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Performance Analysis of OFDMA vs. NOMA in Cognitive Radio Network

E. Alwin Richard[1], Mr. S. Senthil Kumar[2], Mrs. K. Periyarselvam[3], Dr. P. Sivakumar[4]
[1]*PG Student,* [2, 3, 4]*Associate Professor, Department of ECE, GRT Institute of Engineering and Technology, Tiruttani, India*

Abstract: Recent advancements in communication systems have resulted in a new class of multiple access schemes known as non-orthogonal multiple access (NOMA), the primary goal of which is to increase spectrum efficiency by overlapping data from different users in a single time-frequency resource used by the physical layer. NOMA receivers can resolve interference between data symbols from various users, hence increasing throughput. Initially, the combination of SCMA and orthogonal frequency division multiplexing (OFDM) is addressed, establishing a baseline for the overall SER performance of the multiple access strategy. Furthermore, this work suggests the merging of SCMA with generalised frequency division multiplexing (GFDM).GFDM is an intriguing possibility for future wireless communication systems since it is a very flexible non-orthogonal waveform that can imitate various different waveforms as corner cases. This research suggests two methods for integrating SCMA with GFDM.
Keywords: NOMA, SIC AR, 5G , OFDMA , SCMA, QOS

I. INTRODUCTION

The notion of non-orthogonal multiple access (NOMA) for future 5G networks. All modern cellular networks use orthogonal multiple access (OMA) techniques including time division multiple access (TDMA), frequency division multiple access (FDMA), and code division multiple access (CDMA). However, none of these solutions are capable of meeting the high requirements of future radio access systems. The following are some of the characteristics of OMA schemes. Because information for each user is transmitted in non-overlapping time intervals in TDMA [1,] TDMA-based networks need precise timing synchronisation, which can be difficult, particularly in the uplink. Information for each user is allocated to a portion of subcarriers in FDMA implementations such as orthogonal frequency division multiple accesses (OFDMA). CDMA use codes to keep users apart on the same channel. NOMA has been presented as a radio access technology contender for 5G cellular infrastructure. In order to implement real-time power allocation and sequential interference cancellation algorithms in cellular networks, substantial processing capacity is required.

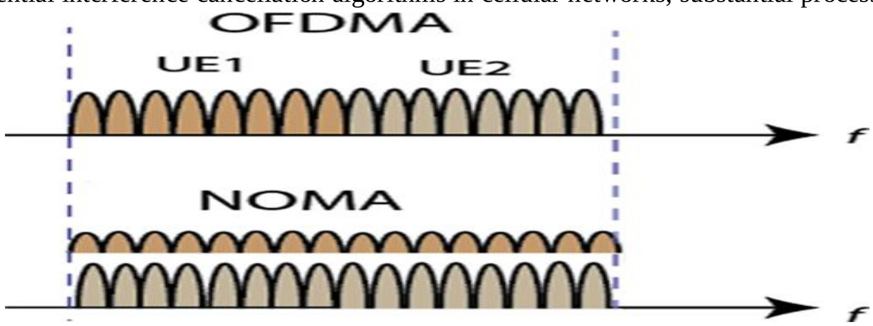

Figure 1 Spectrum sharing for OFDMA and NOMA for two users.

The computing capability of both phones and access points is predicted to be sufficient enough to execute NOMA algorithms by 2020, when 5G networks are planned to be implemented. The modulation strategy is orthogonal frequency division multiplexing (OFDM), and the multiple access strategy is NOMA. As a natural extension of OFDM, orthogonal frequency division multiple access (OFDMA) is used in traditional 4G networks, where information for each user is given to a portion of subcarriers. In NOMA, on the other hand, each user has access to all subcarriers.The spectrum sharing for OFDMA and NOMA for two users is depicted in Figure 1. Both uplink and downlink transmission are covered by this idea. The primary goal of this study is to execute user clustering and power allocation in order to maximise the network's energy efficiency.To increase the spectral efficiency of a network in which two pairs of users share the same channels over which they transfer data. To neutralise the interference caused by other users' signals transmitting across the same spectrum. To deal with non-convexity, the successive convex approximation is used. To reduce interference and improve network efficiency.

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II. RELATED WORKS

The resource allocation challenge in [6] NOMA enhanced relaying networks includes subcarrier assignment (subcarrier pair and subcarrier-user assignment) as well as power allocation. The resource allocation problem is expressed as a mixed integer nonlinear programming problem. As previously mentioned, the resource allocation problem in NOMA systems is hard to resolve due to the tight link between subcarrier assignment and receiver sensitivity. The following are the paper's contributions: The application of NOMA uplink transmission to MEC is studied, with the focus first on the influence of NOMA on MEC latency. When there are several users and a single MEC server, using NOMA ensures that numerous users finish their offloading at the same time, thereby lowering offloading latency.The likelihood that a strong user would finish its offloading by utilising the time that a weak user would only occupy in the OMA mode is first characterised and then utilised to identify the influence of the users' channel conditions and transmit powers on the offloading delay. In comparison to traditional NOMA or OMA techniques, hybrid NOMA offers a number of advantages, including the ability to support a wider range of services, be more spectrum efficient than OMA, be less susceptible to interference than NOMA, and require less successive interference cancellation (SIC) complexity than NOMA.To the best of our knowledge, there have been relatively few research devoted to resource allocation in hybrid NOMA systems, particularly the research of EE driven resource allocation in hybrid NOMA systems. In light of this, we focus in this study on efficiently managing spectrum and power resources in downlink hybrid NOMA systems.

III. PROPOSED METHODOLOGY

The proposed resource allocation framework for PDNOMA- based cooperative multicarrier multicellular networks in which a set of transmitting users want to transmit information towards their corresponding destinations with the help of a BS which acts as a DF BS. The NOMA transmission technology is utilised, in which the first phase transmitters transmit concurrently and the BS conducts joint decoding. The BS decodes all of the received signals, and in the second phase, the BS delivers the overlaid decoded signals to the destinations.The destinations employ SIC to reduce interference from other users. We construct our suggested resource allocation strategy as a non-linear and non-convex optimization problem. To approximate the primary issue by a convex one, we use the sequential convex approximation (SCA) technique using the difference of two concave functions (D.C.) approach as the approximation technique.

We regard NOMA technology to be a transmission method that improves the spectral efficiency of a network by allowing two pairs of users to share the same channels over which they transfer data. The non-orthogonal transmission of users comprises the multiple access channel whose rate region is well understood in the first hop. The transmission at the second hop is based on power domain NOMA technology. Because the transmission is non-orthogonal, interference control is required to meet the necessary QoS and design metrics. We investigate a multicell situation in which two pairs of users send data via shared channels in each cell.

The poor received signal-to-noise ratio (SNR) of the cell edge users typically limits system performance in cellular mobile communications. If the goal of the system design in the case of OMA transmission is to optimise system capacity, then users situated near the cell edge will be scheduled seldom.As a result, it leads to inequitable resource allocation and user starvation. NOMA improves the situation in this part. In specifically, we investigate the SIC receiver recognition technique that uses the power domain in the channel, as well as the power allocation method that takes into consideration the system's user rate fairness criterion.The closed form solution of the NOMA system's power allocation and the accompanying detection technique are determined, and the link between the system, the rate gain, and the power distribution factor is elucidated.

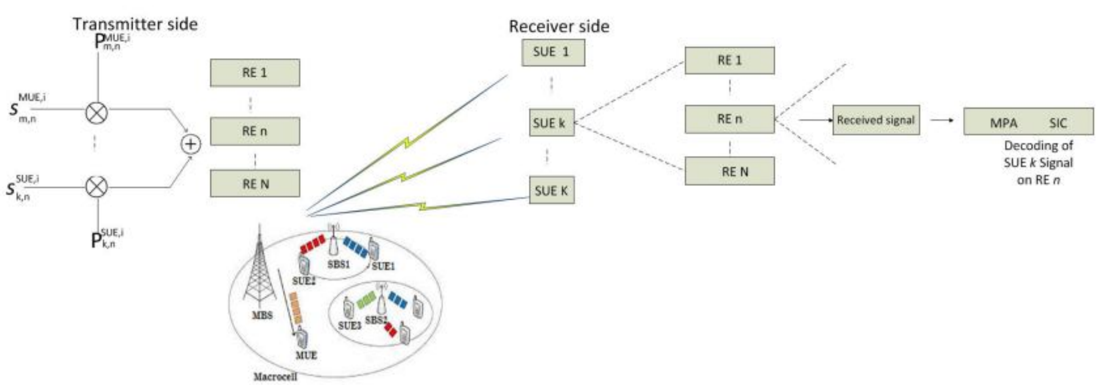

Figure 3.1 Proposed system model

Algorithm 1 Water-Filling Based Power Allocation

1) Input: N, Pmax
2) Output: P = {P SUE,I k,n |∀i ∈ N}
3) Initialize minimum power allocation, P SUE,I k,n , across Res
4) for i=1:F do
5) for k=1:K do
6) for n=1:N do
7) Sort SUEs based on their channel conditions
8) Update power allocation vector P
9) End
10) End
11) Continue process until convergence reached or number of iterations exceeded.
12) end

A. SCME Encoding

Sparse code multiple access (SCMA) is another waveform configuration of the adaptable new air interface. This non-orthogonal waveform enables a new multiple access strategy in which sparse codewords from many layers of devices are superimposed in code and power domains and transported over shared time-frequency resources. Multiplexing of numerous devices is often overloaded if the number of overlay layers exceeds the length of the multiplexed codewords. Overloading is tolerated with SCMA with minimal detection difficulty due to the decreased size of the SCMA multi-dimensional constellation and the sparseness of SCMA codewords. SCMA maps coded bits directly to multi-dimensional sparse codewords drawn from layer-specific SCMA codebooks. The detection complexity is influenced by two key aspects. The first is the codeword sparsity level, and the second is the employment of multidimensional constellations with a limited number of projection points per dimension. An example of device multiplexing with a low projection codebook.

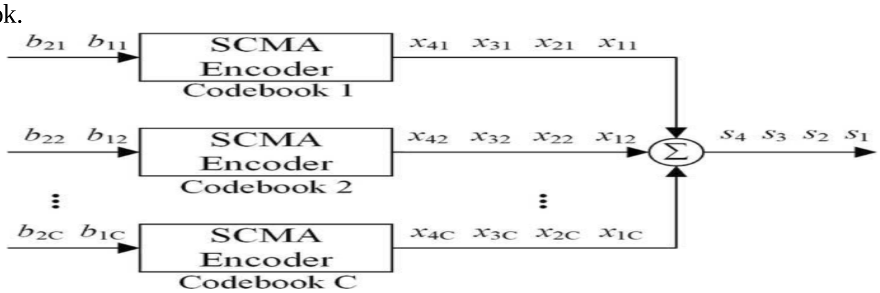

Figure 3.2 Codebook of an SCMA encoder

B. Polar Codes

Polar codes are a major breakthrough in coding theory. When the coding block size is high enough, they can reach Shannon capacity using a basic encoder and a simple successive cancellation (SC) decoder. Polar codes have sparked a lot of interest, and a lot of study has been done, mostly on code design and decoding algorithms for modest code block sizes, one of the most significant decoding methods is SC-list decoding, which may perform as well as the ideal maximum-likelihood (ML) decoding with a list size of 32.Many performance simulations demonstrate that Polar codes combined with cyclic redundancy codes (CRC) and an adaptive SC-list decoder can beat turbo/LDPC (Low Density Parity Check) codes for short and moderate code block sizes.Polar code outperforms all other codes now used in 4G LTE systems, particularly for short code lengths, and is thus seen as an ideal choice for the FEC (Forward error correction) module in 5G air interface architecture.

The encoded bits of a device are first mapped to a codeword from a codebook. A codeword of length 4 is used in the example. The constellation is decreased in the low projection codebook (from 4 points to 3 points). Furthermore, each point (for example, "00") has a non-zero component in just one tone.A zero-PAPR codebook is one that has one non-zero component. A blind multi-device reception methodology may also be used to identify device activity as well as the information transported by them at the same time. Grant-free multiple access can be supported with such blind detection capabilities. Grant-free multiple access is a method that avoids the overhead associated with dynamic request and grant signalling. It is an appealing alternative for sending little packages. SCMA facilitates grant-free multiple access. Because of these advantages, SCMA can provide huge connection, minimise transmission delay, and save energy.

An SCMA encoder is described as a mapper in which Q= log2(J) bits, where J is the size of a J-QAM constellation, are represented by a preset U-dimensional complex codeword. Each U-dimensional complex codeword in the codebook set is a sparse vector with Q<U non-zeroed elements. One SCMA layer is composed of a codebook employed by a user to encode its data to be allocated in a set of U OFDM subcarriers. Figure 1 shows one SCMA layer for Q=2 bits, QAM with J=4 and U=4. The codebook is a U×J matrix where each column is a codework to represent one sequence of Q bits. This approach is comparable to spreading the QAM across U subcarriers, i.e., information that would normally be carried over a single subcarrier is now distributed across U subcarriers.
The SCMA system has C>U separate levels, each with its own codebook. The authors provide a method for determining the maximum overloading factor in an SCMA system. The amount of non-zeroed elements of a specific codeword that can collide with codewords from various codebooks due to the sparsity of the code.Figure 3.4 shows a multi-user SCMA encoder for the downlink channel in mobile networks, assuming Q=2 and U=4. Here, there are C=6 different codebooks, each one employed to send data to a specific user, leading to an overloading factor of 1.5.
Wireless communication system that employs OFDM as the air interface usually adopts a high number of subcarriers, which means that K>>U. In this paper, it is considered that K/U parallel SCMA encoders will be used, each one with C layers. All SCMA encoders use the same codebooks, and the orthogonality among the different SCMA transmit sequences is provided by the OFDM structure, where no intersymbol interference (ISI) is introduced if the cyclic prefix is larger than the channel delay profile and intercarrier interference (ICI) is avoided by the orthogonality among the subcarriers. Figure 3 depicts the block diagram of this SCMA-OFDM system.

IV. RESULTS AND DISCUSSIONS

Assume that there are two users in the network for the sake of discussion and analyze the boundaries of the achievable rate regions for these two users. We consider a symmetric downlink channel so that the users are at equal distance to the BS. SNR1=SNR2=10dB.

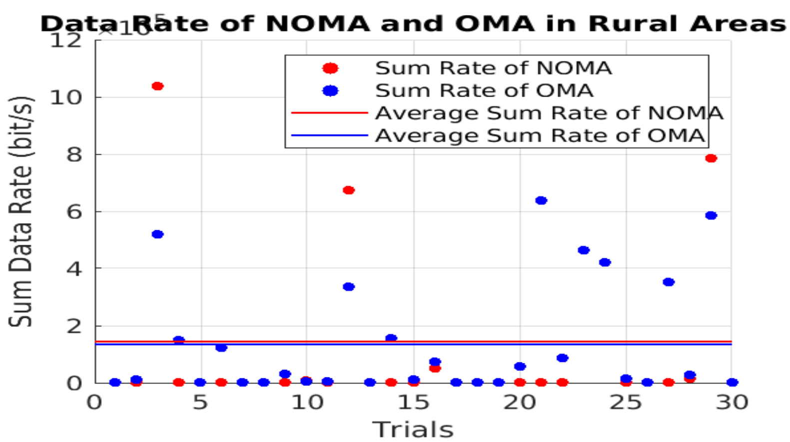

Figure 5.1 Data rate in dense region

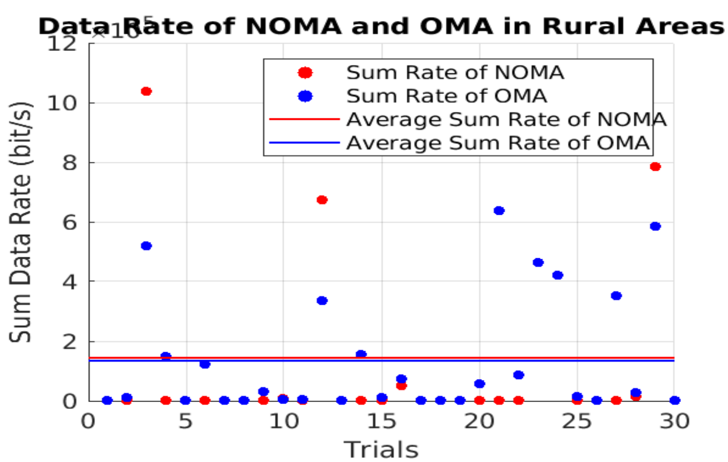

Figure 5.2 Data rate in less dense region

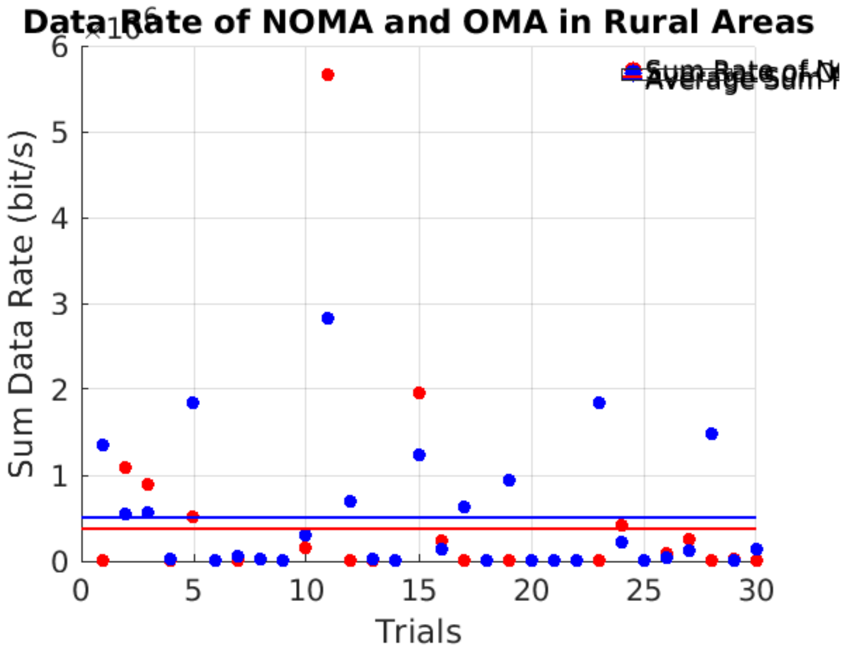

Figure 5.3 Data rate in medium dense region

V. CONCLUSIONS

A new resource allocation paradigm for PD-NOMA-based multicellular networks was described, as well as the principles of NOMA and its improved performance in terms of total capacity, energy efficiency, and spectral efficiency over standard OFDMA. We also discussed the effect of imperfection at the SIC receiver on system performance. With its special characteristics, PD-NOMA remains the most promising contender for future 5G networks. However, there are still significant obstacles to the proper application of PD-NOMA. To begin with, running SIC algorithms at high data rates necessitates a large amount of computer resources.Second, power allocation optimization remains a difficult topic, especially when UEs move quickly in the network. Finally, the SIC receiver is susceptible to cancellation mistakes, which are common in fading channels.In future studies that apply MIMO for NOMA, the influence of channel state information (CSI) is examined in the capacity maximisation issue, and outage probability expressions are generated. However, the current state of the art for NOMA is still far from its potential and requires additional exploration.

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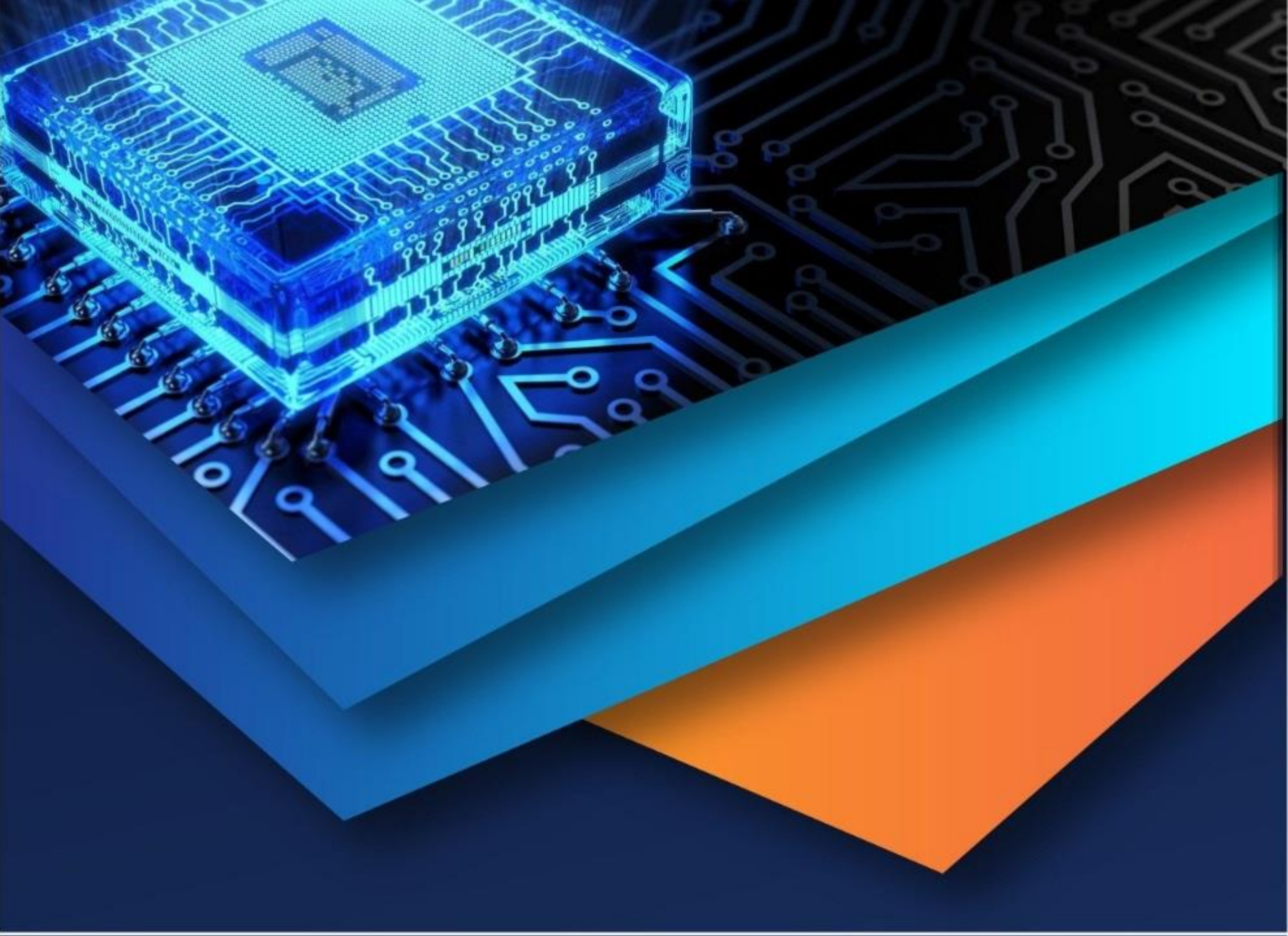

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