# QUANTUM SUPREMACY: A LONG SOUGHT BREAKTHROUGH IN COMPUTING

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**ABSTRACT**

*Quantum computing is a term derived from physics' quantum theory which deals with particles at the most fundamental levels of the physical world i.e. atoms and their subatomic particles. Since these days the size of computers is getting smaller along with the increase in their computational speed, therefore, to meet the physical limits of computer's electronic components, quantum computing has come into the picture as it introduces qubits replacing bits in computers.A Quantum computer uses the phenomena of quantum mechanics superposition and entanglement to perform operations on data. Recently, Google has come up with a scientific achievement named as "Quantum Supremacy", a quantum computer which claims to solve a complex problem, to solve which a supercomputer would take 10,000 years, injust 200 seconds.But the achievement proposed by Google is still theoretical, therefore many researchers with computing background are working to know whetherthe proposed future state of quantum computing would be truly state of the art or not, as it has some disadvantages as well.*

**Keywords:** Quantum Computing, superposition , entanglement, qubit, supremacy.

## INTRODUCTION

Since it's an era of technology and everything goes online, the need of bandwidth for present day date transfer rate has increased together with security and computational requirements. Therefore, the present days' computing requirements are beyond the classical computing approaches. Keeping the requirements in view, world scientists and engineers in technical companies have been working for decades to come up with a new approach of computing which would be reliable for all the increasing demands. Quantum Computing is a technology that uses principles of quantum mechanics such as superposition and entanglement for solving computational problems. These systems work in accordance with Quantum Mechanics theory of Physics. Quantum computing works with objects which are quantum particles in their probable existence whereas objects are supposed to exist in specific place for a specific time in classical mechanics[6]. Recently, a team of researchers from Google under John Martinis has come up with a demonstration called "Quantum Supremacy" in which they claim to achieve the computation speed for a particular task performance in minutes, something that would take thousands of years when done by even the most powerful supercomputer. This paper investigates the evolution, components and current achievements in the field of quantum computing.

## EVOLUTION OF QUANTUM COMPUTING

The concept of quantum computing was first given in 1980 by Paul Benioff by giving description of the computer's first quantum mechanical model. In 1981 Paul Benioff and Richard Faynman proposed the basic model of a quantum computer at MIT. Later, BB84, known as the world's first quantum cryptography protocol was published by Charles Bennett and Gilles Brassard of IBM in 1984.First universal quantum computerby which any other quantum computer could be simulated was described in 1985 by David Deutsch. In 1994, an algorithm was developed by Peter Shorthat allows quicker and moreefficientexponential factorization of large numbersin hours by quantum computers when compared to well known algorithms of traditional computers which take millions of years to solve the same. For constructing a quantum computer, a list of necessary conditions was published by theoretical physicist, DiVincenzo in 1996.In 2005when a semiconductor chip ion trap was built by researchers of the University of Michigan, it paved the way for quantum computing to be made scalable. The first solid state quantum processor having 2-qubit superconducting chips was created in 2009 by Yale University's researchers in which two states could be occupied by a single atom. Then in the same year, quantum optics based silicon chips were created at University of Bristol. Quantum computing achieved a new milestone in 2010when different quantum gates were used to design digital combinational circuits.In 2011; it was proved by researchers that Von Neumann architecture can be used to make quantum computers. With superconducting integrated circuits, IBM scientists introduced several breakthroughs in quantum computing. In 2012, a 2-qubit quantum computer whose functionality is possible at room temperature and which can be scaled up easily was constructed by researchers' team in California. Then, the first working qubit that is based on silicon's single atom was created by Australian researchers. In December 2012, the first dedicated quantum computing Software Company named as 1QBit was founded in Vancouver, Canada. An

announcement was made by Google in May 2013 regarding launching of the Quantum Artificial Intelligence Lab which was hosted by NASA's Ames Research Centre. Google gave some results by mixing quantum and classical computing and some quantum machine learning algorithms were developed. To make the qubits more accurate and increasing their information holding time length, silicon was used as a protectant shell around qubits by university of south Wales' researchers in 2014. Later in 2015, silicon based quantum logic gate was built. Same year, world's first fully operational quantum computer was displayed publicly by NASA, made by D-Wave Systems. In the year 2016, an announcement was made regarding sharing of quantum computing with members via the cloud by IBM and the first reprogrammable quantum computer was built successfully by the scientists of Maryland University. IBM Q, first universal quantum computing systems were made available commercially by IBM in 2017 by which developers and programmers, those having no deep knowledge of quantum physics, could build interfaces between its existing 5-qubit cloud based quantum computers and the classical ones. In September 2019, a paper named 'Quantum Supremacy' was published by Google AI Quantum and NASA in which programmable superconducting processor and supplementary material was used. In this paper, it was claimed that Synamore, Google's quantum computer took 200 seconds to complete a task which would be completed in 10,000 years by the most powerful supercomputer [7].

## COMPONENTS OF QUANTUM COMPUTING
### Qubit

Qubit, abbreviation of quantum bit, is the basic unit of information in a quantum computing which acts same as the bits in the conventional computers. These qubits can exist in both ground i.e. 0 and excited states i.e. 1 at the same time. The two logical states of each qubit must be mapped onto the eigenstates of some suitable physical system[1].

### Superposition

Quantum superposition is a fundamental principle of quantum mechanics. It states that two or more quantum states can be added together and the result will be another valid quantum state; and conversely, that every quantum state can be represented as a sum of two or more other distinct states.[2]

### Entanglement

Quantum entanglement is a quantum mechanical phenomenon in which the quantum states of two or more objects have to be described with reference to each other, even though the individual objects may be spatially separated.

This leads to correlations between observable physical properties of the systems [3].

## QUANTUM SUPREMACY

Quantum Supremacy is a term introduced by John Preskill, which is assumed to give the advantage of hypothetical speedup in a quantum computer and would override the classical computer. In 2017, Google had made an announcement regarding achievement of quantum supremacy in short time period and it took around two years to come up with its accomplishment. Recently, in October 2019, Google has come up with a demonstration of quantum supremacy. This achievement has been seen as a critical milestone in the computing world as it outperforms the classical computer calculations by solving problems in fraction of minutes which traditional computers would solve in millions of years. A microchip named "Sycamore" has been built by Google team in which a 0 or a 1 has been represented by 53 loops of wire where current flows around them at two different energies. The microchip has been placed into a dilution refrigerator which is of a closet's size by which wires have been cooled to a hundredth of a degree above absolute zero, making them to superconduct. These energy levels when behave as quantum bits for a moment i.e. for millionth part of a second, cause superpositions of the 0 and 1 states[4].

## CONCLUSION

Since quantum computing systems has advantages of higher computional speed than the traditional systems for solving particular problems, it is attracting interest of a number of industrials actors including high corporations like Google and Microsoft and also of nanoelectronics and nanotechnology based companies like IBM, Intel and LockheadMartin [5]. But after a number of decades spent by researchers and engineers, to achieve the quantum computing, no physical quantum computing machine exists even today. Google has claimed recently to demonstrate such computation which is supposed to be done by quantum system. Still some companies like IBM are questioning their achievement. Therefore, Google's claim has given a hope that scientists will be able to able to do computations using quantum mechanics in near future.

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