iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 11 **Issue:** V **Month of publication:** May 2023

DOI: https://doi.org/10.22214/ijraset.2023.52905

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue V May 2023- Available at www.ijraset.com

A Study on Green Cloud Computing

Priyanka Vijay Khutwad[1], Dr. Nisha Auti[2], Dr. Sulochana Sonkamble[3]
[1, 2, 3]*Department of Computer Engineering*, JSPM NTC

Abstract: ***Cloud computing provides computing power and resources as a service to users across the globe. This scheme was introduced as a means to an end for customer's worldwide, providing high performance at a cheaper cost when compared to dedicated high-performance computing machines. This provision requires huge data-centers to be tightly-coupled with the system, the increasing use of which yields heavy consumption of energy and huge emission of CO2. Since energy has been a prime concern of late, this issue generated the importance of green cloud computing that provides techniques and algorithms to reduce energy wastage by incorporating its reuse. In this survey we discuss key techniques to reduce the energy consumption and CO2 emission that can cause severe health issues. We begin with a discussion on green matrices appropriate for data-centers and then throw light on green scheduling algorithms that facilitate reduction in energy consumption and CO2 emission levels in the existing systems. At the same time the various existing architectures related to green cloud also discussed in this paper with their pros and cons.***

Keywords: Green cloud computing, energy efficiency, CO2 emission, Cloud, Environment safety,

I. INTRODUCTION

According to Wikipedia [wiki], Cloud computing is a collection of a variety of computing concepts in which thousands of computers communicate in real-time to provide a seamless experience to the user, as if he/she is using a single huge resource. This system provides multiple facilities like – web data stores, huge computing resources, data processing servers etc. The concept of cloud computing is around since the early 1950s, although the term was not coined back then. Time sharing systems was how it was addressed back then. During the period of 1960 -1990, a host of experts did hint the era of cloud computing in their books or quotes. The term dumb terminal attached to the mainframes was more famous in this period, in-lieu of the term cloud computing. In the early 1990s, even the telecommunications companies. began offering VPNs (Virtual Private Networks) instead of dedicated connections, which were decent in QoS but were comparatively cheaper. In 1999, Salesforce.com was among one of the first to provide enterprise applications via a website. This move aided the advent of cloud computing which was introduced around 2002 by Amazon, the organization which can be considered as one of the pioneers in the field with their Amazon Web Services (AWS) and Elastic Compute Cloud (EC2). Since 2009, after the introduction of web 2.0, other big shots in the web industry viz. Google, Yahoo etc. have also joined the club

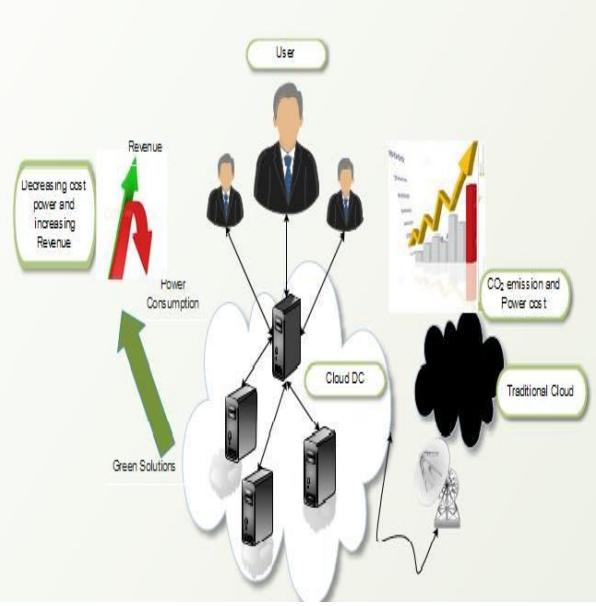

Figure 1. Cloud and Environment

Cloud computing can be considered as a hierarchy of concepts, which comprises of several models. The first model is the Service Model [11] which further includes three models namely – software as a service, platform as a service and infrastructure as a service. Second is the Deployment model [11] which further comprises of public cloud, private cloud, community cloud and hybrid cloud.
According to National Institute of Standards and Technology (NIST) – "the major objective of cloud computing is to maximize the shared resources and at the same time the disadvantage is its high infrastructure cost and unnecessary power consumption."
According to National Institute of Standards and Technology (NIST) – "the major objective of cloud computing is to maximize the shared resources and at the same time the disadvantage is its high infrastructure cost and unnecessary power consumption."
Global warming has been a big concern of late, with high power consumption and CO2 emission acting as a catalyst to increase the same. The world has become highly protective about the environment with inputs from contributors such as – Greenpeace, Environmental Protection Agency (EPA) of the United States and the Climate Savers Computing Initiative to name a few. With the continuously increasing popularity and usage of cloud computing and the increasing awareness of the people across the globe towards the use of eco-friendly resources has forced the researchers to devise concepts towards an eco-friendly energy efficient flavour of cloud computing called green cloud computing. According to the previous works green cloud computing facilitates the reduction of power consumption and CO2 emission along with the reutilization of energy in an efficient way.
Cloud uses thousands of data-centers in order to process the user queries and to run these data-centers bulk amount of power is used for cooling and other processes. Every year this power consumption is gradually increasing and green cloud computing endeavours to reduce the same thus playing a helpful role to curb these issues. There are various techniques and algorithms used to minimize this expenditure [13]. Among various avenues, one area of research focuses on reduction in energy consumption by computer servers [11], whereas the other lays stress on dynamic cluster server configuration [20, 21] to reduce the total power consumption by balancing load and effectively utilizing only a subset of the resources at hand. Similarly Dynamic CPU clock frequency scaling [22, 23] again incorporates some form of load balancing to save power during different load conditions. In addition to these, some more techniques are used to measure the power consumption in data-centers. The first one was developed by the Green Grid called Power Usage Effectiveness (PUE) metric to measure the effectiveness of data centers. PUE tells about the amount of extra power required for cooling IT equipment [16]. It is clear from Figure 1 that in cloud scenario power consumption is very high with high carbon emission whereas at the same time in green cloud this is very less as compared to traditional cloud. Green clouds avoid power wastage and this is the reason for adoption of this technology by IT companies like Google, Microsoft, Yahoo!, etc. According to a survey done in the year 2007 IT industries contribute to 2% of the total carbon emission every year [19]. European Union (EU) is also of the view that severe reductions of the order of 15%-30% is required to maintain the global temperature and stop it from increasing drastically before 2020.

II. LITERATURE REVIEW

The use of Green Cloud Computing has increased substantially in the recent past. A lot of research has been done to incorporate and enhance the applicability of Green Cloud in real life scenarios with these help of various parameters. Usage of energy is dramatically increases in data centers. Cavdar et al., [1,2] introduced for improving the energy efficiency of the running data centers, the Green grid is proposing some parameters like Power Usage Effectiveness (PUE)[7] and Data centre Efficiency (DCE) metrics [10], TDP (Thermal Design Power) [2], etc. PUE is the common parameter.
According to Wikipedia "PUE is a measure of how efficiently a computer datacenter uses its power "The range of PUE is varies from 1.0 to infinity. If the value of PUE approaching 1.0 it means efficiency is 100% and full power is used by IT equipment's. In recent years some companies achieved low PUE levels, like Google PUE with 1.13 [9]. If the value of PUE is 1.5 it means that energy consumed by IT equipment in 1kWh, by data centre 1.5 kWh and 0.5 WH energy has wasted as fruitless work like cooling, CPU dissipation and other work. Table I explain some parameters proposed for data centers. In many data centre the value of PUE reached to 3.0 or more but by using correct design 1.6 values should be achievable [5]. This calculation is done in Lawrence Berkley National Labs [8] which illustrate that 22 data centers 22 datacentres. measured had PUE values in the 1.3 to 3.0 range [8].
Truong Duy, Sato and Inoguchi et al., [3] implement the green scheduling algorithm combines with neural network predictor for reducing the energy consumption in cloud computing. In this algorithm, the server predicts the load from time t to the time it takes for restarting and calculates the peak load.
According to the peak load the number of server state is decided. Let, No is the number of server in ON state and Nn is the number of necessary servers. If the Nn > No then, choose server in OFF state, signal them to restart and if Nn < No choose server in ON state and signal them to shut down.

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Fumiko Satoh et al., [4] also focus on reducing the usage of energy in data centers. But for the future energy management they develop an energy management System for cloud by the use of sensor management function with an optimized VM allocation tool. This system will help to reduce the energy consumption in multiple data centers and results shows that it will save 30% of energy. This system also used to reduce the energy in carbon emissions.

Cooling is other major issue that consumes huge amount of energy in data centers. Previously, the cooling is done by using mechanical refrigerator that supply chilled water for the IT equipments. Now a day's pre cooling also called as free cooling is used. Free cooling minimizes the use of mechanical cooling. Like Face book deploys their data centre in Sweden which has cold and dry climate. Microsoft leaves servers in open air in order to cool the servers easily. Also Google uses river water to cool their data centre [1]. There are different hardware technologies like virtualization and software technologies like software efficient algorithm used to decrease the consumption of energy.

Rasoul Beik et al., [6] proposes an energy aware layer in software –architecture that calculate the energy consumption in data centers and provide services to the users which uses energy efficiently. Bhanu Priya et al., [11] gave a cloud computing metrics to make the cloud green in terms of energy efficiency, different energy models has been discussed in this paper to reduce the power consumption and CO2 emission to make cloud more green. This survey takes three major factors under consideration; any cloud can be green by following these factors, first cause to make cloud greener is virtualization, Second is Work load distribution and third is software automation, some other factors are also discussed like pay-per-use and self-service which is proved as a key for reduction of energy consumption.

According to Kliazovich and Pascal Bouvry [12] expenses on cloud data centers maintenance and operation done in cloud are gradually increasing. In this paper author has focused on the work load distribution among the data centers so that energy consumption can be calculated in terms of packet level. By this technique packet level communication is achieved. Packet level simulation of energy has been done through the simulator, like for green cloud NS2 simulator and for cloud only one existing called "cloudsim". This simulation is done at three levels: "two-tier, three-tier, and three-tier high-speed data center architectures". Kaur and Singh et al., [13] performed the different challenges in the field of energy in cloud computing, a model is proposed by author to calculate the energy wasted by producing various gases in environment. The proposed model contains various fields Data, Analysis, Record, Put on guard, restrain along with the virtualization concept in green cloud to make it energy efficient and for healthy environment.

Hosman and Baikie et al., [14] gave a new challenge in the field of cloud computing, datacenters consumes a lot of energy and energy is available every time is not necessary, so the author is discussing in his paper about the solar energy. How the solar energy can play a vital role in data centers energy consumption is the hot topic of discussion. In this paper author proposed a small level cloud data center which is the combination of three technologies are "less power consumption platform, energy efficient cloud computing and DC power distribution". Owusu et al., [17] performed a survey to establish the current state of the art in the area of energy efficiency in cloud computing. They beautifully mention the field of energy efficiency as a controversial area to cloud computing. This paper discusses one area of controversy; the energy efficiency of cloud computing.

Yamini et al., [18] Introducing the key approaches like virtualization, Power Management, Recycling of material and telecommuting of green cloud computing very beautifully. The major focus of this paper is the consolidation or scheduling of task and resource utilization in green cloud computing to reduce the high consumption of energy. The decent results shown in the paper not for the direct drastic energy reduction but applies possible saving of electricity in huge cloud data centers. According to Buyya [19] the demand of cloud is drastically increasing now a day and the consumption of energy and excretion of harmful gases is also extreme which is very harmful and a big issue in the field of health care and also a big reason of the increase in cost of operations in cloud. Buyya gave a presentable and evidential literature survey of the various different members of cloud which participate in the total energy consumption. Structure of cloud are discussed in this paper which turn on the use of green cloud computing.

Buyya et al., [24] Contributes carbon green cloud architecture which points on the third party concept, consist of two types of directories named as green offer and carbon emission. These directories help us to provide and utilize the Green services from users and providers both. Green brokers access the services from green offers directory and scheduled services according to least CO2 emission. Beloglazov and Buyya et al., [25] focuses on virtual machine for the reduction of the energy consumption. An author proposes the dynamic reallocation technique for VMs and toggles off the unused servers which results, considerable energy saving in the real Cloud Computing data centers.

Nimje et al., [28] addressed the security of the cloud data centres in order to achieve green cloud environment by using virtualization concept. Various methods are involved in the paper to address the security and reduction of power consumption.

Virtualization here came in to picture because it reduces the load from the data centres and provides deployment, management and delivery of resources in simple manner. Nimije included hypervisor environment to provide the virtualization and works as a security tool to achieve high level of security in green cloud computing.

III. PROPOSED SYSTEM

An Information and communication technology's dynamic field includes cloud computing technologies. It is a distributed parallel computing technique with great performance, scalability, affordability, and dependability. Green cloud computing technology is made possible by variables including increased energy efficiency, reduced carbon footprint, and reduced e-waste. Many servers and data centres are dedicated to offering users pay-per-use services. These materials consume a lot of electricity and take up a lot of space. The four basic forms of cloud computing architecture are as follows.

1) External or public architecture: In this design, resources are maintained by an outside provider on a pay-per-use basis.
2) Internal or private architecture: A cloud computing system that is used only by one particular business.
3) Community architecture: Several organisations share a cloud and have related problems.
4) Hybrid architecture: This allows for the integration of both public and private clouds with outside service providers.

Power management, energy consumption and efficiency, greenhouse gas (GHG) and CO2 emission, virtualization of servers, and the preservation of natural resources are some of the main issues with cloud computing. With the fundamental principle of sustainable development, the idea of "green computing" first emerged in 1987. This development's main goal is to lower energy usage. Green computing refers to the environmentally friendly use of computers and related technology. An energy-conscious technique that has recently been applied in the cloud computing environment is the migration to virtual machines. When compared to conventional data centres, Nano Data Centres (NaDa) offer a distributed computing platform and up to 30% more energy efficiency [11]. Task consolidation is done to improve the system's energy efficiency and simplify the use of resources. Other notable energy-saving techniques that can be used in a green cloud computing environment include hardware temperature control, server consolidation, compiler optimisation, application software power optimisation, dynamic energy consumption enabled operating system, virtual machine manager optimisation, virtual machine live migration, and network environment optimisation.

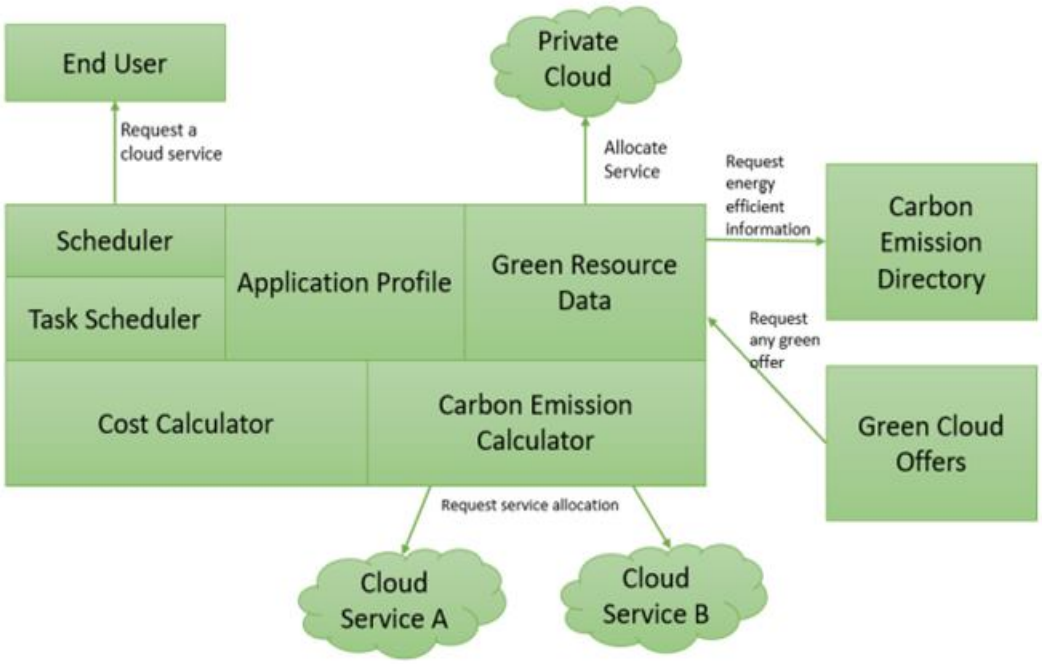

Figure 2 Green Cloud Computing Architecture

A straightforward architecture for green cloud computing that includes all necessary devices and software. Here, the cloud data centres are cloud service A, cloud service B, and the private cloud. These cloud data centres offer software as a service (SaaS), platform as a service (PaaS), and infrastructure as a service (IaaS) among other services.

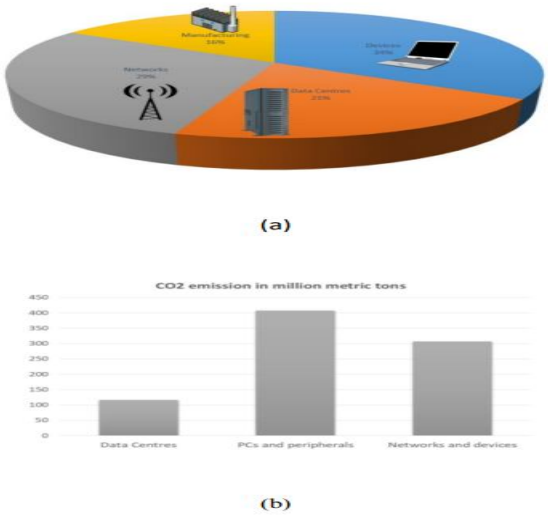

Figure 3 Estimated 2017 CO2 emissions in millions of metric tonnes from the IT sector and its components.

In order to reduce carbon footprint, improve environmental friendliness, and optimise operational costs in a green cloud computing environment, we apply data mining and model-driven engineering techniques. The client side and the server side are the two components of this architecture. The manager and users are present on the client side, which deals with the location where the job will be executed, while the green cloud middleware, green broker, and sub servers like processing servers and storage servers are present on the server side. The green broker layer of IGCA uses the directory concept to organise all the data in the public cloud and give users the best green services possible. There are two parts to the green cloud middleware. The manager is the principal figure who oversees one element and maintains all of the middleware's data. the user's PC usage, the servers located on private clouds, and all the data. the different sever frequencies, such as high, medium, and low. The middleware component also contains information about energy consumption, storage capacity, and other topics. When the client requested it, the manager received it. The request is divided up into jobs and given to the users while the job information is also stored in the component. Users can compute and see how much energy and carbon are expended when a task is carried out on a client's PC, on a public cloud using a green broker, or on a private cloud using servers. The manager chooses the best green offer while also taking the job's level of security into account. When the manager makes a choice, this information is saved in an XML file for further use.

The optimal place to carry out the task depends on a number of parameters, including processing speed, energy consumption, bandwidth, and others. The middleware will compute and evaluate the location from the three locations by taking into account all the parameters. The IGCA offers balance in the way jobs are carried out and offers clients security and high-quality service. The manager distributes the work and the best green solution by taking into account all the locations. In this design, the manager serves as the central coordinator, assigning tasks to users and making all decisions. However, the manager is also the weakest link in this design since it is the primary point of failure; if the manager fails, the entire structure crumbles.

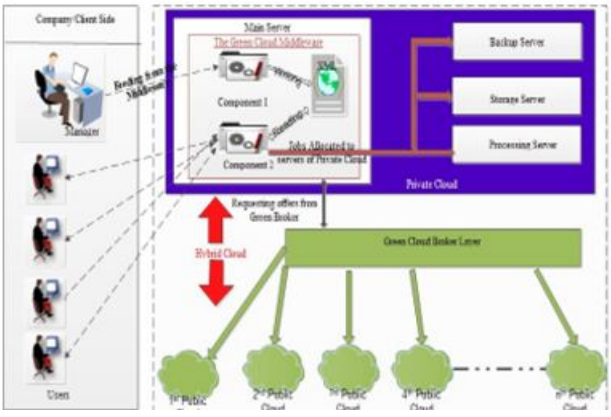

Figure 4. Integrated green Cloud architecture (IGCA)

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IV. CHALLENGES IN THE IMPLEMENTATION OF GREEN COMPUTING

A. Awareness of Green Computing

People generally don't have a good knowledge of green cloud computing. The majority of people are ignorant of its environmental impact. People demand People generally don't have a good knowledge of green cloud computing. The majority of people are ignorant of its environmental impact. People demand

B. Cost of Equipment

People believe that using old methods is preferable since they are not particularly expensive, but in the long term, such a way of thinking is likely to boomerang on humanity. People need to exercise caution on the effects that their goods, either directly or indirectly, have on the environment.

V. CONCLUSIONS

The quantity of energy used by these cloud data centres is rising quickly as more and more companies migrate to the cloud, thus increasing their energy consumption and carbon footprint. Green cloud computing offers a solution to this issue by cutting down on energy use and optimising resource usage. Strong AI methods are promoting the development of green cloud computing. IoT and big data analytics are only two examples of sectors where green computing may be applied. The general public has to be educated on the value of green computing.

Future use of green computing will be very advantageous for the environment.

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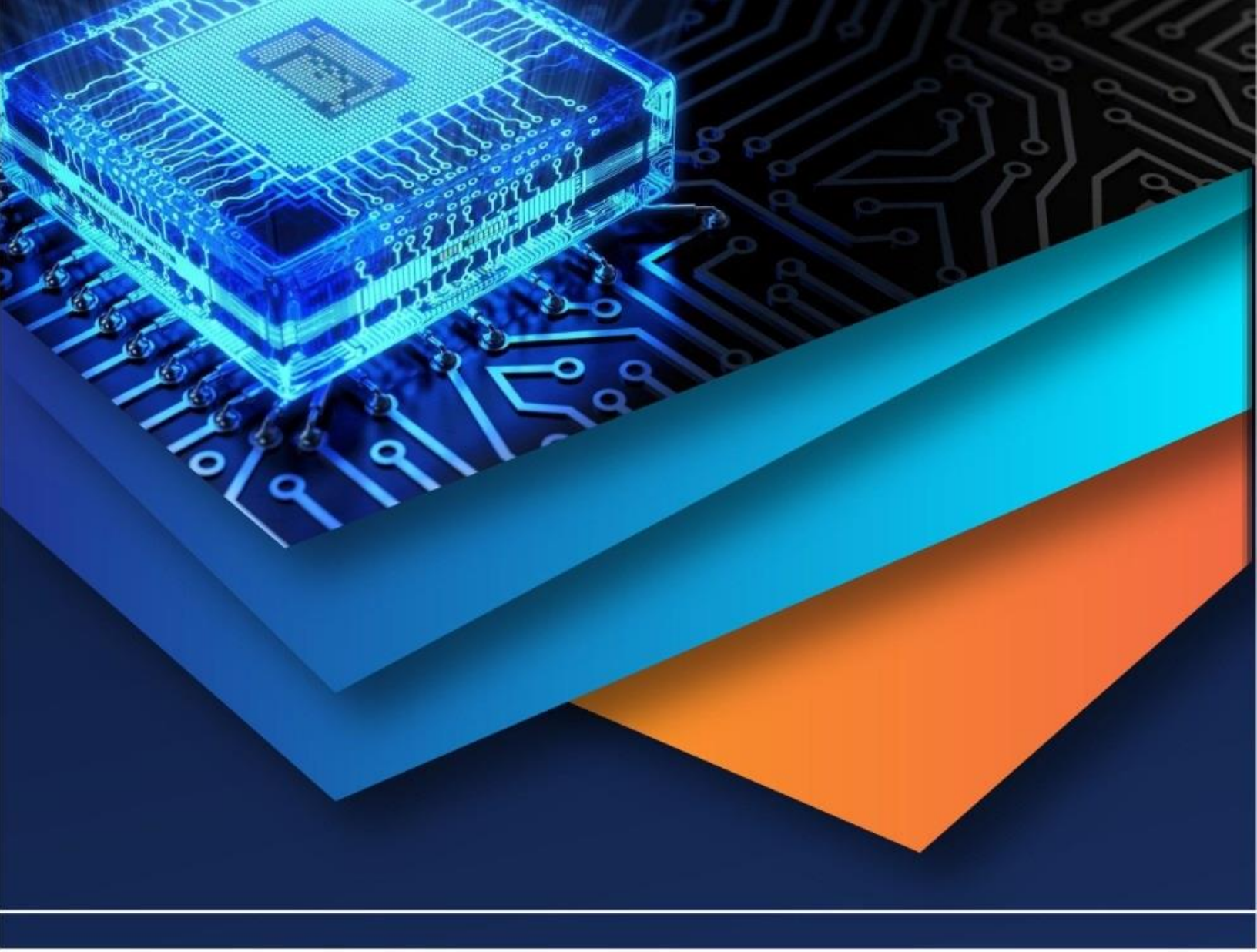

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