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Burba M., Lapitskaya T.

Quantum computing

Belarusian National Technical University
Minsk, Belarus

The study area that concentrates on the implementation of quantum theory principles for developing the computer technology is called Quantum computing. The main focus here is given to clarify the nature and character of energy and matter on the level of quantum. There is a lot of development in the quantum computing from the last billion-fold area in increasing the capacity of quantum computer in the similar way how the development from abacus to today's super computer. Quantum computing can be understood by learning the quantum laws of physics by which so much of processing power is achieved and the capacity will be developed to several states and these will together help in executing the tasks in terms of parallel attainable combinations. Generally quantum computing depends on quantum laws of physics because there are many advantages from the quantum physics atoms and nuclei properties which are definite, as the quantum physics laws and quantum computing are permitted by these properties to work mutually as quantum bits or simply as qubits, to be the processor or memory of a computer. The advantage of qubits is particular calculation are made faster exponentially when compared to the usual computers.

The computations on usual binary characters is not the base for qubits always, because by using the usual computers the information is encoded using the binary characters particularly into bits is encoded into '1' or '0' and also the calculations for only one set of number can only done at a time.

But in case of the quantum computers information is encoded into a series of quantum mechanical states like electrons in spin direction or arrangement of photon polarization which can also be represented with '0' or '1', or can also be represented as superposition of many numbers which are not similar and sometimes represented as a number that express the state of qubits represented among '1' or '0' anywhere or may also represented as orientation of both.

Consider a quantum bit as an electron or photon in a magnetic field, with the electron's spin being either in phase with the field, a situation known as spin-up state or out of phase with the field, a situation known as spin-down state. The direction of the electron's spin which represents the qubit states can be changed from one state to another by applying a laser beam in the magnetic field assuming that only one unit of the laser energy is applied. Halving the amount of laser energy applied isolates all external disturbances to the particles forcing the particles into a superposed state of both 0 and 1 according to the laws of quantum physics and therefore behaving as if in both states simultaneously. Each of the quantum bit used could acquire the superposition of both 0 and 1 state. A quantum computer is therefore capable performing 2n number of computations where n represents the number of qubits used. A quantum computer of 500 qubits would therefore perform 2500 computations in a single execution. This results into a massive parallelism which is not possible with classical computers. The question therefore arises of how these particles would interact with each other. These concerns would be answered by a concept called quantum entanglement.

Particles in a magnetic field interact with each other such that the quantum states of the different interacting particles create a single entangled state. These entangled states are depended on one another so that the knowledge of spin state of one entangled electron whether up or down makes it possible for the spin state of the other entangled particle state which must be in the opposite direction to be known. From the concept of superposition, a particle is simultaneously in both spin up and spin down states and therefore measuring it entangles it to either of the states. According to Einstein phenomenon, the state of a particle is known at the time of measurement and the correlated particle assumes the opposite state (Thomas, n.d). Quantum superposition and entanglement concepts yield a massive computational power. For example, taking a 2-bit register in a classical computer, only one of the four possible configurations 2n, where n=2 (00, 01, 10, 11) can be stored at a time. On the other hand, a 2-qubit register in a quantum computer is capable of storing all these configurations simultaneously. This storage capacity is exponentially increased with an increase in the number of qubits. Despite the numerous sound advancements in quantum computing, there still exist a number of challenges and obstacles. Interference, error correction and output observance are among the most common difficulties that quantum computation presents. During the computation of a quantum problem which is performed at a superposed state, any measurement causes the computation to collapse into a single state, a condition referred to as decoherence. For computations to give correct results, decoherence must be maintained as low as possible. Error correction arises as a result of interactions between qubits and the environment which causes the collapse of stored information resulting into errors into calculations. Output observance becomes difficult because retrieval of the output of a quantum computation might corrupt the data. For a 2500 quantum computation, there is only one chance between 1-2500 available options of observing the right output. A method to ensure that the observed value gives the desired output should be devised. This has been achieved by Grover's algorithm which ensures that measurements results into a decoherence state which gives the correct answer. The main advantage of quantum computing is it can execute any task very faster when compared to the classical computer, generally the atoms changes much faster in case of the traditional computing whereas in quantum computing it changes even more faster. But all the tasks can't be done better by quantum computing when compared to traditional computer. In quantum computing qubit is the conventional superposition state and so there is an advantage of exponential speedup which is resulted by handle number of calculations. The other advantage of quantum computing is even classical algorithm calculations are also performed easily which is similar to the classical computer.

The main disadvantage of computing is the technology required to implement a quantum computer is not available at present. The reason for this is the consistent electron is damaged as soon as it is affected by its environment and that electron is very much essential for the functioning of quantum computers. There have been tremendous improvements in the field of quantum computing in the last decade despite the challenges and problems it has faced. Efforts to tackle these obstacles should be put in place to propel the enormous computational power of quantum computers into feasible reality. Great progress has been made concerning error correction with the development of error correction algorithms and with concerted efforts, a robust computer that is capable of withstanding decoherence would be built.

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