Quantum Computers

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Abstract- *Quantum computers can bring an unimaginable change in the computing technology. Made of qubits, instead of binary bits, they hold many advantages over classical computers like energy efficiency, less time utilization, high speed (100 million times faster) and better security (un-hackable systems can be created). Though the system of qubits are complex and not easily handled, it is still not possible to create a quantum computer at industry level, but many companies have successfully invented some systems related to quantum computing. This concludes that the purpose is not impossible. When invented, the quantum computers will be ruling the world of computers.*

Keywords- Quantum Computers, Quantum Computing, Schrodinger's Cat, Qubits,Topological Qubits, Parallel Processing, Entanglement, un-hackable computer systems.

I. INTRODUCTION

In early 19th century, Charles Babbage started a new era of computers by inventing the first mechanical computer. Then, Richard Feynman, a physicist, intrigued a bizarre revolution in the era by urging the world to build a quantum computer.

Quantum computers, as the name suggests, use the concepts and theories of different branches of quantum physics and quantum mechanics.

The basis of invention of quantum computer lies in a thought experiment, the Schrodinger's Cat, in which a cat is theoretically both alive and dead at the same time. This is the unpredictable nature of quantum mechanics. Similar to this, the researchers and scientists made some ions to exist in two states simultaneously by creating an effect called entanglement. This, in itself, is challenging the very fabric of reality. [1]

II. HOW CAN A QUANTUM COMPUTER BE MADE?

2.1 0s, 1s and both

In our macroscopic world, everything is expected to be clear and distinct but at microscopic level, this is neither necessarily required nor is this possible. For example, electrons and photons, these tiny particles exhibit different states simultaneously. This fact provided the basis of qubits.

Unlike the classical computers that work on binary bits, 0s and 1s, the quantum computers work with particles of size less than that of an atom. These particles represent quantum bits, which are popularly known as qubits. The sequence of qubits consists of the 1 and 0 state along with the quantum superposition of these two states, providing different energy levels to the qubits. Such qubits are known as qudits. [2] [3]

2.2 Entanglement

Qubits create non-trivial correlated states of different number of qubits. These states are known as entangled states. And describing a system of several qubits with all the correlations between them using the ordinary classical information is known as entanglement. As the number of qubits in a system increase, increases the number of their correlations, that too, exponentially, which provides us a relation that if there are n numbers of qubits in a system, then the number of correlations between them is 2n. [4]

2.3 Topological Qubits

Scientists haven't yet found a simple way to control the complex systems of qubits. So building a computer with today's qubits is like a tall, narrow tower with the blocks; the more you add the less stable it becomes. Seeing these limitations Microsoft Inc. announced another solution to achieve the goal by building a more stable qubit, which it called topological qubit.

Qubits store the information in volatile states which are easily prone to be lost, like a sand painting, whereas the topological qubits store the information in a more stable form, like a knot in a thread, whatever happens to the thread, the knot remains intact.

It is believed that once a topological qubit is built, building a stable quantum computer on a large scale would become possible. [3]

III. QUANTUM COMPUTERS V/S CLASSICAL COMPUTERS

Considering an example of entanglement, if there exists a system of 200 qubits, to describe its 2200 correlations, numbers fall short, i.e., classical bits cannot even help to write the information contained in a few hundred qubits system. This limitation of classical systems gives a reason to think that a quantum computer can perform tasks that a classical computer can't. [5] [6]

3.1 Power Efficiency and Time Minimization

Qubits exhibit the unique behavior of the tiniest objects in the world. Quantum Mechanics allows qubits to store much more complex information than traditional bits so that each qubit added to the computer doubles its processing power, an exponential gain which is not possible with the classical computers. Also, when the qubits are made to work, they interact coherently which helps them solve multiple complex problems in a fraction of seconds whereas in classical computers, as the binary bits are stored separately, the same task requires much more time.

3.2 Parallel Processing

As qubits provide the ability to the quantum computers to store multiple data simultaneously, these systems can work in parallel unlike the classical machines that work serially. This parallel processing is known as quantum parallelism.

3.3 Redefined Security

With high speed processing quantum computers can bring vast differences in the field of encryption and cryptography. Quantum computers can beat the financial security in conventional computers. The present financial security systems are based on factoring large numbers which is nearly impossible to be cracked by the classical computers whereas quantum computers can crack the same in reasonable period of time. Plus, they will also be able to provide unbeatable security techniques, for which some algorithms have already been designed, like, Grover's algorithm for searching an unstructured database and Shor's algorithm for factoring large numbers.

3.4 Turning Point in AIs

300 qubits could map the entire universe. Quantum computers will be able to accelerate the rate of machine learning, exponentially, by reducing the time from years to seconds.

IV. ACHIEVEMENTS IN QUANTUM COMPUTING TILL DATE

4.1 In February, 2010 with the help of different quantum gates, digital combinational circuits like adders, subtractors were designed.

4.2 In September, 2011 researchers proved that quantum computers are possible to be made with the help of Von Neumann architecture.

4.3 In November, 2012 scientists of University of Science and Technology of China reported the first quantum teleportation from one macroscopic object to another.

4.4 In December, 2015 NASA displayed the world's first fully operational quantum computer, though only two of such computers have been made so far.

4.5 In August, 2016 the first reprogrammable quantum computer was built by the scientists of the University of Maryland.

4.6 In May, 2017 IBM built its most powerful universal quantum computing processors.

4.7 In November, 2017 the research team at the University of Sydney made a microwave circulator which is an important quantum computer part. This circulator is 1000 times smaller than a classical circulator.

4.8 In December, 2017 a preview version of a 'Quantum Development Kit' was released by Microsoft which includes a programming language, Q#. This language can write programs to run on emulated quantum co mputer. [6]

V. CONCLUSIONS

From reducing size of the machines to increasing the efficiency, quantum computers hold a lot many advantages. In fact, it can perform a certain task in hours and minutes, which takes years when performed on classical computers. But this is all theoretical. As the qubits have no fixed state, just like an electron, it is difficult to generate an output for a particular problem without any error. Multiple states of a single qubits, in spite of providing fascinating perks, make it difficult to handle their complexity. At some extent, researchers and scientists have reached the stage of developing some quantum computing parts and even some quantum computing systems. But establishing quantum computers like the way classical computers are still remains a dream. In addition, it is not certain that when creating a quantum computer becomes completely possible, it would still hold these many leads over classical computers because advancements in these is never slow. [7]

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