



INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

QUANTUM COMPUTING - AN APPROACH TO NEW COMPUTING TECHNOLOGY

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Abstract— Computers hold a great importance in today's era. It not only reduces human's efforts but also plays a great role in increasing the effectiveness in several places. To push the technology forward different has been devised to increase the performance of the computers. One such approach is Quantum Computing. Quantum computing has amalgamated two great scientific revolutions of the 20th Century which are Quantum Computers and Quantum Physics. Quantum physics reigns over the way nature behaves at the scale of atoms, electrons and protons. That is, it makes us understand how everything works. On the other hand, we have Computing machines that operate on "classical Boolean logic" percept. Quantum computing thus is a design of hardware and software that merges Boolean logic with quantum law of physics. This concept has provided us with a new line of scientific thought and approach. It is now no longer that the term "quantum" is associated with physicists. Computer Scientists have now made a way to move towards the law of physics. At the time when Quantum Computers would get started it would be able to solve large computation problems in a short amount of time. Classical computers that now require billions of days to process and analyze a complex problem would be solved in a few minutes/days by making use of quantum computers. Of course, Quantum computing resembles Classical Computing in the aspect that it too receives input and produces output. Thus, Quantum computing is all about how fast output could be generated as compared to classical techniques. This research paper gives an overview on Quantum Computing and its applications.

Keywords – Quantum, Boolean, classical computers, amalgamation, electrons, protons

1. Introduction

With the increase in advancement of research in Science and Technology scientists are now focusing on finding out different ways to increase the speed of computers that will match to the speed of light. As of 2022 actual quantum computers are yet to be designed but various levels of experiments are carried out that would work on quantum computers. Several ways are being tackled to solve large complex problems which are considered to be unsolvable by the classical computers. Quantum Computing hence stands as one of the important ways wherein we can increase the processing speed and solve large complex problems which would take billions of years by the classical computers to find the solution. Research in this area is being funded by the government. The term Quantum means "a smallest part of something, especially energy" whereas computing means "use of technology". Hence Quantum Computing means using computer technology in a manner that will apply quantum laws while processing the data. Atoms needed to represent a bit of memory have been decreasing. As per "Moore's law" the processing speed of computers doubles every eighteen months. Hence there would be a time when each bit of information has to be encoded by a system of subatomic size. Processing the data operations in quantum computing are performed by making the use of superposition which is one of the kinds of physical phenomena. Classical Computers would process the data using bits whereas quantum computing would be making use of qubits. Let us say, if we have a total of 11 seats available and we want to find out how many ways we can accommodate people, finding answers to such types of questions would take much time in classical computers whereas if we go with quantum computing it would be solved in a few milliseconds. Quantum computing will soon replace classical computers in the upcoming years.

Quantum mechanical properties used in Quantum Computing

Quantum interference

A sub product of superposition is termed as Quantum Interference. It measures the state or a set of states for a qubit. Due to the quality of superposition a qubit could hold a value zero or a value one or both the values at the same time. Qubits have a value of zero or one depending on their arrangement. This is determined by quantum interference.

Quantum decoherence

A concept of quantum mechanics that hinders the progress of quantum computing is termed as Quantum decoherence. When we try to observe a quantum particle, it may collapse the superposition state. This is decoherence. Quantum decoherence makes it difficult to preserve superposition for a long time to perform calculations.

Quantum Entanglement

This allows quantum particles to be entangled. Once the particles are entangled they will be considered as a single system. When we apply operation to one quantum particle the other one in the system would automatically be affected.

Qubits

Every organization dealing with quantum computers seems to be aware of the word Qubits. Qubits are the most basic unit of information of quantum computers. This information could be useful for computations and communications. We can carry a handful of bits on a hard drive but sustaining their state is quite difficult.

LITERATURE SURVEY

This paper would give a brief overview on what's happening in the field. Quantum computers was proposed in the 1980s by Richard Feynman and Yuri Manin. Scientists previously constructed a model to demonstrate exactly how quantum computers would be working in the near future for the problems that are considered as unsolvable. They further did the analysis where they proved that there are some problems which classical computers would not be able to solve. In fact if classical computers were given the problems to solve they would take approx. billions of years to solve. As solutions on classical computers require exponential growing time quantum computations can be done in polynomial time. In 1985 showed that any physical process, in principle, could be modelled perfectly by a quantum computer. Hence quantum computers would definitely have capabilities far beyond classical computers. Consequent efforts have been made since the 1980s when the idea of quantum computers was proposed to find interesting applications. Peter Shor In 1994 a method was set out by Shor for using quantum computers to crack an important problem in number theory which was namely factorisation. He showed how quantum computers would be helpful to find factorization of large integers. This factorized value would further be used for encryptions. With this important development, quantum computing has taken a transformation from just academic research to interest all over the world.

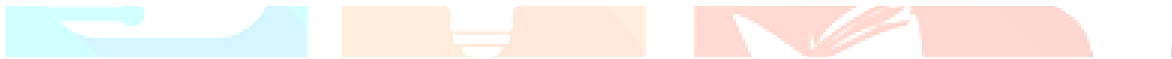
Public Key Cryptography –

Public key Cryptography – A Traditional encryption method that is used to protect data, transactions, processes, and many more things. This process requires a pair of a public key and a private key that enables communicating parties to encrypt and decrypt data to protect it from unauthorized access. After the encryption process is applied to the data decoding it takes a very long time. This approach is very effective in the current world where classical computers are used.

Quantum computers are quite powerful than the classical ones. They would take approx. few milliseconds to decode the key. In the upcoming decade quantum computers are expected to find the vulnerabilities in this type of algorithm. And finding vulnerabilities would just require a polynomial time of a few milliseconds.

Objectives of Quantum Computing Technology

1. The technology promises the way to find factorization of large integers. This way would be a primary motivator for advancement in the field of quantum computing.
2. An array of business operations can be improved and enhanced due to quantum computing as multiple possible solutions for one given problem statement simultaneously.
3. The technology would deliver tremendous speed-ups for specific types of problems.
4. An immense help for problems related to optimization will be provided by quantum computers.
5. As the technology tries to make use of qubits another key aspect to use this technique is to secure our data.
6. Additional applications in various domains such as military applications, finance sectors, banking sectors and many more would rely on the technology of quantum computing for the purpose of data security and to increase speed of the process.



Applications of Quantum Computing

Cyber security

Quantum computing could play a vital role in future need for security in cyber technology. A fully functional quantum computer could be used to break all the existing algorithms that are present in today's date and are working with classical computers. This is a part of concern and therefore work is going on to create quantum proof cryptography.

Database

Quantum computing techniques could also be used to save a massive amount of data generated per day in the database. This could definitely be done by combining concepts of big data analytics, machine learning and quantum technology.

Weather Forecasting

In the field of meteorology vast amounts of data are to be taken into consideration for predicting the forecast. Sometimes even supercomputers fail to predict the correct information with respect to weather. However quantum computing could boost up the same funda along with giving the accurate information.

Network coverage

To get the best coverage network for a mobile phone is still one of the ongoing challenges for many of the network providers. With the use of Quantum technology one can easily find a spot of the optimal satellite coverage position.

Traffic flow optimization


With the help of quantum computing, one could easily find the optimal route thus optimizing the traffic flow and hence solving the concept of traffic congestion.

Research Methodology

The first goal under this project is to design various quantum algorithms by exploring a variety of new ideas such as quantum walks, qubits, teleportation, quantum equations etc.

The second goal is to understand the limitations of classical computers and to work on areas where classical computers can fail. Under this goal research work on identifying problems that are even difficult to solve by quantum computers are to be found. Security aspects under quantum computers will be yet another area to implement.

The next goal relies on researching different applications of quantum computing. Where and how they can be used in different sections of the real-life field. Connections between real world and quantum computing are to be found under this goal. The mathematical models from quantum computing algorithms can be used to solve classical problems in real life. Study of behavior of atoms can be found in quantum computing techniques.



Quantum computer will be connected to the classical computer and will operate on a processor akin to classical computers. A classical computer will help to perform the quantum operations and will also provide different methods for fault tolerance. Quantum computers will then take all sorts of input in the form of qubit and will provide the final result after processing. The front end in this module will be a software that takes quantum language and backend will be resources such as emulators to demonstrate the processing of bits.

Conclusion

Quantum computers have the ability to change the face of computing by making certain types of changes under classical computers. Although no quantum computers have been yet designed that could solve a problem which classical computers cannot but still the work is under progress. A few start-up companies are focusing on this concept and trying to make progress. They are also trying to provide fundings in different research areas associated with quantum computing. Additionally simulators are also contributing to the field to a large extent. The progress mentioned would definitely make the upcoming researchers gain a lot of insights about quantum computing.

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