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An Interactive Approach to the Next Generation Quantum Computing

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Abstract: Time and Computation are very tightly coupled in terms of performance. Quantum Computing enables much better performance statistics over traditional computers. The mentioning of Qubits changes the fate of computing where we have the delay in finding the solutions for much complex problems. The phenomenon used in this approach resembles the Quantum theory in which it imparts the features of superposition and entanglement. By holding all the bit positions may lead to storage issues but with the superposition we may find the combination at any one the state. Sometimes it even given drastic changes to the computing community. The top level MNC's are also trying to have a quantum computer to reduce error rates, achieving faster response times and tracking of satellites etc. It is equivalent to the performance of supercomputer in a cost-effective way. By the process of annealing I will produce better results. On periods it creates the dilemma by the feature of superposition. The way it operates the feature of de coherence is remarkable. But with the existing hardware performing robust error detections and achieving better performance is miles away.it has a special combination of Qubit organisation where it combines the with adjacent 8-bit combos. To make effective algorithms to work with level of high expectations with this normal hardware is disastrous. A different hardware has been accompanied to design the strong algorithms which moves the traditional computer computational strategy to the knees of this. Moreover, it will take some years of time to sustain as a general computer, researchers striving hard to make this happen.

Keywords: Qubits, superposition, entanglement, Host processor, control plane.

I. INTRODUCTION

In recent times most of the people got awareness over the word Quantum in the fields of computing, which gives abnormal solutions to the specific problems in a hasty way unlike traditional computers solves. That's maybe a good reason, why many people thought it is a game-changer in computing speeds. Problems of the domains like commerce, corporate business, mathematics and physics will get accurate solutions with this technology and raise the financial status. It was recognised earlier but, yet unfulfilled. These are much byzantine to structure and to work. It comes with a bunch of errors in the noise and causes loss of quantum equilibrium, which collapses before a worthwhile program. This de-coherence can be caused by temperature fluctuations, EMW, impacts of outer things destroy the rich properties of quantum. If we have these then our system will give a passive result with medium execution time. Even the relevant structures also facing the same problem, so none of the hardware bases gives strong error correction mechanism, which is essential for MEGA computation, expecting a breakthrough in nearby years. There should be a question that was roaming in everyone's mind is how the result becomes unreliable before it finishes a complex computation. Solutions are fetching with the thorough analysis over industry people, R&D committees and some National level laboratories to have the best methods to shrink errors. One approach is what we get as an output of the model depending on that we are going to frame the definition of error-free computation over different noisy ranges. Other is designing a complex perfect algorithm which Is capable of solving critical sections of the program where normal code runs in a strong traditional computer. Many others also trying to deal with the noise reduction. On the other hand, traditional computers are also affecting the bunch of errors which can be shaped with the nominal amount of additional logic. The error correction schemes of the medium quantum are live but conserve many Qubits unlike for actual Qubits. This may result in a nominal part on Defect-free hardware. In the field of quantum, the essence of Qubits is high compared with the analogous gates whose circuits are formed with these on the computers, tablets and mobile devices where it will take lakhs of them. Hardly 50 -60 Qubits are enough to enrich the work.

II. WHAT DOES QUANTUM COMPUTING MEAN?

We all know the plank's idea, which states that individual units consist of energy. By taking this as a primary concern, a person named Paul Benioff introduced the theory of Quantum computing. With that, the idea of creating a general-purpose quantum computer had grabbed the eye with the latest trending technologies in quantum theories. Quantum computing mainly focusses on modern physics, which explains the behaviour of the matter and energies of atomic and subatomic levels.

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The quantum computing0 may use quantum bits and the principle of superposition to implement data operations. By mentioning these, computing becomes extremely complex compared to traditional computer machines.

In traditional computers, BIT is a term to hold the information. Unlike quantum computing uses Qubits, to hold the information, which consists of a two-state quantum-mechanical system where it shows on two distinguishable quantum states.

In a period if we don't know the state of a specific object, then there may be a chance that it can present on all objects which it emphasises the principle of "superposition". The enhancement of this is where mass and energy are correlated irrespective of distance is termed as "Entanglement".

III. HARDWARE MODEL FOR QUANTUM COMPUTER

Computers can be acted as interfaces In so many situations to process the data over networks unlike traditional computers quantum computers need to hold effective hardware to yield perfect results the reason why we insist effective is that it works on the Qubits rather Bits so phenomenal approach is needed to work with these systems.

To emphasise this hardware model we need to frame four layers where its having their own functions to yield better response "Plane for quantum data------place where we keep qubits" "measurement and control plane----- carrying operations on Qubits" " processor for control plane ----which is capable of holding the precise operations done by the control plane to yield proper outcome" " Host Processor ------this will runs the operating system and accommodates the needful things like accessing the networks ,large volumes of storage, offers needed bandwidth to control the processor etc."

A. Plane for Quantum Data

This is crucial for a Quantum Computer like a heart because the data is very much important. It has the raw Qubits, supporting structures and other relevant circuitry to measure and control the states of Qubits. A strong communication is required between two qubits in Analog systems this layer will provide the needful.

We have a separate layer in Quantum computer unlike Conventional computer is merging both data pane and control pane on the same device. Transmission must be implemented in a high degree, so it affects only the desired qubits not all other side it makes difficult as qubits increases.so we need to have another layer to control over this.

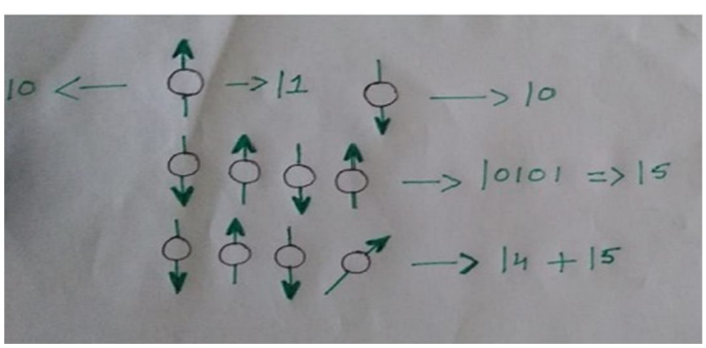
The essential properties the decide the quality of data plane are error rate of single qubit and two qubit, qubit coherence, inter qubit connectivity in a single module.

B. Measurement and Control Plane

It mentions what operations that the qubits need to perform. any misbehave with the signal may cause small control to appear for the change in their qubit state luckily both qubits are systematic and change slowly by the mechanical behaviour. The control signals are dependent on the Qubits behaviour. Unlike the rest the control signals are dependent on the precision of the delivered output for the quantum operation. For getting the precise values we need much more specific generators. All these having impact on the gate speeds which for now as 10-100 of nano seconds for super conducting Qubits and 1-100 microseconds for trapped ion Qubits.

C. Processor for control plane and Host Processor

The composing of Qubits is different from a classical computer take as an example to demonstrating this to represent a n-Qubit in a traditional computer represents 2^n Complex computational coefficients whereas for a normal binary system it requires only n values. Care must be taken to choose that the Qubits are in probabilistic superposition mode. This directly saying that the measured Qubits are already in the before measurements with equivalent possible configurations. Unfortunately, this may directly affect the computation outcome.



Qubits are made up of controlled particles.

To get good understanding of this take a system of 3-bit register where its exact state is not known, it may be related with distributional probabilities over the strings (010,100,011,000,001,101,110,111) if there is no uncertainty then it is exactly same as one of its states with 1 as the probability also there is a chance to have other states occurrence.
Now take the same phenomenon for a 3-Qubit Quantum Computer by 8D vector.
Here make sure that the coefficients are complex numbers and their squares are absolute values must be equivalent to 1. Each absolute value gives the state information of the system with the measurement. Because it is a complex number, we have two (magnitude and direction) the differentiation may lead in a meaning full way. This is one of the fundamental differences between a Quantum computer computation to a normal computer computation.
Measuring the probability of the individual bits gives the state of the Quantum bit.
We have so many ways to take the 8D vector like orthogonal, unit length etc. which varies with the resultant.
In quantum computing allowed operations are rotations by means of unitary matrices. Rotations can't be backward, so Quantum rotations are reversible. On the execution of algorithm result must be read off.
We have so many algorithms that give answers with some probability. By performing repeated executions, initiations Quantum computers fives most accurate answers on the other hand frequent measurements are the part of counter factual computation model.

D. Quantum Search

Quantum algorithms offers best known polynomial speeds besides factorization for so many problems although it is unlikely considered because the is no mathematical proof. However, it offers some recognisable speeds. The most famous example is Quantum data base Search which can solved by Grover's algorithm. Even though there are some problems, but it seems to be the best.

E. Quantum Simulation

Many of the people believe that it is the best application of Quantum computing. Under this we have so many, but it is impossible to simulate a few like nanotechnology and chemistry etc. QS also useful to simulate behaviour of the atoms.

F. Quantum Annealing (or) Adiabatic Optimization

As we all know the adiabatic theorem where the system is in ground state while it is slow throughout the process. With this as the reference we place our system in ground state performs operations towards the top by mentioning the ground level as the result.

G. Quantum Supremacy

It says in a specific field the quantum computer gets an advantage over speeds compared to the classic computer. This is not achieved yet. Some of the scientists said that it is possible, so other means and the research is still going on.

H. Quantum Decoherence

It is one the challenging issue in QC .it means isolating the systems with its interactions to the other world. It is highly controlled and effectively not unitary i.e. not reversible.
Some Qubits need to cool 20mk to prevent de-coherence it may trigger to time delays also there might be a chance of getting superposition. These issues are more difficult for optical shaping things are going good for now.

I. Shor's Algorithm

Shor's algorithm is used to factor numbers into their components (which can potentially be prime). It does this in roughly On3quantum operations, while the best-known classical algorithms are exponential. Since the difficulty of factoring is believed to be exponentially hard it forms the basis of most modern crypto systems. Hence, being able to factor in polynomial time on a quantum computer has attracted significant interest.
In this section we are going to begin by constructing a set of tools needed to implement Shor's algorithm. Then we put these tools together to factor. Our first tool is how factoring is related to another problem: order finding.

J. Factoring and Order-finding

For positive x, N such that x < N, the order of x modulo N is the least positive integer r such that
$[x^r \pmod{N}] = 1$

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K. Why do we Care about This Problem?

Suppose N = 77 and x = 10

r	0	1	2	3	4	5	6	7	8	9	10	11	12	13
x^r|N	1	10	23	76	67	54	1	10	23	76	67	54	1	10

Suppose N = 15 and x = 4

r	0	1	2	3	4	5	6	7	8	9
x^r|N	1	4	1	4	1	4	1	4	1	4

Suppose N = 15 and x = 11

r	0	1	2	3	4	5	6	7	8	9
x^r|N	1	11	1	11	1	11	1	11	1	11

Observe that the period of repetition is one less than a factor of N! Shor’s algorithm can be summarized in this way:
1) Choose some random x (x co-prime of N)
2) Use quantum parallelism to compute $\mathbf{x^r}$ for all r simultaneously.
3) Interfere all of the $\mathbf{x^r}$ ‘s to obtain knowledge about a global property of the structure (i.e. the period) of the solutions.
4) Use this period to find the factor of N

IV. THE PRACTICALITY OF QUANTUM COMPUTERS

D-Wave Systems is the first to sell the largest built quantum computer. Even NASA and GOOGLE are also competing to buy thee quantum machines, even they won’t hold endless applications.

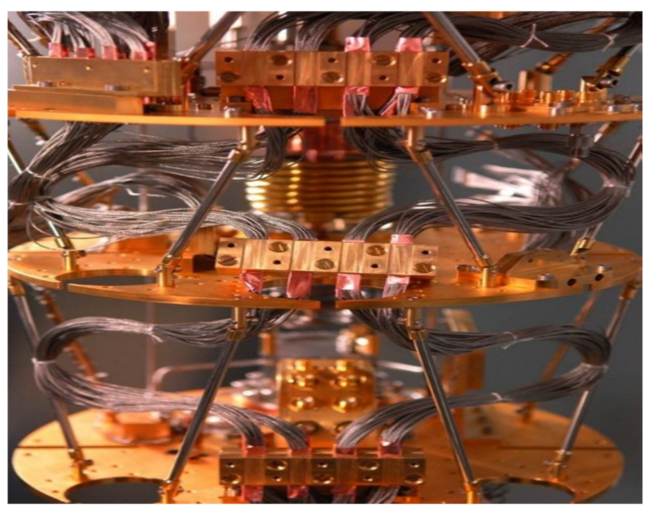
Especially google uses this to solve optimisation problems to achieve faster web search, unlike NASA using this to recognise patterns, advanced mission planning and moreover air traffic control.

One crucial issue with these has come to be noticed that it is “not performing the actual quantum physics mechanic.” Sometimes it is identified that quantum processors are 10X faster than the traditional computers at the same time it found that it is 100X slower than traditional computers.

With these considerations we can’t make a strong statement over these, still, a lot of research has t e taken place, moreover, it has a long way to advance. Sometimes it is considered to design it for everyone but even as of now the DLINK is focussing on the clients of the high end like google and NASA. As we considered that a normal traditional computer can do a lot of tasks of a quantum computer.

A. The first Quantum Computer

For the first D-wave came with the new scenario of quantum computing which is having the capacity of solving a problem i.e. annealing.



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There, a question raises that if it works really with quantum computing nature? Then D-wave came with a team of researchers, among them performed well to design the first quantum computer to perform quantum annealing. With a few recognisable scores it emerged as a simulator of a quantum computer.

The major problem with this is entanglement which, it intrinsically having. Researchers working with this have shown this with the entire 8-bit Qubit.

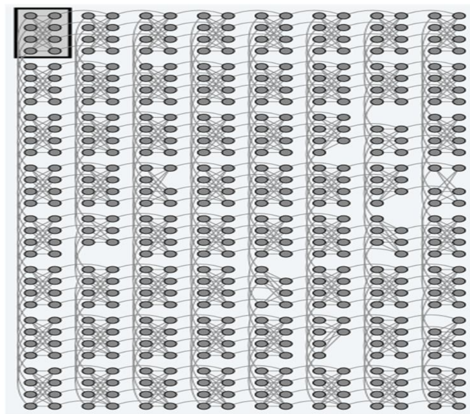


Fig: 8-bit Qubit organisation

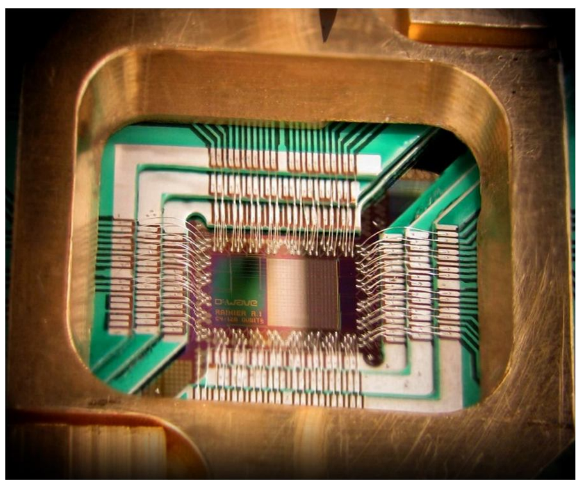
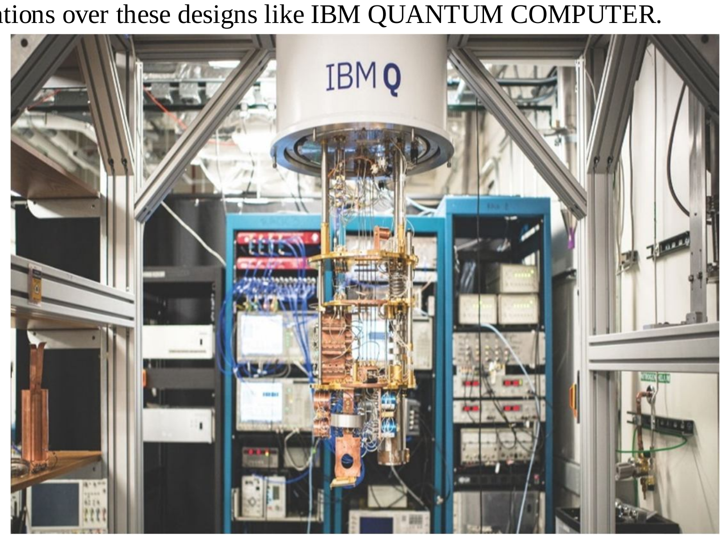


Fig: D-Wave 128 bit processor

Later we have some implementations over these designs like IBM QUANTUM COMPUTER.



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V. DEVELOPMENTS

There are so many QC models varies with the basic elements in the decomposition that it uses.

We have FOUR popular models

1) *Quantum Gate Array:* few Qubit quantum sequence
2) *On way Quantum Computer:* sequence of one Qubit measurement
3) *Adiabatic Quantum Computer:* Quantum annealing
4) *Topological Quantum Computer:* Braiding of anyone

All these 4 models yield similar results with no measurable polynomial overhead. Quantum Turing machine is important in theory, but the realistic implementation is not pursued.

For physical implementation of the QC we have so many are pursued like optical lattices, electrons on helium, trapped ion, coupled wire etc. all these won't give rapid progress also we have vast amount of flexibility.

VI. DRAW BACKS: TAMING DEFECTS TO GET SOMETHING DONE.

A. Few faults on the workflow

Our guess challenges quantum mechanics. Somehow to fight to sort out the best solution in terms of algorithms for doing worthful tasks. To overcome this one of the teams developing a new scenario to invent and integrate algorithms to do essentials on noisy quantum Systems. Algorithms are the series of actions that tells a computer that what to do and what not, contrastingly these quanta provide best, short possible solutions for the noisy issues on hardware devices. That precisely activates the algorithm to have a greater number of instructions within a restricted frame, before lossless coherence reduces.

In the work of Quantum computing, we are assuming a crucial step in getting algorithms executes effectively, the major thought is to have an integrated number of gates to get lossless coherence and to reduce the chance of getting sources of errors.

To equivalent the operations of a specific quantum computer we use machine learning techniques to do simulation. Unlike, the past recent trends in quantum computers got a breakthrough that it can evaluate its own algorithms as it triggers to easier simulation methods rather computational delays. The point to choose this is it reduces the effects of noise quite easily besides machine learning strategies. It is observed that one qubit gives comparatively integrated noise to that of the other, therefore it uses better qubits. With this as a key, the ML algorithms perform the assigned task with less amount of computational and logic gates which yields a larger lifetime to the algorithm. Now it is available to the public for the cloud with limited access and had the benefit of scalability provide to the large algorithms in the future with quantum machines.

The recent works give tools to the professionals to have a great development over many fields. Mainly the developers can take advantage of this to yield the best potentials over traditional computing. If it succeeds, then we have many robust and more reliable solutions to the real-world complex problems that bring the traditional functionalities to the ground.

VII. IMPROVEMENTS

We got some confirmation that there is a quantum computer. Now the question is how to improve this?

We theorised that not every time quantum computer is better over the traditional computer. Even more, we must prove that it is pretty good as compared to the supercomputer.

A few points this, its architecture is less than the ideal. As it only offers less than 100 effective Qubits compared with 512 Qubits of newer systems, because its architecture is partly connected. The connections of 8-Qubits have 8 and 2 other Qubits of adjacent blocks.

D-Wave is trying to accommodate more Qubits it offers in the system but the performance we may expect because we have only 2 other connections to adjacent blocks.

A. When We Can Make this as Common Technology?

The answer, for now, is you would not. There are plenty of reasons that it never makes a drastic change over personal computing. The fact that relies on large volumes of liquid nitrogen.

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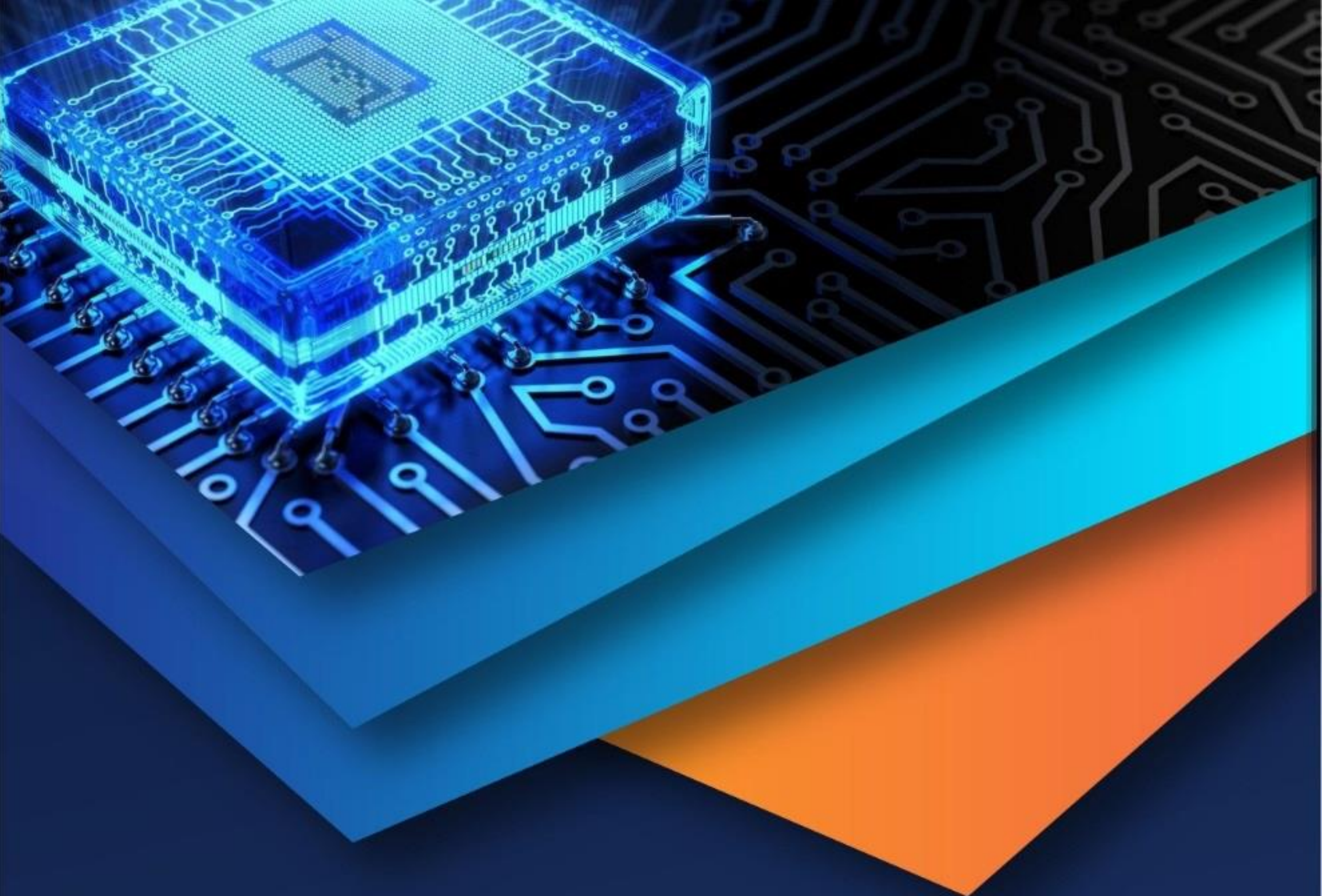

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