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PROPOSAL FOR ESTIMATING THE IMPACT OF QUANTUM COMPUTATION ON ENVIRONMENTAL EVALUATION

Mazhar Mahmoud Hefnawi
Department of Siting and Environment
Nuclear and Radiological Regulatory Authority,
Cairo, Egypt

Abstract— **Environmental evaluation is performed through three primary scientific tools which are (I) direct field observations; (ii) laboratory scale tests and physical modeling studies; and, (iii) mathematical modeling. Now days both of physical modeling and mathematical modeling are performed by computer programs. For some cases these programs takes several days or may be several weeks to accomplish the required modeling. These programs are working according to a classical computation via classical computer. If these programs are working according to a quantum computation via quantum computer then they will have significant advantage in terms of speed over the classical computation. Quantum computation also significantly speeds up the database search algorithm, which is important in computer science because it comes as a subroutine in many important algorithms. Quantum database search of Grover achieves the task of finding the target element in an unsorted database in a time much faster than the classical computer. In this work we review the quantum computation, estimate the impact of quantum computation on environmental evaluation. The estimated impact shows speeding up the environmental evaluation by about hundreds times then classical computation.**

Keywords— **Quantum computation, Environmental evaluation, Superposition**

I. INTRODUCTION

Since more than one century rules of classical physics were put to expect and explain the behavior of things which their sizes are bigger than things their sizes are equal or below the atomic level. But these rules can’t expect the behavior of things which their sizes are equal or below the atomic level. Therefore the new rules related to quantum physics science were put to expect and explain the behavior of these things. In the quantum physics, or things their sizes are at the atomic level objects can exist in what is called a superposition of states: A hypothetical atomic-level light bulb could simultaneously be both on and off. This strange feature has important ramifications for computing [1].

The smallest unit of information in classical mechanics – and, therefore, classical computers – is the bit, which can hold a value of either 0 or 1, but never both at the same time. As a result, each bit can hold just one piece of information. Such bits, which can be represented as electrical impulses, changes in magnetic fields, or even a physical on-off switch, form the basis for all calculation, storage and communication in today’s computers and information networks [2].

Qubits – quantum bits – are the quantum equivalent of classical bits. One fundamental difference is that, due to superposition, qubits can simultaneously hold values of both 0 and 1 in the same time. Physical realizations of qubits must inherently be at an atomic scale: for example, in the spin of an electron or the polarization of a photon. Another difference is that classical bits can be operated on independently of each other: Flipping a bit in one location has no effect on bits in other locations. Qubits, however, can be set up using a quantum mechanical property called entanglement so that they are dependent on each other even when they are far apart. This means that operations performed on one qubit by a quantum computer can affect multiple other qubits simultaneously. This property akin (to, but not the same as, parallel processing) can make quantum computation much faster than in classical systems.

Now days Large scale quantum computers that is, quantum computers with hundreds of qubits has been exist but until now it is not available for commercial purpose because the challenging to build because they require operations and measurements to be done on an atomic scale via superconductor material which require cooling system to about -273 degree. Therefore the cost for quantum computer is very high with relative to classical computer [3].

II. HISTORY OF QUANTUM COMPUTATIO

In 1980, Paul Benioff, was the first to propose a computer which operated under quantum mechanical principles. The next year, Richard Feynman, proved it was impossible to simulate quantum systems on a classical computer. Feynman did propose how a quantum computer might be able to simulate any quantum system, including the physical world.

His concept borrowed from Benioff's quantum Turing computer.

In 1985, David Deutsch, a published a paper describing the world's first universal quantum computer. He showed how such a quantum machine could reproduce any realizable physical system. He was the first to set down the mathematical concepts of a quantum Turing machine, one which could model a quantum system.

In 1994 Peter Shor proposed a method for factorizing large integers. This had serious implications for cryptography, which relies on this operation being hard to keep codes secure. Shor's algorithm searched for periodicities in long integers - sequences of repeated digits. It uses the quantum principles of superposition to scour for periodicities in the blindingly fast time of a few minutes. To perform this same computation on a classical computer would take longer than the age of the Universe.

In 1995 Christopher Monroe and David Wineland of demonstrate the first quantum logic gate, the C-NOT gate.

In 1996 Lov Grover, used quantum mechanics to solve an old problem: search for a single target item in an unsorted database, i.e., the elements of the database are not arranged in any specific order, If N is the number of queries undertaken, then on wrest case a classical computer would need N queries to match each target record. Grover's algorithm uses the theory of quantum superposition to reduce the number of queries to $\sqrt{N}$, significantly faster. This algorithm boosted interest in building quantum computers by revealing yet another use for them.

In 1998 Oxford researchers used a working 2-qubit NMR machine to solve simple computer problems twice as fast as a classical computer. A 3-qubit NMR quantum computer followed later that year. NMR stands for Nuclear Magnetic Resonance, and is often used in hospital scanning machines.

In 2000, the first working 5-qubit NMR computer was put through its paces at the Technical University of Munich. Shortly after, the Los Alamos National Laboratory surpassed this feat with a working 7-qubit NMR quantum computer.

In 2001 is Shor's algorithm was first demonstrated. A team at the IBM Almaden Research Center in California succeeded in factorizing the integer 15 into 5 and 3. They used a thimbleful of a bespoke liquid containing billions of molecules. The molecules were constructed from five fluoride and two carbon atoms, each with their own nuclear spin state. The molecules worked as a 7-qubit quantum computer when pulsed with electromagnetic waves and monitored using NMR.

In 2006, scientists at the Institute for Quantum Computing and Perimeter Institute for Theoretical Physics presented a new operational standard by controlling a 12-qubit quantum system with only minimal decoherence. NMR quantum information processors were used to decode the computation. These hitherto unattained levels of quantum control led to the hope that larger quantum computers might one day evolve. At The same year, Bonn researchers took a step closer to the building of a quantum gate, the quantum representation of a mathematical rule. By using 'laser tweezers' they succeeded in lining up seven cesium atoms in a row, all at precisely the same distance from each other. Also at the same year, researchers at the University of Arkansas created molecules of quantum dot pairs. These have great potential for quantum computers, especially if more complex molecules can be created and At the University of Camerino, scientists developed a theory for entangling macroscopic objects. Their experiment employed lasers and mirrors. The results could one day lead to quantum computers operating on a macroscopic, i.e., visible, scale.

2007 saw the first use of Deutsch's algorithm in a cluster state quantum computer. Belfast and Vienna researchers studied the superposed interaction of four quantum encoded photons. Later the same year, a company called D-Wave Systems claimed to have built the first working 28-qubit quantum computer. It was demonstrated on November 12, using a chip made at the NASA Jet Propulsion Laboratory in California. They raised the bar the following year by claiming to have produced a 128-qubit computer chip. Many regard their claims as controversial, because D-Wave use methods that are counter to using quantum logic gates.

In 2011, D-Wave Systems developed quantum annealing. Shortly after, they introduced their adiabatic quantum computer, D-Wave One. This was the world's first commercially available quantum computer system, priced at $10,000,000. Quantum annealing is a process where sequences of coupled qubits are set up to find their lowest energy state. Shunning the much faster Shor's algorithm, D-Wave One instead uses a special adiabatic algorithm to solve problems.

In 2012, a group of Chinese physicists were able to use adiabatic quantum computing to find the factors of the integer 143, using only four qubits. The previous quantum factorization best was 21, achieved in 2012 but by using Shor's algorithm.

In 2012 D-Wave Systems brought out their 512-qubit quantum computer, called Vesuvius. Bought by Google, it was installed at NASA's Ames Research Center.

In 2013, D-Wave Systems published a report comparing the speed of a quantum computer with a high-end PC. The quantum computer ran an optimization algorithm 3,600 times faster than the desktop PC. London's Institute of Physics produced evidence that D-Wave chips did indeed act in a quantum manner.

In 2015, D-Wave Systems unveiled their 1,152-qubit D-Wave 2X quantum computer.

At the beginning of 2017, they surpassed this with the D-Wave 2000Q, fitted with 2,048 qubits, and sold to Temporal Defense Systems. This achievement continues their record of doubling the number of qubits on their quantum processors every two years. The more qubits, the more complex are the problems that can be solved.

Recent advances have brought the prospect of a first general-purpose quantum computer much closer. One innovation being explored is to use nitrogen vacancy doped nano diamonds as qubits. Diamond's big advantage is that qubits manufactured from it are relatively stable at room temperature. Getting rid of the need for bulky cryogenic superconducting elements would be a major step in bringing a quantum computer to market [4].

III. A BRIEF INTRODUCTION TO QUANTUM COMPUTATION

Classical bit which represents the smallest storage unit in classical computer can be prepared in one or two different states representing 0 or 1 .In Quantum computation qubit is the smallest storage unit in quantum computer in one or two or three different states representing 0 or 1 or 01 at the same time because they exit in superposition state. Table 1 shows the difference between one classical bit and one qubit and also register contains 3 bits and register contains 3 qubits. From table 1 it is clear that n bits can store one of 2n numbers at any time while n qubits can store all 2n numbers at once. This means that adding qubits can with superposition state increase storage exponentially and can do operations like parallel computation. Figure 1 shows how eight qubits at superposition state increase storage exponentially to 256 bits. One math operation on 2n numbers encoded with n bits requires 2n steps or 2n parallel processors. The same operation on 2n numbers encoded by n qubits takes 1 step. This makes problems in which are solved in years by classical computer can be solved in minutes by quantum computers.

For example from the previous section Shor (1999) [8] proposed a quantum method for factorizing large integers in O((log N)2(log log N)(log log log N)) steps where N is the number of input bits. This is substantially faster than the most efficient known classical factoring algorithm, the general number field sieve, which works about

$$O(e^{1.9\,(\log N)^{\frac{1}{3}}(\log\log N)^{\frac{2}{3}}})\ \text{Steps.}$$

Figure 2 shows the huge difference between Shore algorithm and the most efficient known classical factoring algorithm. From this figure it is clear that shore algorithm or quantum algorithm can factors a large integer which is content in 10 e+11 bit or have 210e+11 digits in about five hour while best classical factoring algorithm factors this number in more than one year and half.

Another important example from the previous section Grover (1996) [9], used quantum mechanics to solve an old problem: search for a single target item in an unsorted database, i.e., the elements of the database are not arranged in any specific order, If N is the number of queries undertaken, then classical computer would need O (N) queries to match each target record. Grover's algorithm uses the theory of quantum superposition to reduce the number of queries to O ($\sqrt{N}$) significantly faster [5]. As shown in figure 3.

Table -1 One classical bit and one Qbit and also register of 3 bits and register of 3 Qubits

Possible values for 1 classical bit	Possible values for 1 Qubit
0	0
1	1
	01 at the same time in superpostion state
Possible values for 3 classical bits	**Possible values for 3 Qubits**
000	000
001	001
010	010
011	011
100	100
101	101
110	110
111	111
	000,001.010,011,,100,101,110,111 at the same time in superpostion state

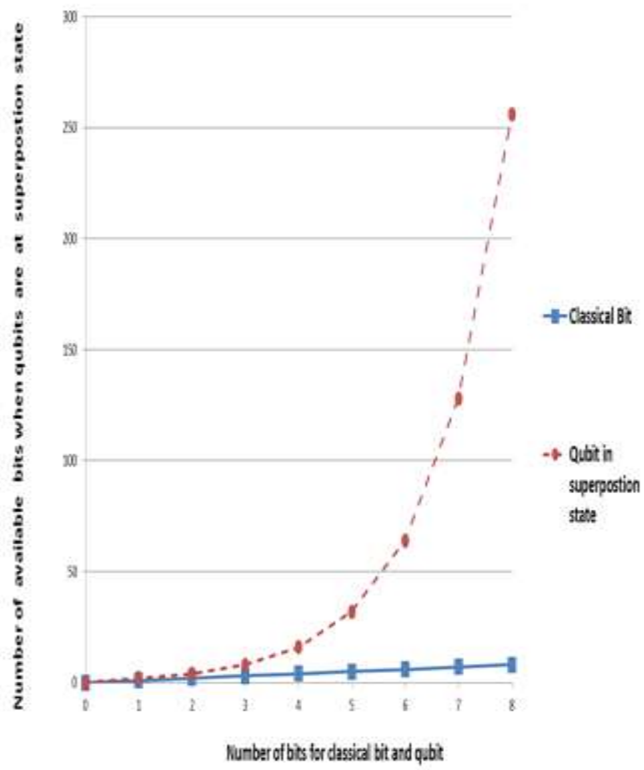

Fig. 1. Classical bits Vs qubits

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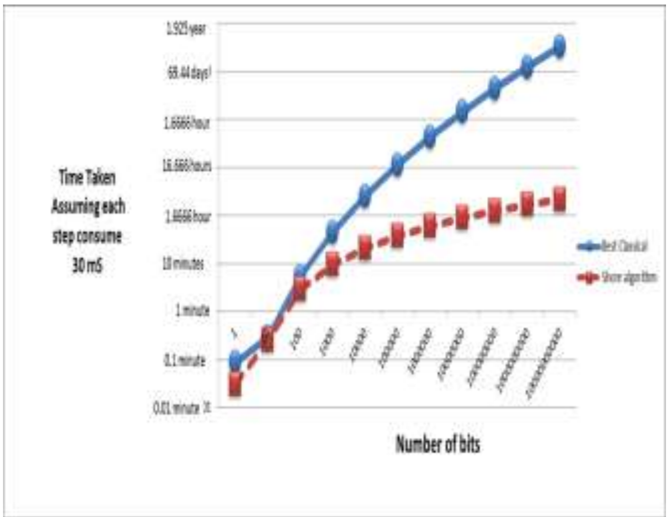

Fig. 2. Shore algorithm vs Best classical factoring algorithm

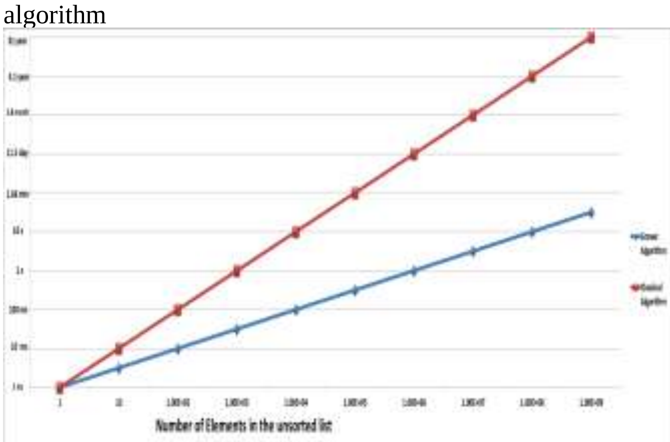

Fig. 3 Grover algorithm vs classical algorithm

IV. ESTIMATION THE IMPACT OF QUANTUM COMPUTATION ON ENVIRONMENTAL EVALUATION

Environmental evaluation is performed through three primary scientific tools which are (i) direct field observations; (ii) laboratory scale tests and physical modeling studies; and, (iii) mathematical modeling.

If mathematical modeling is implemented by a quantum computation via quantum computer then it will have significant advantage in terms of speed over the classical computation as previously shown in the previous section [14]. Also the quantum computation will expand the limitation in which is faced with classical computation [15]. For example quantum computation can enable to simulate the dispersion for all kinds materials in very big wide area while classical computation its simulation capabilities is limited to few kinds of materials in very small area with a big amount of time to accomplish this task.

Quantum computation can implement several methods for environmental modeling, compare between them and finally select the best solution in one application at one time. In other words we can call the pervious as an expert system. Classical computation can't implement this expert system because in this case classical computation will need a computer with a huge amount of memory and also a huge amount of processors [6, 7, 10, 11, 12, and 13].

V. CONCLUSION

Quantum computation via quantum computer will have significant advantage in terms of speed over the classical computation in the area of environmental evaluation.

Quantum computation exceeds the capabilities of simulation in time consummation, area of the sites, amount of the input data and quality of the output results.

Quantum computation can implement several methods for environmental modeling, compare between them and finally select the best solution in one application at one time. In other words we can call the pervious as an expert system. Classical computation can't implement this expert system because in this case classical computation will need a computer with a huge amount of memory and also a huge amount of processors.

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