International Journal of Scientific Research and Engineering Development-– Volume 4 Issue 5, Sep- Oct 2021

Available at www.ijsred.com

RESEARCH ARTICLE OPEN ACCESS

In and Out-System Issues of Quantum Computers

Rishikesh Yadav
Budhanilkantha School, Kathmandu, Nepal
Email: rishikeshadh4@gmail.com

--************************----------------------------------

Abstract:

Quantum computers have been one of the ultimate achievements of the century and works on perfecting them are still going on. Multiple researches have already been done on quantum computers, its supernatural functions and the achievements that the world can get. In the list of those researches, one more is going to get added of a different subject which was distinctively not spotted anywhere in the web. This research was done on a real quantum computer at IBMQ Experience. We figured out that, being a machine, quantum computers, of course, entail multiple issues, which directly affects its efficiency. Thus, the arisen issues are to be sorted out as soon as possible.

Keywords **—Quantum Computers, Issues, Decoherence, Superconductivity, Majorana States**

--************************----------------------------------

I. INTRODUCTION

Present scenario predicts that the quantum computers are going to change the entire world, probably with some kind of supernatural powers. And, there are no doubts that the prediction isn't misleading.

Because the original meaning of the term "quantum supremacy," as proposed by John Preskill in 2012, was to describe the point where quantum computers can do things that classical computer can't, this threshold has not been met [1]. There are no uncertainties that quantum computing is becoming more and more progressive every day. The qubits are being cleaner, the gates are getting better, and the algorithms are getting more complex. It's probably a few years for the Quantum Computers to become a chief technology. However, a prominent hurtle remains that will require great efforts to overcome.

This work (literally, experiment) functions to present the issues/problems faced in the execution of the Quantum computing and also put forth the corresponding solutions.

II. ANALYSIS

Despite loads of effort from the IBM and Google, the problems in the implementation of the quantum computer still exists. The entire problems can be divided into two parts, as;

*1) **In-System Issues:*** The in-system issues basically include the Superconductivity and the production of Majorana States. For example: Grand Challenges in Silicon Technology [2]. In addition to this, quantum mechanics have always been better than the silicon-based quantum system.

*2) **Out-System Issues:***Theout-system issue entails difficulty in the Pre-Entanglement with the Environment. These issues play a prominent role in making the quantum computers inefficient up to some extent.

III. DECOHERENCE

As Quantum Computers have the in-built entanglement, this has not only advantages, but also disadvantages. There is no doubt that quantum entanglement can be found while the Quantum Computers are in operation. Nevertheless, a case that the qubits get interacted with the surrounding even before an operation occurs. If the qubits are pre-affected with the environment, their states may get changed and the information stored by them also get lost. As a result, the efficiency of such computers decreases.

Decoherence could come from many aspects of the environment: changing magnetic and electric fields, radiation from warm objects nearby, or cross talk between qubits. Quantum scientists have their work cut out for them in wrangling all of these potential sources of decoherence. [3]

However, it's not that the problem arisen doesn't have a pragmatic solution. One way to deal with the problem is to play with the atom's spin states such that there won't be pre-entanglement of the qubits with the environment.

In addition to this, Quantum Error Correction can also be used to minimize the errors. But, there's again a problem. Such error correction only mitigates errors in lesser number. So, in order to correct errors in higher magnitude, one can use multiple qubits in the making of a logical qubit. For example; with 10^4 qubits, it is possible to have a failure rate of 10^{-15}.

IV. SUPERCONDUCTIVITY & THE PRODUCTION OF MAJORANA STATES

Quantum computers that rely on superconductivity have to be keep at the superconducting temperature regime for the materials they're built with. Topological quantum computers, for example, are made from flux vortices in superconducting thin films. The eternal problem in superconductivity has always been finding materials that keep the superconducting phase at closer to normal atmospheric temperatures; it's the "Holy Grail" of the topic.

Alternatively, quantum computers could benefit from being built in ways that don't rely on superconductivity, such as hopefully in silicon. Silicon computing is almost universally a semiconductor-based set of technologies, where its useful derives from the fact that there's virtually no overlap between conductance band and valence band. Superconductors, on the other hand, rely on Cooper pairs created by an attractive phonon interaction typically at very low temperatures. It would be hard to mistake a superconductor for a semi-conductor--they're basically very distinct phases of matter existing under totally different temperature and/or pressure conditions, but graphene (of course, damned graphene) might somehow bridge the gap, hypothetically.

In the beginning, the Quantum Computers were merely based on quantum particles: protons, electrons and et cetera. Slowly and gradually, particle(electrons) and anti-particles(holes) were also taken into consideration, whose combined form gave Fermions. Generally, it's quite impossible to make superposition between the particles and the anti-particles as they have opposite charges, however, at zero energy, those particles seem to be congruent as under;

$$\gamma(E) = \gamma^{\dagger}(-E)$$

These ideas are found to be implemented on the Topographic Quantum Computers which show as their topological properties do not change due to small but cumulative perturbations, this architecture is much more stable than those that make use of trapped quantum particles, such as the superconducting systems. However, errors induced by thermal fluctuations are still a problem for topological quantum systems. [4]

Of course, errors induced by thermal fluctuations are still a problem for topological quantum systems, but this can be circumvented by dramatically decreasing the temperature and separating the quasiparticles by a reasonable distance. [4]

The statistics of "braiding flux vortices" are "anyonic," but it's particle exchange statistics that are responsible for the entire Quantum Computer concept.

We get phase factors under "particle exchange." Because of this, in effect, all we care about are half-integer-rotation counts of one flux vortex around another. So, we can actually carry out the braiding at macroscopic distances, like with an electron microscope tip to drag one vortex around another at an arbitrarily large distance, even visible to the human eye.

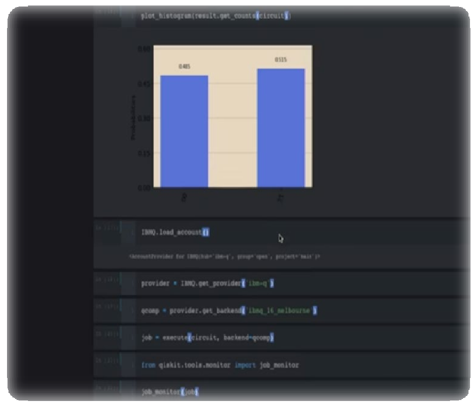
If the rotation is off an exact half-rotation by a tiny bit, we only get a tiny bit of error in the particle exchange statistics, and therefore only a tiny bit of noise in the qubit.

However, we see no reason why the radius of rotation couldn't be 10cm, for example, at least in theory, "macroscopic." It's easy to get close to an exact half-rotation count, that way.

V. EXPERIMENT

In the research process, an experiment using realquantum computer from ***IBM Quantum Experience***was done. The main motto of the experiment was to detect and predict the occurrence of errors in the present Quantum Computers using some statistical tools.

During the experiment, we made a Quantum program in 'Qiskit' (written in Python) and wrote code in 'Jupyter Notebook'. In the program, we built Quantum Register and Classical Registers and made a Quantum Circuit. To create an entanglement, we also made a Hadamard's Gate. Alongside, a two-qubit operation, called a Controlled X Gate (like logical IF), was also made.Then, we measured the qubits and took those measurements and stored in the classical bits. And we got the following results.This process was based on Abraham Asfaw's, a Qiskit Developer Advocate, guidance.



The experiment was performed on two devices. Firstly, on a simulated Classical Computer and finally on a real Quantum Computer. However, we found varying results.

In the simulated case, we got all the results on zero-zero (00) state and one-one (1-1) states which we can see in Figure(a). But, on a real Quantum Computer, we also got results on zero-one (0-1) and one-zero (1-0) states despite the fact that zero-zero (00) state and one-one (1-1) states had dominated the result, which we can observe in Figure(b). We encountered on zero-one (0-1) and one-zero (1-0) states in the real quantum computer due to some quantum errors, some of which are mentioned in the beginning of this paper. Nevertheless, we got a 100% accurate result on the simulated case because of the fact that the simulated one behaves like a perfect Quantum Computer.

Probability of Error on the above experiment= 0.049+0.046

= 0.095

= 9.5%

Probability of Correct Result = 1-0.095

= 90.5%

VI. CONCLUSIONS

We have examined the problems faced in the implementation of the Quantum Computers at the present scenario. Also, we presented plausible solutions for the same.

At present, the scientists at IBM, Microsoft, Google and et cetera are trying their best in the making of Quantum Computer. We hope the aforementioned points will be considered by the concerned authorities and make perfect Quantum Computers. Though it will take years in the making of a perfect quantum computer, we can still hope for Quantum Computers with optimum accuracy and efficiency.

ACKNOWLEDGMENT

I would like to thank Mr. Daniel Strano, the developer of "Qrack" - a high-performance quantum bit and gate simulator, for his guidance while writing this paper.

REFERENCES

[1] Edwin Pednault, John Gunnels & Dmitri Maslov, and Jay Gambetta, *“Quantum Supremacy”*, Blog, IBM, October 21, 2019
[2] Engineering and Physical sciences Research Council *"Grand challenges to Silicon Technology."* EPSRC(1989): 2-5
[3] Katherine McCormick, *“Decoherence Is a Problem for Quantum Computing, But ...”*, Blog, Scientific American, March 30, 2020
[4] Zhang, Hao, et al. *"Quantizedmajorana conductance."* Nature 556.7699 (2018): 74-79.

