

## Qubits : Concepts Behind Quantum Computing

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**Abstract:** Quantum Computing is entirely different way of computing as our classical computer are able to compute in binary individual bit 0's and 1's meaning its operations are based on one of two positions 0 or 1 but in quantum computing leverage quantum mechanical phenomena to manipulate information. As we know that the classical bits can be operated on independently of each other changing zero to one or one to zero a bit in one location has no effect on bits in other locations but Qubits can be set up using a quantum mechanical property called entanglement so that they are dependent on each other. In this paper, we will discuss what is quantum computing, its concept and applications, possible threats by the technology, companies using quantum computing and a case study of Google.

**Key Words:** Bit, quantum, computing, Qubits, encryption, decryption.

### 1. INTRODUCTION: QUANTUM COMPUTING

In the 1980s, Richard Feynman proposed the concept of simulating physics with a quantum computer and postulated that by manipulating the properties of quantum mechanics and quantum particles one could develop an entirely new kind of computer the quantum computer. Quantum Computing is entirely different way of computing as our classical computer are able to compute in binary individual bit 0's and 1's meaning its operations are based on one of two positions 0 or 1 but in quantum computing leverage quantum mechanical phenomena to manipulate information. To do this, they rely on quantum bits or qubits. A quantum bit or qubit can be 0 or 1 before being measured, a property called superposition. if we have two quantum bits, there are four possible states that you can put in superposition and it increases exponentially( $2^x$ ), if we have four quantum bits, there are 16 possible states that's how its saves memory. A quantum computer can solve some problems faster than a classical computer by using the concept of Superposition, Entanglement and Interference. As we know that the classical bits can be operated on independently of each other changing zero to one or one to zero a bit in one location has no effect on bits in other locations but Qubits can be set up using a quantum mechanical property called entanglement so that they are dependent on each other.

### 2. LITERATURE REVIEW: CONCEPTS OF QUANTUM COMPUTING

In quantum computing at one particular time the state can be 0 or 1 or both at the same time keep on switching to either 0 or 1. In our computer calculation can be performed one at a time but in quantum computer it can perform multiple calculations at once isn't this great which saves a lot of time and makes it even much faster. The quantum bits contains or represents electrons, photons and atoms and the respective control devices acting as a computer memory and a processor. Quantum computer can contain all these things or multiple states at the same time , and with all this it has the potential to be much more times powerful than the supercomputers we use today. As quantum computing inherent parallelism because of superposition of qubits. Because of this parallelism a quantum computer will perform millions of calculations at once, while the normal pc we use today works on one.

- **Quantum Mechanics** is the branch of Quantum Physics. Quantum Mechanics theory of laws that apply on the microworld. The law for the smallest things at the scale of atoms and electrons on the subatomic particles that makes an atom and at that level our conventional law fails.
- **Superposition** is the state of having combination 0s and 1s (it keeps changing).Superposition is the fundamental principle of the quantum computing. It allows more than one bit to take a single state makes the functioning of quantum computers faster there will be two states at a single time and much more information can be stored at the same time. Let's take an example of a coin, a coin can have 2 face heads and tails assume it as 0 and 1, zero for tail and one for head. As we spin the coin while its spinning the coin can be any of state.



Figure 1: Spinning coin

In the above figure 1, the coin can be tail or head this position is called superposition.

- **Entanglement** is like two objects connected in some or the other way, by knowing about the one we can have a fair idea of the another without even have to measure it that's is what the entangled means. or let me first try to explain with a simple example think of a pair of socks. If you found a left sock in your room, you know for sure the missing sock would fit the right leg. The two socks could be said as entangled, knowing something about the one say a left sock would tell me about the something important about the other sock say the right sock which isn't a random occurrence.
- **Interference** is the fundamental idea in quantum computing is to control the probability a system of qubits collapses into particular measurement states. Quantum interference is a by-product of superposition, is what allows us to bias the measurement of a qubit toward a desired state or set of states

If we think to replace our classic computer with quantum computer, no it is not going to happen soon because Classical computers are better at some tasks than quantum computers (email, spreadsheets and desktop publishing to name a few).quantum computer can solve specific type of problems many times faster than the classic computers The intent of quantum computers is to be a different tool to solve different problems, not to replace classical computers.

### 3. APPLICATIONS OF QUANTUM COMPUTING:

Although this field is a work in progress here is the preliminary assessment where the power of quantum computing can be a breakthrough. This assessment is based upon the discussion of the experts working in this field.

- **Machine Learning:** Machine learning is a treading area now a days because we can now see significant deployments at the consumer level of many different platforms. We are now seeing aspects of this every day in voice, image and handwriting recognition, to name just a few examples.
- But it is also a difficult and computationally expensive task in terms of data and processing here the quantum bits help a lot.
- **Weather Forecasting :** The weather forecasting need fast computation of huge data and if classical computer is used to perform such analysis might take longer than it takes the actual weather to evolve .Now this researchers at MIT are working to find the equations governing the weather possess a hidden wave nature which are amenable to solution by a quantum computer.
- **Cryptography :** As we know the quantum computer are very powerful machine for computation of any equation. It will be so easy to decrypt any data encrypted by the classic computer. Encryption and Decryption will be too powerfull and easy for quantum computers.
- **Molecular modeling :** Today the Quantum chemistry is so complex that only the simplest molecules can be analyzed by today's classic computers. Chemical reactions are quantum in nature as they form highly entangled quantum superposition states. But fully-developed quantum computers would not have any difficulty evaluating even the most complex processes.
- **Drug Design:** Drug design is a promising area of application that will find a number of uses for these new machines. As a prominent example, quantum simulation will enable faster and more accurate characterizations of molecular systems than existing quantum chemistry methods.
- **Data storage:** As we know Quantum computer use quantum bits(qubits) and it increases exponentially( $2^X$ ). The amount of numbers that can be stored on the device doubles each time a qubit is added. 2 qubits can store 4 numbers, and 12 qubits can store 4096 numbers. If you have a quantum computer that has 100 qubits, it can store more than 1 nonillion numbers.

#### 4. POSSIBLE THREATS FROM QUANTUM COMPUTING:

Fortunately, researchers have been working to develop public-key algorithms that could resist code-breaking efforts from quantum computers, preserving or restoring trust in certificate authorities, digital signatures, and encrypted messages. But quantum computer is so powerful that the encryption by the classic computer will be noting to solve. The hacking using the quantum computer will be like impossible to crack.

#### 5. CORPORATE HOUSES IN QUANTUM COMPUTING:

- AT&T
- Google
- Microsoft
- Nokia
- Intel
- IBM
- Toshiba

#### 6. A CASE STUDY: GOOGLE IN THE FIELD OF QUANTUM COMPUTING:

Google researchers officially announced a major breakthrough in quantum computing known as Quantum Supremacy It's a term of art that mean they have used a quantum computer to solve a problem that would take a classical computer an impractically long amount of time. after creating a processor that is capable of performing calculations exponentially faster than even the most powerful supercomputers. The technology giant's Sycamore quantum processor was able to perform a specific task in 200 seconds that would take the world's best supercomputer 10,000 years to complete. This feat was achieved using a 54- qubit processor, named "Sycamore" that was crafted using high-fidelity quantum logic gates.

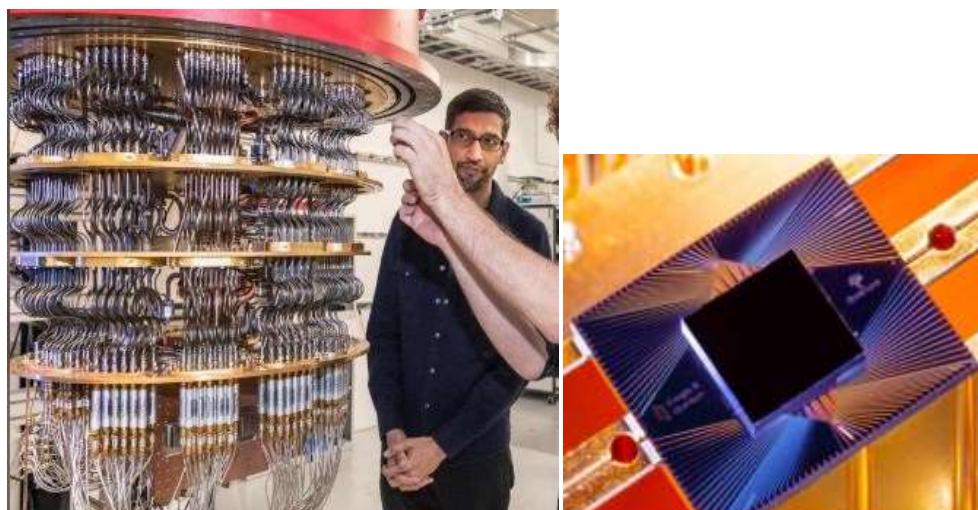


Figure 2: Google in Quantum Computing

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