

Quantum Computing

Quantum Computing:-

Quantum computing is a multidisciplinary field comprising aspects of computer science, physics and mathematics that utilizes quantum machines to solve complex problems faster than on classical computers. The field of quantum computing includes hardware research and application development.

Principles of quantum computing:-

A quantum computer works using quantum principles. Quantum principles require a new dictionary of terms to be fully understood, terms that include superposition, entanglement, and decoherence. Let's understand these principles below.

1. Superposition:

Superposition states that, much like waves in classical physics, you can add two or more quantum states and the result will be another valid quantum state. This superposition of qubits gives quantum computers their inherent parallelism, allowing to process millions of operations simultaneously.

2. Entanglement:

Quantum entanglement occurs when two systems link so closely that knowledge about one gives you immediate knowledge about the other, no matter how far apart they are. Quantum processors can draw conclusions about one particle by measuring another one. For example, they can determine that if one qubit spins upward, the other will always spin downward and vice-versa. Quantum entanglement allows quantum computers to solve complex problems faster.

3. Decoherence:

Decoherence is the loss of the quantum state in a qubit. Environmental factors, like radiation, can cause the quantum state of the qubits to collapse. A large engineering challenge in constructing a quantum computer is designing the various features that attempt to delay decoherence of the state, such as building specialty structures that shield the qubits from external fields.

Components of quantum computing:-

- Quantum hardware:
Quantum hardware has three main components.

i. Quantum data plane:

The quantum data plane is the core of the quantum computer and includes the physical qubits and the structures required to hold them in place.

ii. Control and measurement plane:

The control and measurement plane converts digital signals into analog or wave control signals. These analog signals perform the operations on the qubits in the quantum data plane.

iii. Control processor plane and host processor:

The control processor plane implements the quantum algorithm or sequence of operations. The host processor interacts with the quantum software and provides a digital signal or classical bits sequence to the control and measurement plane.

- Quantum software:
Quantum software implements unique quantum algorithms using quantum circuits. A quantum circuit is a computing routine that defines a series of logical quantum operations on the underlying qubits. Developers can use various software development tools and libraries to code quantum algorithms.

How companies use quantum computing:-

Quantum computing can revolutionize industries. We give some example use cases below:

ML:

Machine learning (ML) is the process of analyzing vast quantities of data to help computers make better predictions and decisions. Research in quantum computing studies the physical limits of information processing and is breaking new ground in fundamental physics. This research leads to advances in many fields of science and industry, such as chemistry, optimization, and molecular simulation. It is also a growing area of interest for financial services to predict market movements and for manufacturing to improve operations.

Optimization:

Quantum computing can improve research and development, supply-chain optimization, and production. For example, you could apply quantum computing to decrease manufacturing process-related costs and shorten cycle times by optimizing elements such as path planning in complex processes. Another application is the quantum optimization of loan portfolios so that lenders can free up capital, lower interest rates, and improve their offerings.

Simulation:

The computational effort required to simulate systems accurately scales exponentially with the complexity of drug molecules and materials. Even using approximation methods, current supercomputers cannot achieve the level of accuracy that these simulations demand. Quantum computation has the potential to solve some of the most challenging computational problems faced in chemistry, allowing the scientific community to do chemical simulations that are intractable today. For example, [Pasqal](#) built their QUBEC computational software to run chemistry simulations. QUBEC automates the heavy lifting necessary to run quantum computational tasks from automatic provisioning of the computing infrastructure to running pre- and post-processing classical calculations and performing error mitigation tasks.

How can you get started with quantum computing:-

If you want to try quantum computing, you can get started with a quantum hardware emulator on your local machine. Emulators are regular software that imitates quantum behavior on a classical computer. They are predictable and allow you to see quantum states. They are useful if you want to test your algorithms before investing in quantum hardware time. However, they cannot recreate real quantum behavior.

You can also use a cloud quantum computing service to code on a true quantum computer without investing in expensive hardware.