**Quantum Computing with AI**

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**ABSTRACT**

The 20th century witnessed Albert Einstein offering a quantum-based theory – one whose rules are in contrast with from those of the physical world – one which described the nature of atomic and sub- atomic particles. As time progressed, quantum theory became one of the greatest achievements of 20th century, holding prime significance more half a century later as well. More than half a century later the quantum theory meets the computer world and the quantum computing is born. The quantum computing will allow new kinds of computers to do calculations at speeds that are inconceivable with today’s technology.

*KEYWORDS: - Quantum Computing, Quantum Supremacy, Entanglement, Qubit, Superposition Simulated annealing, interference*

**INTRODUCTION**

The idea of computational devices based on quantum mechanics was first explored

in the 1970’s and early 1980’s by physicists and computer scientists at IBM, Watson Research Centre, Argonne National Laboratory in Illinois, University of Oxford and Caltech. The idea emerged when scientists were pondering on the fundamental limits of computation.

In 1982 Feynman was among the fewer to attempt to provide conceptually a new kind of computers which could be devised based on the principles of quantum physics.

Later, in 1985, Deutsch realized that Feynman assertion could eventually lead to a general-purpose quantum computer. He showed that any physical process, in principle

could be modelled perfectly by a quantum computer. Thus, a quantum computer would

have capabilities far beyond those of any traditional classical computer.

MODERN DAY DEVELOPMENT

Google stated in October 2019 that it “Has achieved a long-sought breakthrough called ‘Quantum Supremacy’”, which could allow forthcoming computersto perform calculations at speeds inconceivable with today’s technology. The Google gizmo did a mathematical calculation in 3 minutes 20 seconds – the same problem could not be completed by supercomputers anywhere under 10,000 years, the company said in its paper.

This was countered by IBM, stating “An ideal simulation of the same task can be performed on a classical system in 2.5 days and with far greater fidelity. This is in fact a conservative, worst-case estimate, and we expect that with additional refinements the classical cost of the simulation can be further reduced.”

WORKING PRINCIPLE

Quantum computing applies the properties and characteristics of quantum physics to process information. It reimagines the classical binary encoded computing approach, which comprises of bits of zeroes or ones (0’s and 1’s) represented electrically as “ON” or “OFF” states by replacing bits with **qubits** that can simultaneously exhibit multiple states as they are generally defined in classical physics. Operating with nanoscale components at temperatures, approaching to the absolute zero (0 K) quantum computing has the potential to solve some of the world’s toughest challenges. Quantum computers will enable new discoveries in the areas of healthcare, energy, environmental systems, space exploration and research, and beyond.

WHAT IS QUBIT?

A quantum bit is a unit of quantum information—similar to a classical bit.

While classical bits hold a single binary value (0 or 1), a qubit can hold both the values simultaneously. When multiple qubits are acting coherently, they can process multiple options together. This allows them to process more information in a fraction of the time, compared to even the fastest nonquantum systems. Physically qubit can be visualized by the spin s=1/2 of one electron system, the two state +1/2 and –1/2 being two eigen states of Sz

(z component direction of an external magnetic field of spin ½.). Alternatively, a beam of

single photon can also be used, the total states being the state of polarization (horizontal

or vertical) with respect to some chosen axis. Thus qubit can take 2 values, 0 or 1, which

are associated with two eigenstates of a spin of a single electron (say):

|1> = |↑>

|0> = |↓>

|0> + |1> = |↑> + |↓

CONCEPT

The most intriguing feature of quantum computing is quantum parallelism. A quantum system, in general, is not in a “classical state”, but is in a “quantum state” – broadly consisting of a superposition of many classical, or like states. This is known as the principle of linear superposition, and is used to construct the quantum states. If this superposition can be shielded away from unwanted entanglement with the environment (also known as decoherence), a quantum computer can produce results depending on details of all its classical like states. This is quantum parallelism- parallelism on a serial machine.

ARCHITECTURE OF QUANTUM COMPUTER

In order to work with qubits for extended periods of time, they must be kept very cold. Any heat in the system can introduce error, which is why quantum computers are designed to create and operate at temperatures near absolute zero.

Here’s a look at how a quantum computer’s dilution refrigerator, made from more than 2,000 components, exploits the mixing properties of two helium isotopes to create such an environment for the qubits inside.

One of two amplifying stages is cooled to a temperature of 4 Kelvin. Attenuation is applied at each stage in the refrigerator in order to protect qubits from thermal noise during the process of sending control and readout signals to the processor. In order to minimize energy loss, the coaxial lines that direct signals between the first and second amplifying stages are made out of superconductors. Cryogenic isolators enable qubits signals to go forward while preventing noise from compromising qubit quality. Quantum amplifiers inside of a magnetic shield capture and amplify processor readout signals while minimizing noise. The quantum processor sits inside a shield that protects it from electromagnetic radiation in order to preserve its quality. The mixing chamber at the lowest part of the refrigerator provides the necessary cooling power to bring the processor and associated components down to a temperature of 15 mK — colder than outer space.

QUANTUM COMPUTING IN ARTIFICIAL INTELLIGENCE % ITS FUTURE ASPECTS:

1. Logistical and optimization problems:

A quantum computer will slice through a mountain of variables without breaking a sweat and provide best solutions in very little time.

2. Weather and Climate Modelling:

Using a quantum computer, weather scientists can not only forecast near-term weather patterns perfectly, but they can also create more accurate long-term climate assessments to predict the

effects of climate change.

3. Personalized Medicine:

Quantum computers will also allow Big Pharma to better predict how different molecules react with their drugs, thereby significantly speeding up pharmaceutical

development and lowering prices.

4. Space exploration:

With a mature quantum computer combined with machine-learning, enormous amounts of data can finally be processed efficiently, opening the door to the discovery of hundreds to thousands of new planets daily by the early-2030s.

5. Fundamental Sciences:

The raw computing power these quantum computers possess enables scientists and engineers to devise new chemicals and materials, as well as better functioning engines and of course, cooler Christmas toys.

6. Machine Learning:

With quantum computing, machine-learning software can begin to learn more like humans, whereby they can pick up new skills using less data, messier data, often with few instructions.

7. Data Encryption:

If quantum computers work as advertised, all industries will be at risk, at worst endangering the entire world economy as quantum computers unlike supercomputers can generate a lot more password combinations, until we build quantum encryption to keep pace.

8. Real-Time Language Translation:

Quantum computers will also enable near-perfect, real-time language translation between any two languages. Therefore, language will no longer be a barrier to business and everyday interactions.

COST

In order to compute anything significant in nature– like the chemical properties of a novel substance – would easily require more than a million qubits. Adding to it is the fact that scaling up from 50 qubits to several million qubits is not feasible at all. In fact, this challenge is formidable. A support-cast of traditional computers, and other devices, to program, operate and monitor them would be essentially needed. This is further accompanied by the computational burden of the machine’s output. A quantum computer with 10 million qubits, running at a few GHz would pour out more than 10 terabytes of data per second.

Today, a single qubit will slam you with a $10,000 receipt– and that’s even before you consider the research and development costs. A useful universal quantum computer –hardware alone – comes in at least $10bn.

**CONCLUSION**

This paper gives us the basic idea of what a quantum computer is, the process involved future scopes and aspects of quantum computing. Yes, we are far behind the real-life applications for quantum computing but the companies like IBM, Google and D-wave have already started exploring this concept further and complex. Reversibility of quantum computation may help in solving NP problems, which are easy in one direction but hard in the opposite sense. Global minimization problems may benefit from interference effects. Simulated annealing methods may improve due to quantum tunnelling through barriers. There are still unknowns like with more qubits the decoherence increases so we won’t be able to maintain a large system. If quantum computers are ever to help solve humanity’s problems, they will have to improve dramatically. Quantum supremacy will be a landmark for computing, but it is where the hard work starts, not where it ends.

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