QUANTUM COMPUTING

What Is It?

Quantum computing is a simulation of quantum mechanics. This deals with the behaviour of atoms and fundamental particles like electrons and photons. The sight can further be extended to the likes of molecules which are a group of atoms bonded together.

A **bit** is a fundamental building block for classical computing. It can store information and be represented logically by 0 or 1. It has two definite states. In a quantum computer, the rules are changed. They execute these quantum operations using quantum bits, or qubits. These can exist in the classical 0 or 1 state, however, it can be in a state where it is a ratio of 0 and 1. This is called **superposition**. They reside in a three-dimensional space referred to as the **Bloch Sphere**. Operating on a singular qubit, essentially performs the operation on both values simultaneously. Increasing the number of qubits can exponentially increase this 'quantum parallelism' obtained from the system.

Applications

Quantum Encryption - Quantum uncertainty can create private keys for encrypting messages from one location to another. Hackers would not be able to secretly copy the key because the qubits would be in a superposition. This kind of encryption is already being tested by banks and institutions worldwide.

Drug Development - The difficulty of describing all the quantum properties of a molecules can be mitigated by using quantum computer. This is because the quantum computer operates using the same quantum properties as the molecule it is trying to simulate. Future large-scale quantum simulations for drug development could lead to treatments for diseases like Alzheimer's.

Material Science - The same could be said for material development. This can aid in creating room temperature superconductors that could easily circulate electricity generated by the sun around the world. This could help alleviate the energy crisis which could subsequently diminish climate change.

Artificial Intelligence - Quantum computing could help train the next-next generation of Artificial Intelligence. This could help and combat fraud detection.

History

The basis of quantum computing, quantum mechanics, has been around since 400BC. It was introduced by an Ancient Greek philosopher, **Democritus**. The concept of quantum computers was brought forward around the late 1970s and early 1980s. **Richard Feynman** was often accredited for introducing the theory of quantum computing. However, he was not he only one in his time to anticipate this idea. Scientists like **Paul Benioff** and **Yuri Manin** also exhibited the theory in their works.

Current State

Quantum computing has garnered the attention of private investors and governments. Large tech companies like Google, IBM and Alibaba are investing vast amounts of money to create quantum processors. Start-up quantum companies received $450 million in 2017 and 2018 alone even though the science is still young, and the machines required to accommodate quantum processors are large and meticulous. Quantum chips need to be sealed and stored at a temperature a degree above absolute zero (-273°C). Looking at the refrigerator for quantum chips alone, displays how cumbersome this technology is now.

Google announced that they have achieved 'quantum supremacy' in October 2019. Quantum supremacy describes the ability of a quantum computer to carry out a task impossible to a classical computer, a term proposed by physicist John Preskill in 2012. Google's 53-qubit quantum processor named Sycamore, ran a program which randomly generated numbers and performed it in 200 seconds. Google claimed that this program would have taken classical supercomputers 10,000 years. However, IBM took issue with the findings and they announced that this task can be performed in 2.5 days. Regardless, quantum supremacy has been achieved.

IBM established a website called IBM Q Experience. It is a cloud-based platform for designing and testing quantum programs. It allows the user to build quantum circuits by selecting quantum gates represented graphically as blocks in the Composer workspace. Users can then run these programs on the actual quantum processor or a simulator.

Impact on Computer Science

- It has put modern cryptography methods and cybersecurity defenses in peril.
- The development of quantum algorithms has prompted experts to review classical algorithms.
- Developments in this field contribute to advancements in other emerging fields in Computer Science namely Artificial Intelligence.
- Ultimately this technology is redefining storage capacities and processing time beyond what Computer Scientists once thought was possible.