Quantum Computers

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Abstract— Common digital electronic classical computers requires data to be encoded in the bits, of which each is always in one of two defined states of either 1 or 0. Quantum computation uses Quantum Bits, which are in superposition of states, i.e 0 and 1 at the same time. Quantum Computers, which makes use of the superposition and entanglement of physical states, to perform operations on data, can very well outperform their counterparts in solving certain types of problems. The capacity of calculations is increased exponentially compared to the current digital electronic computers and therefore can help in factoring a large number into its primes, which would allow us to break cryptographic codes and so discoveries in various fields including trade, quantum science, trade, medical science , national security etc is possible.

Key words: Quantum Computers/ Computing, Super positions, Quantum Bits, Schrödinger's Cats Theory

I. Introduction

Paul Benioff[1]and Yuri Manin[2] initiated the field of quantum computing by their work in the year 1980. The main difference between the Quantum computers from binary classical digital electronic computers are based on the transistors.

Quantum theory is the branch of physics that deals with atoms and the smaller subatomic particles inside them. But the difference is that atoms does not behave the same way as the normal physics like everything else in the world, but they behave differently in their own little tiny ways — on the atomic scale and sub-atomic scale, the rules of physics on large objects changes and the "classical" laws that we take for granted in our everyday world no longer automatically applies in the quantum theory.

Now, we ask what does this have to do with the quantum computers? Because there is something called Moore's Law[3]—suppose we keep on making transistors smaller and even smaller ones into tiny ones and push the limits sp until they get to the point where they stop obeying the ordinary laws of physics (like old-style transistors) but instead the tiny quantum mechanics laws.

The big question that arises is that can computers designed with quantum mechanics laws can do things that our classical conventional computers can't do. If we can only predict using mathematics, can we actually make them work like that in practical? - We see the signs and we can say that the age of Quantum computers has started.

A. What is qubit?

In quantum computers a qubit/quantum bit/ or qbit is a unit of quantum bit the comparable to that of the classical digital computer bit.

In Classical computer, bits are always in one state or the other. However, in quantum computing, qubits are allowed to be in a superposition state of both state at the one time. This is what gives a quantum computer its superior computing power.

This concept was introduced in 1983 by Stephen Wiesner, in his proposal for quantum money, which he wanted to be published for more than a decade.[3][4]

The important feature of qubit versus classical digital bit is that quantum entanglement can be exhibited by multiple qubits. Now we see, what is Entanglement.

Entanglement is a nonlocal property which allows to express higher correlation between a set of qubits e.g. the following state is a entangled two qubits in the Bell state

$$\boxed{\frac{1}{\sqrt{2}}(|00\rangle + |11\rangle).}$$

This state is known as an equal superposition, the probability of measuring either $|00\rangle$ or $|11\rangle$, as $|1/\sqrt{2}|^2 = 1/2$ are equal.

B. Schrödinger's catexperiment

Austrian physicist Erwin Schrödinger devised Schrödinger's cat experiment in 1935. It is a thought experiment. It is sometimes described as paradox[4]. Basically, this experiment demonstrates the problem of the Copenhagen interpretation [look F. point] he saw of quantum mechanics applied to objects, specially that are larger in size like a cat.

The scenario is that, there is a cat placed inside a closed box, Cat may be simultaneously both alive AND dead .This state is what is a referred to as Quantum superposition, based on the random sub atomic events that may or may not occur.

He also used radioactive material, internal monitor (e.g.Geiger counter), poison, and a hammer in his experiment. Radioactive material was tiny enough such that there was half chance of being detected over an hour. The hammer will hit the poison bottle if the counter detected the radiation, therefore killing the cat.

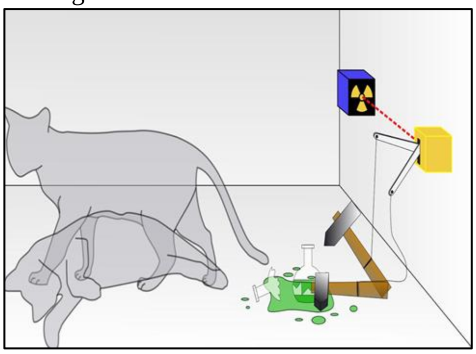

Fig. 1: Cat

We don't know the state as long as the cat is not observable inside the box, the movement we see it , the superposition state is lost, i.e. we now know that the cat is dead OR alive, only in one of the state. Thus until and unless the box is opened the cat will be in the superposition state.

Schrödinger's claimed, that it was ridiculous. The quantum superposition does not work on larger organic object like cat. Since it is impossible for organic cat to be dead and alive at the same time.

Therefore, he reasoned the Copenhagen interpretation instead of popular belief which people interpreted as that he supported the premise.

C. Entangled Particles

Entangled particles are emitted in a single event. It is a phenomena of physical dependency between the pairs or groups of particles such that it cannot be defined independently, even when the particles are separated by large distance.

We discussed earlier through Schrödinger's cat

experiment about the cat, being a larger organic object. But modern experiments shows that the quantum superposition does indeed works.

Its experiment have been observed using photons [6][7][8], neutrino[9], electrons[10][11] because electrons observed so far in our history are always black or white in color. They have property of Hard or Soft all simultaneously until observed.

e.g, It's possible to prepare a single quantum states 2 particles such that if the observation is spin-up, then by default, the other one observed has to be and will always be spin-down and vice versa, despite all this being impossible to predict that which set of measurements will be observed.

Therefore, the result of one measurement instantaneously affects the other one entangled with it. But the information entanglement doesn't happen faster than the speed of light.

D. Copenhagen Interpretation

Copenhagen interpretation is one of the most commonly held interpretation of quantum mechanics. It states that an object can be present at all the possible configurations, but observing the system, forces the object's configuration to collapse into just one possible state.

eg. Dots are plotted on a graph such that they are plotted everywhere, but they exist on the graph at every possible configuration until it is observed. The moment it is observed it collapses into just one point, which is then the only observable state.

E. Many-Worlds Interpretation

Hugh Everett, coined this theory of the "many-worlds" interpretation of quantum mechanics. In his theory he doesn't count observation as being a special process rather each possibility is a branch point to another universe.

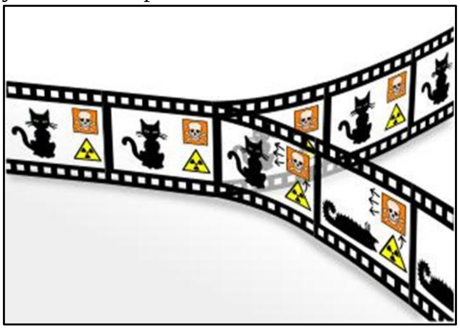

Fig. 2: Many-Worlds Interpretation

He says it doesn't matter whether the box is opened or closed - the cat is alive in one branch of universe and is dead in other branch - but the "alive state" and "dead state" of the cat, both of them are counted as separate branches of the universe, which are equally real, i.e both exist in parallel or multiple universe at the same time, but the branches cannot interact with each other.

F. Quantum particles being at two places at once

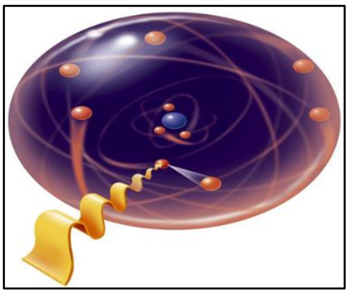

Fig. 2: Quantum particles being at two places at once

In this theory a quantum particle exist at two places at once Quantum mechanics boast of all sort of odd features which sounds absurd. In football game can there be a goal or no goal at once? Absurd as it sounds on the larger object like football but in quantum mechanic, a quantum particle can exist at two place at a time. A particle can be on the left and right at the same time. We've referenced about the experiments on photos, electrons etc see Ref. 6 to 11.

G. Schrödinger's cat with the calculation of qubit

To generate entangled state, coherent manipulation of increasing number of qubit was needed. The more number of the qubits there is the better will be the computer's performance, so this has been the important goal for an emerging field of quantum mechanics.

States of six photonic qubits or up to six or eight atoms, have been demonstrated before. The reference quoted, reports "the creation of hyper-entangled six, eight, and ten-qubit Schrödinger cat states" [12]

Companies like IBM are performing this tasks on more than 16 bits or 17 bits and the numbers are increasing which is a good sign.

II. METHODS

The experiment is a theoretical one, and machine of that calibre has not yet been constructed. However successful experiments quoted in references, in modern age of quantum physics has made way for quantum computer of that calibre to be constructed.

In quantum computing, there is a word known as "cat state" which is frequently referred to as the quantum bits special entanglement. The cat state bits are in an absolute equal superposition, of all being 1 and all being 0; e.g.

$$|\psi\rangle = \frac{1}{\sqrt{2}}\left(|00\ldots0\rangle + |11\ldots1\rangle\right).$$

Several other methods of calculation are referenced in the reference which they experimented.

III. RESULTS

Schrödinger's did reasoned for larger objects but experiments on relatively large (by quantum physic standards) objects are been performed.[13]

A "cat state" - on large objects(by quantum physic standards) had been achieved with the photons.[14]

Major players have started to build quantum computers, few being build to some extent, but a lot more to come in the near future. IBM has also deployed two new processor of 16 qubits for public and 17 qubits prototype for commercial processor in their Watson U.S.A headquarter. [15]

IV. DISCUSSION/CONCLUSION

As of 2017, the actual quality quantum computers is still in its primary development state, but efforts have been and are made to make quantum computers a real reality. Recently, more experiments are carried out by the companies where quantum computational process power and their operations were executed on a very small number of quantum bits.

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