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Applications of Social Network using Quantum Computing

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Abstract- *Social network handle large volume of data day by day as there are thousands of new entrants in the social sites. To handle those data and computing efficiently and fast, we require a fast computing device rather than classical computing which is unable to do this kind of complex computing in the days to come. As quantum computing has the capable of complex computing with ease and efficient, the social network analysis seems to be appropriate application for such type of environment. The paper starts with brief discussion on basic issues related to quantum computing and then proposes a scenario for implementing social networking analysis through quantum computing environment.*

Keywords: bit, qubit, classical computing, quantum computing, social network

I INTRODUCTION

The creation of the first computer in 1941 by the Germany based engineer KonradZuse was clearly inspired from the early ideas of Charles Babbage, who is also known as the father of Computer. The huge bulky devices weighing about 30 ton equipped with some 18000 vacuum tubes and 500 miles of wiring can be considered as the ancestors of today's high speed computer and processing devices. With the due passage of time, technologies have advanced drastically leading to the emergence of more compact technologically superior computers thereby increasing the performance in performing an assigned task with ease. Talking about the task of earlier days to these days, it is almost same i.e. to manipulate and interpret an encoding of binary bits into a useful computational result.

A classical computer has a memory made up of bits, i.e. 1 or 0 which are used for all the computational purposes. In terms of physical representation, each can be physically realized through a macroscopic physical system, such as the magnetization on a hard disk or the charge on a capacitor.

If a document has n-characters to be stored on the hard disk of a typical computer can be described as a string of eight numbers of 0s and 1s. The classical computer obeys the laws of classical physics. Whereas the quantum computer obeys the laws of quantum-mechanical phenomea. The data operations take place with the help of its superposition and entanglement.

A quantum computer is a device that harnesses physical phenomenon unique to quantum mechanics (especially quantum interference) to realize a fundamentally new mode of information processing. Quantum computing is a quantum computational operations are executed on a very small number of qubits (quantum bits).

II QUANTUM COMPUTER

A classical computer obeys the well understood laws of classical physics, where as a quantum computer is a computation system that makes direct use of quantum-mechanical phenomena, such as superposition and entanglement, to perform operations on data. A

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quantum computer [2, 3, 8] is a device that harnesses physical phenomenon unique to quantum mechanics (especially quantum interference) to realize a fundamentally new mode of information processing. Quantum computers are different from digital computers based on transistors. Whereas digital computers require data to be encoded into binary digits (bits), each of which is always in one of two definite states either 0 or 1. Quantum computation uses qubits (quantum bits), which can be in superposition's of states. In a quantum computer, the fundamental unit of information is called a quantum bit or qubit, which is not binary but quaternary in nature. This qubit property arises as a direct consequence of its adherence to the laws of quantum mechanics which differ radically from the laws of classical physics. A qubit can exist not only in a state corresponding to the logical state 0 or 1 as in a classical bit, but also in states corresponding to a blend or superposition of these classical states. In other words, a qubit can exist as a 0, a 1, or simultaneously as both 0 and 1, with a numerical coefficient representing the probability for each state, which is shown in "Figure 1".

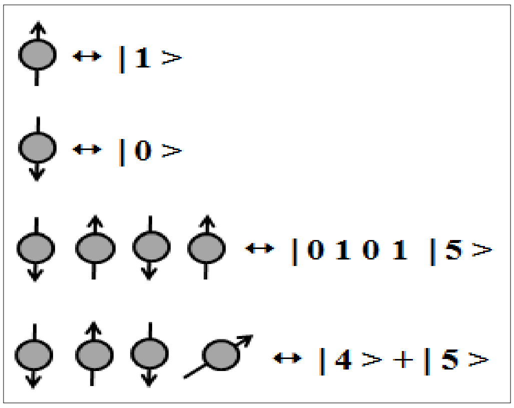

Figure 1.Qubits can be in a superposition all the classically allowed states [1]

This concept sounds exactly contrary to what our common sense would suggest as our real world is governed by the concepts of classical physics. But quantum computers are the one that are more concerned with the atomic level of the concepts.
"Figure 2" explains everything in a more elaborate manner. Here a light source emits a photon along a path towards a half-silvered mirror. This mirror splits the light, reflecting half vertically toward detector **A** and transmitting half toward detector **B**. A photon, however, is a single quantized packet of light and cannot be split, so it is detected with equal probability at either detector **A** or **B**.

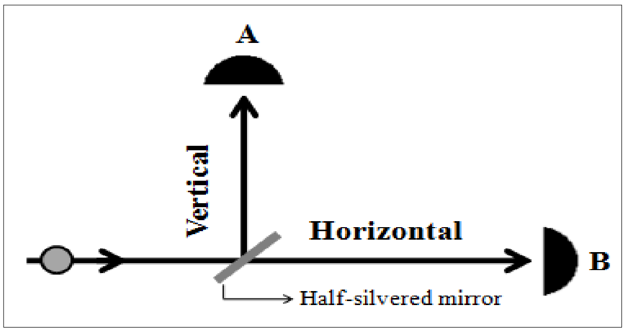

Figure 2. Photon movement in either of one direction [1]

The photon randomly leaves the mirror in either the vertical or horizontal direction. However, quantum mechanics predicts that the photon actually travels both paths simultaneously. This is more clearly demonstrated in "Figure 3".

In "Figure 2", where a photon is fired at a half-silvered mirror, it can be shown that the photon does not actually split by verifying that if one detector registers a signal, then no other detector does. With this piece of information, one might think that any given photon travels vertically or horizontally, randomly choosing between the two paths. However, quantum mechanics predicts that the photon actually travels both paths simultaneously, collapsing down to one path only upon measurement. This effect is known as single-particle interference, which is shown in "Figure 3".

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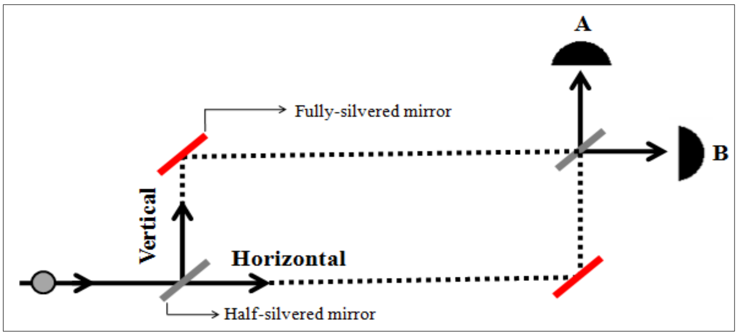

Figure 3. Photon movement in both of the directions [1]

In “Figure 3” the photon first encounters a half-silvered mirror, then a fully silvered mirror, and finally another half-silvered mirror before reaching a detector A or B, where each half-silvered mirror introduces the probability of the photon traveling down one path or the other. Once a photon strikes the mirror along either of the two paths after the first beam splitter, the arrangement is identical to that in “Figure 2”, and so one might hypothesize that the photon will reach either detector A or detector B with equal probability. However, experiment shows that in reality this arrangement causes detector A to register 100% of the time, and never at detector B. And that is a big question to answer. If a single photon travels vertically and strikes the mirror, then, by comparison to the experiment in “Figure 2”, there should be an equal probability that the photon will strike either detector A or detector B. The same thing happens for a photon traveling down the horizontal path. However, the actual result is drastically different.

The only conceivable conclusion is therefore that the photon somehow traveled both paths simultaneously; creating interference at the point of intersection that destroyed the possibility of the signal reaching detector B. This is known as quantum interference and results from the superposition of the possible photon states, or potential paths. When only a single photon is emitted, it appears as though an identical photon exists and travels the 'path not taken', only detectable by the interference it causes with the original photon when their paths come together again. If, for example, either of the paths are blocked with an absorbing screen, then detector B begins registering hits again just as in “Figure 2”. This unique characteristic, among others, makes the current research in quantum computing not merely a continuation of today's idea of a computer, but rather an entirely new branch of thought. And it is because quantum computers harness these special characteristics that give them the potential to be incredibly powerful computational devices.

III QUANTUM COMPUTING: POTENTIAL AND POWER

A classical computer has a memory made up of bits, where each bit represents either a one (1) or a zero (0). A quantum computer [2, 3, 8] maintains a sequence of qubits. A single qubit can represent a one, a zero, or any quantum superposition of these two qubit states; moreover, a pair of qubits can be in any quantum superposition of 4 states, and three qubits in any superposition of 8. In general, a quantum computer with n qubits can be in an arbitrary superposition of up to 2n different states simultaneously; this compares to a normal computer that can only be in one of these 2n states at any one time. In other words, classical computers have their information encoded in a series of bits, and these bits are manipulated via Boolean logic gates arranged in succession to produce an end result. Similarly, a quantum computer manipulates qubits by executing a series of quantum gates, each a unitary transformation acting on a single qubit or pair of qubits. A quantum computer can perform a complicated unitary transformation to a set of qubits in some initial state by applying these gates in succession.
The qubitscan then be measured, with this measurement serving as the final computational result. We can conclude that a classical computer can simulatethe functioning of a quantum computer by taking into account the similarity that both possess in the end result calculation procedure.

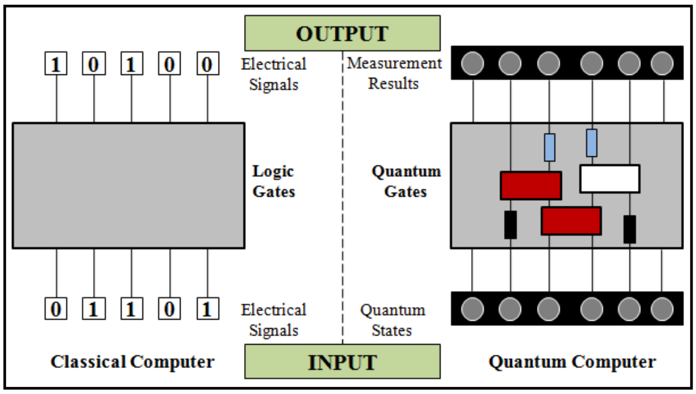

Figure 4. Gate comparison between Classical and Quantum Computer [1]

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Then the question that arises is that, if the traditional computer can do everything that a quantum computer can do, and then what lead to the evolution of the latter one. And the answer that follows is that although a classical computer can theoretically simulate a quantum computer, it is incredibly inefficient, so much so that a classical computer is effectively incapable of performing many tasks that a quantum computer could perform with ease. The simulation of a quantum computer on a classical one is a computationally hard problem because the correlations among quantum bits are qualitatively different from correlations among classical bits, as first explained by John Bell.

The first one to recognize the potential in quantum superposition for solving such problems much faster was Richard Feynman . For example, a system of 500 qubits, which is impossible to simulate classically, represents a quantum superposition of as many as 2500 states. Each state would be classically equivalent to a single list of 500 1's and 0's. Any quantum operation on that system for example a particular pulse of radio waves, whose action might be to execute a controlled NOT operation on the 100th and 101st qubits would simultaneously operate on all 2500 states. Thus in a time period of like 1 second , a quantum operation could compute not just on one machine state, as serial computers do, but on 2500 machine states at once.

Peter Shor, who was a researcher and computer scientist at AT&T's Bell Laboratories in New Jersey, provided such an application by devising the first quantum computer algorithm. Integer factorization is believed to be computationally infeasible with an ordinary computer for large integers if they are the product of few prime numbers (e.g., products of two 300-digit primes). By comparison, a quantum computer could efficiently solve this problem using Shor's algorithm to find its factors. This ability would allow a quantum computer to decrypt many of the cryptographic systems in use today, in the sense that there would be a polynomial time (in the number of digits of the integer) algorithm for solving the problem. In particular, most of the popular public key ciphers are based on the difficulty of factoring integers or the discrete logarithm problem, which can both be solved by Shor's algorithm. Shor's algorithm harnesses the power of quantum superposition to rapidly factor very large numbers (on the order ~10200 digits and greater) in a matter of seconds. The premier application of a quantum computer capable of implementing this algorithm lies in the field of encryption, where one common (and best) encryption code, known as RSA, relies heavily on the difficulty of factoring very large composite numbers into their primes. A computer which can do this easily is naturally of great interest to numerous government agencies that use RSA.
Encryption, however, is only one application of a quantum computer. In addition, Shor has put together a toolbox of mathematical operations that can only be performed on a quantum computer, many of which he used in his factorization algorithm. Furthermore, Feynman asserted that a quantum computer could function as a kind of simulator for quantum physics, potentially opening the doors to many discoveries in the field. Today the functionality of the quantum computers is just a theoretical concept, but with the full-fledged advent of it will lead to the inventions of more new and interesting applications in the near future.

IV HISTORY OF QUANTUM COMPUTING [9]

The idea of a computational device based on quantum mechanics was first explored in the 1970's and early 1980's by physicists and computer scientists such as Charles H. Bennett of the IBM Thomas J. Watson Research Center, Paul A. Benioff of Argonne National Laboratory in Illinois, David Deutsch of the University of Oxford, and the late Richard P. Feynman of the California Institute of Technology (Caltech). The idea emerged when scientists were pondering the fundamental limits of computation. They understood that if technology continued to abide by Moore's Law, then the continually shrinking size of circuitry packed onto silicon chips would eventually reach a point where individual elements would be no larger than a few atoms. Here a problem arose because at the atomic scale the physical laws that govern the behavior and properties of the circuit are inherently quantum mechanical in nature, not classical. Then raised the question of whether a new kind of computer could be devised based on the principles of quantum physics.

Feynman was among the first to attempt to provide an answer to this question by producing an abstract model in 1982 that showed how a quantum system could be used to do computations. He also explained how such a machine would be able to act as a simulator for quantum physics. In other words, a physicist would have the ability to carry out experiments in quantum physics inside a quantum mechanical computer.

Later, in 1985, Deutsch realized that Feynman's assertion could eventually lead to a general purpose quantum computer and published a crucial theoretical paper showing that any physical process, in principle, could be modeled perfectly by a quantum computer. Thus, a quantum computer would have capabilities far beyond those of any traditional classical computer. After Deutsch published this paper, the search began to find interesting applications for such a machine.

Unfortunately, all that could be found were a few rather contrived mathematical problems, until Shor circulated in 1994 a preprint of a paper in which he set out a method for using quantum computers to crack an important problem in number theory, namely factorization. He showed how an ensemble of mathematical operations, designed specifically for a quantum computer, could be organized to enable a such a machine to factor huge numbers extremely rapidly, much faster than is possible on conventional computers. With this breakthrough, quantum computing transformed from a mere academic curiosity directly into a national and world interest.

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V RESEARCH AND OBSTACLES [2, 3]

Significant advancements are made in the field of quantum information processing since its conception, including the building of two-qubit and three-qubit quantum computers capable of some simple arithmetic and data sorting. But there are still a certain number of factors that hinder in the advancement of this modern day world technology in competing with the then digital computers. Among these difficulties, error correction, decoherence, and hardware architecture are probably the most important. Errors are the ones that need to be corrected but what the kind of errors that is needed to primarily find out. So errors that need to be corrected out first are the ones that arise as a direct result of decoherence, or the tendency of a quantum computer to decay from a given quantum state into an incoherent state as it interacts, or entangles, with the state of the environment. These interactions between the environment and qubits are sort of impossible to avoid, and thus induce the breakdown of information stored in the quantum computer, and thus errors in computation. Before any quantum computer will be capable of solving hard problems, research must devise a way to maintain decoherence and other potential sources of error at an acceptable level. In the year 1995 the theoretical concept of error correction in quantum computation was first proposed and ever since then the practical developments in the same has been successfully carried out.

Small scale quantum computers have been built and the prospects of large quantum computers are in the verge of development. Probably the most important idea in this field is the application of error correction in phase coherence as a means to extract information and reduce error in a quantum system without actually measuring that system.

In 1998, researches at Los Alamos National Laboratory and MIT led by Raymond Laflamme managed to spread a single bit of quantum information (qubit) across three nuclear spins in each molecule of a liquid solution of alanine or trichloroethylene molecules. They accomplished this using the techniques of nuclear magnetic resonance (NMR). The experiment was significant because spreading out the information actually made it harder to corrupt. According to the theory of Quantum mechanics, the direct measure of the state of a qubit invariably destroys the superposition of states in which it exists, forcing it to become either a 0 or 1. The technique of spreading out the information allows researchers to utilize the property of entanglement to study the interactions between states as an indirect method for analyzing the quantum information. Rather than a direct measurement, the group compared the spins to see if any new differences arose between them without learning the information itself. This technique gave them the ability to detect and fix errors in a qubit'sphase coherence, and thus maintain a higher level of coherence in the quantum system. This milestone has provided argument against skeptics, and hope for believers. Currently, research in quantum error correction continues with groups at Caltech (Preskill, Kimble), Microsoft, Los Alamos, and elsewhere.

At this point, only a few of the benefits of quantum computation and quantum computers are readily obvious, but before more possibilities are uncovered theory must be put to the test. In order to do this, devices capable of quantum computation must be constructed. Quantum computing hardware is, however, still in its infancy. As a result of several significant experiments, nuclear magnetic resonance (NMR) has become themostpopular component in quantum hardware architecture. Only withinthe pastyear,a group from Los Alamos National Laboratoryand MITconstructed the first experimental demonstrations of a quantum computer using nuclear magnetic resonance (NMR) technology. Currently, research is underway to discover methods for battling the destructive effects of decoherence, to develop optimal hardware architecture for designing and building a quantum computer, and to further uncover quantum algorithms to utilize the immense computing power available in these devices. Naturally this pursuit is intimately related to quantum error correction codes and quantum algorithms, so a number of groups are doing simultaneous research in a number of these fields. To date, designs have involved ion traps, cavity quantum electrodynamics (QED), and NMR. Though these devices have had mild success in performing interesting experiments, the technologies each have serious limitations. Ion trap computers are limited in speed by the vibration frequency of the modes in the trap. NMR devices have an exponential attenuation of signal to noise as the number of qubits in a system increases. Cavity QED is slightly more promising; however, it still has only been demonstrated with a few qubits. Seth Lloyd of MIT is currently a prominent researcher in quantum hardware. The future of quantum computer hardware architecture is likely to be very different from what we know today; however, the current research has helped to provide insight as to what obstacles the future will hold for these devices.

VI APPLICATIONS OF SOCIAL NETWORKING

In the arena of computation and processing of data in many applications, data structure and graphs are becoming increasingly important in modeling sophisticated structures and the process of their interactions. In many cases, Graph theoretic representation of social network attributes for knowledge extraction seems to be suitable in terms of reducing complexities [4]. Further, in this direction, mining frequent sub-graph patterns for further characterization, discrimination, classification, and cluster analysis becomes an important task [7]. Graph representation that link many nodes together through respective edges, is used to model different kinds of networks such as telecommunication networks, computer networks, web and special community networks and so on [5, 6]. When such networks have been studied elaborately in the context of social networks; their analysis is known as social network analysis. Further, the processing becomes complex when the social network consisting of information in form of a relational database such that objects are semantically linked across multiple relations. Mining of such a relational database often requires mining across multiple interconnected relations, which is complex and demands for better computation facilities in terms of hardware and compatible software for reducing time complexities and increase accuracy.

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As the social networking data is exponentially increasing with the use of network by thousands of new users daily soon the size of data will be so huge that the classical computation facilities will unable to compute them with ease and speed in acceptable time. As earlier discussed, such situation can be handled with ease and efficient with fast computing devices which we can propose here under the concept of quantum computing. As this quantum computing is motivated as much by trying to clarify the mysterious nature of quantum physics as by trying to create novel and super powerful computers. Thus happening of it will become easy for computing and processing very large volume of data in large social network with efficient and accuracy. Apart from social network analysis, many other scientific and commercial applications need patterns that are complicated than frequent item-sets and sequential patterns. Such sophisticated patterns go beyond sets and sequences, towards tree, lattices, graphs, networks, and other complex structures, will find quantum computing environment as a suitable platform from execution.

VII FUTURE WORK

Today the theory of quantum computers and quantum information are at its developing phase. All the obstacles that can affect the growth of quantum computers are dealt with, so that the high speed computations which the quantum computer performs with ease are recognized as well as made popular worldwide. Finding out of errors and thereby devising out mechanisms for correcting the same have gained importance lately that eventually lead to the building up of more robust computers. Hardware's utilized in the building of quantum computers are simplified to a significant extent but still they need to be more developed for computing on some of the complex algorithms like Shor's algorithm and other quantum algorithms. It will not be wrong for us to say that in the near future a day will definitely come when the digital computers will be soon replaced by the fastest quantum computers.

VIII CONCLUSIONS

The basic idea of quantum computing has derived from basic principle of quantum mechanics. This paper gives an overview of quantum computing. It is obvious that quantum computing will be a far better choice than traditional computing devices for complex and large data compilation with time constrains. Hence, an application having huge data set with a complex mapping in between the data will be an appropriate example for being getting executed in quantum computing environment. Social network handle enormous volume of data and with passing of each day thousands of new entrants are joining the social sites, increasing the size of data. To handle data of such size efficiently and fast, we have proposed the use of quantum computing for complex computing with time limitation. Initial part of the paper highlights issues related to quantum computing and then it proposes a scenario for implementing social networking analysis through quantum computing environment with appropriate advantages.

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