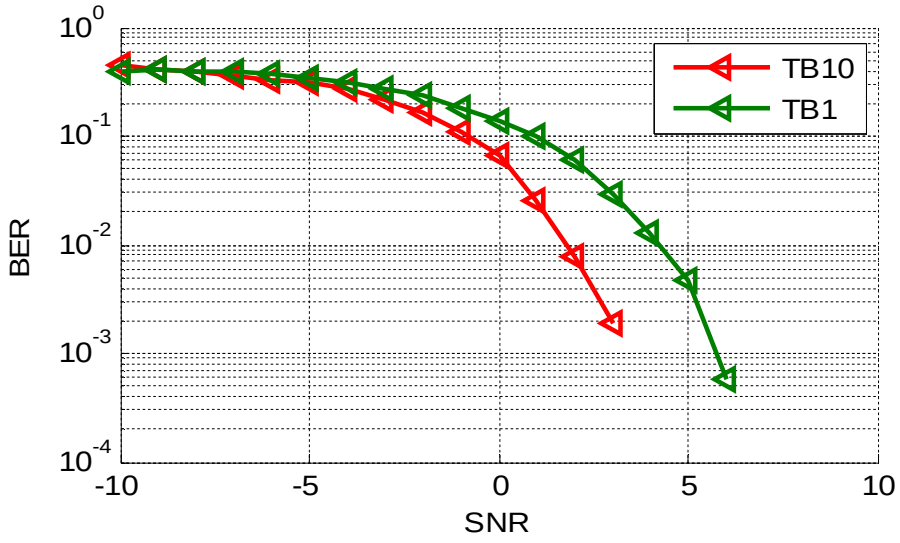

Fig. 8 BER performance WiMAX-QPSK for Rayleigh channel

D. Case: 4

1) Channel : Rayleigh channel
2) Channel equalizer : MLSE
3) FEC code : Turbo code
4) Modulation technique : QAM-8

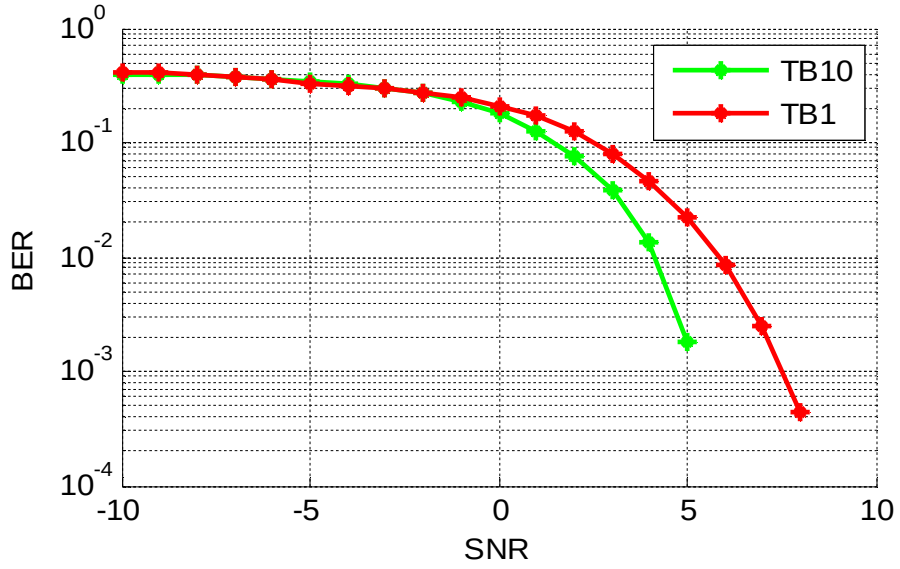

Fig: 9 MLSE equalizer WiMAX system is showing similar behavior for turbo code.

From the above graphs, it is clear that improvement using turbo code is valid for all channels. Further the performance of turbo code has also checked with the other FEC code,

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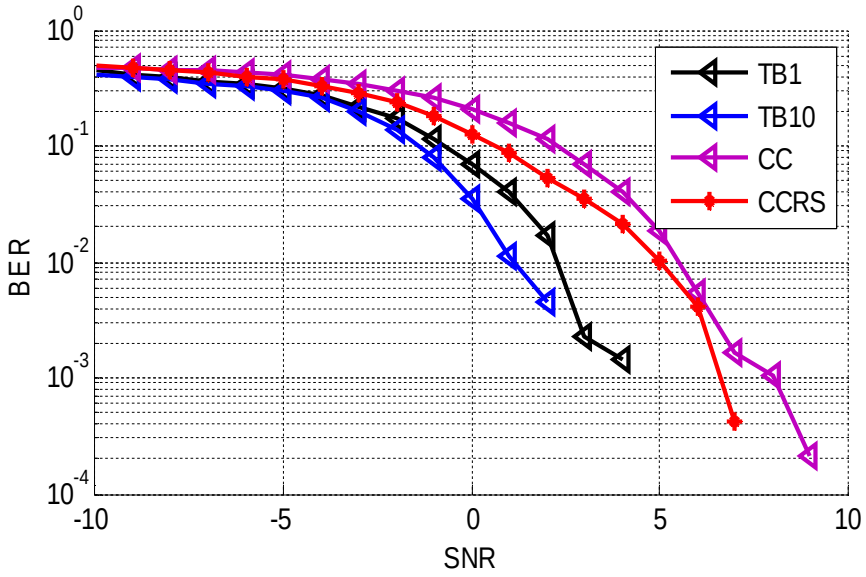

Fig. 10 Turbo is behaving better compare to other FEC.

VIII. CONCLUSION

In this paper, performance enhancement of WiMAX-MIMO system is done with adaptive modulation. The uses of Multiple-Input Multiple-Output system and FEC code are most common in wireless standard for provide the fast and reliable communication. The BER for different adaptive modulation techniques are evaluated in slow frequency selective fading channel. Finally, performance of WiMAX system is evaluated using adaptive modulation. Using FEC code technique is improved bit error rate and low signal noise ratio.

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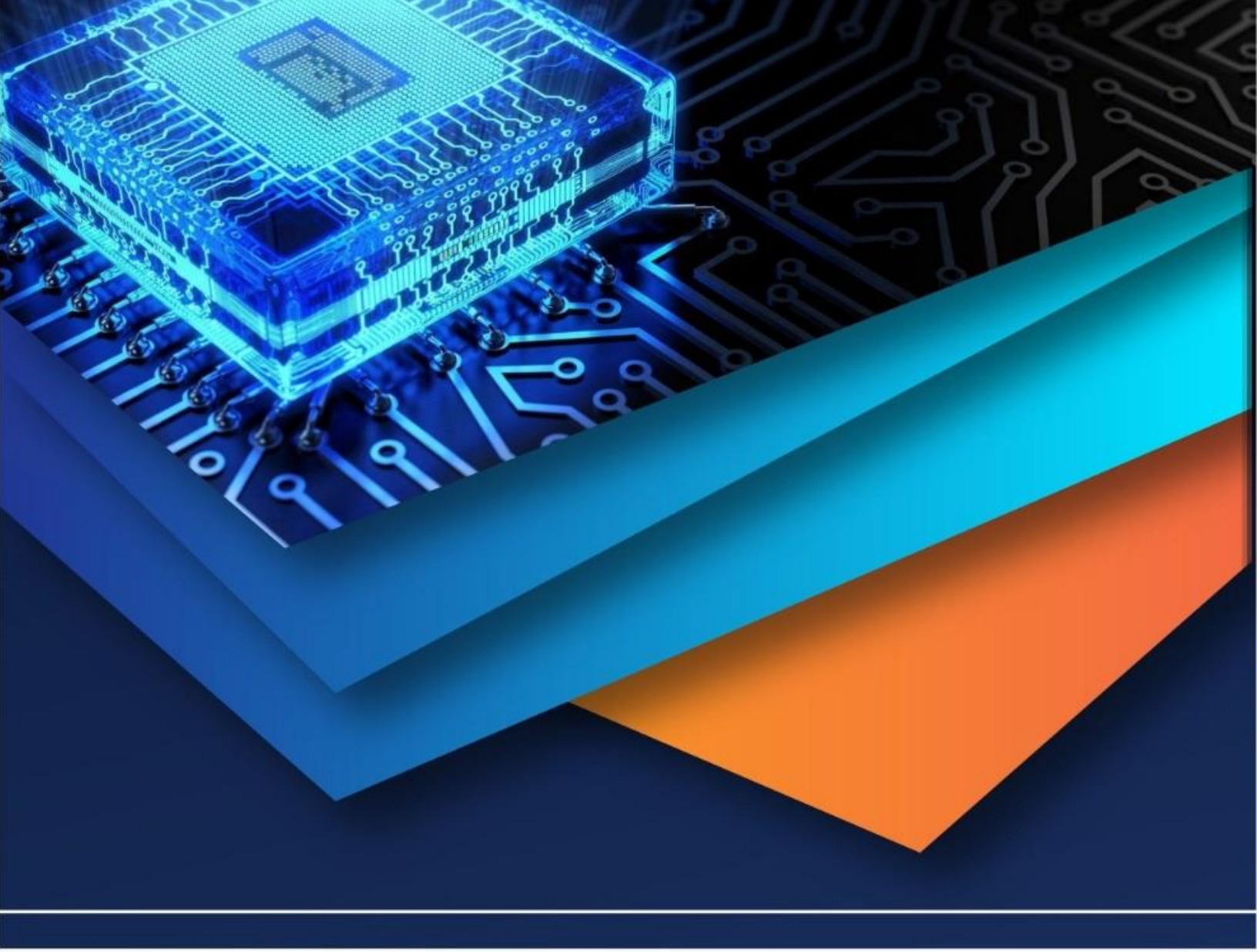

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