1. Qubit (Quantum Bit) - What Is It?

A qubit (quantum bit) is the fundamental unit used for storing and processing information in quantum computers. Unlike classical computers, where bits are the fundamental units, qubits rely on the principles of quantum mechanics. A qubit is a system that, according to the principles of quantum mechanics, can simultaneously exist in both the 0 and 1 states. This means that, unlike classical bits, qubits can be in a state called superposition. Qubits also possess another feature known as quantum entanglement. When two qubits are entangled quantum mechanically, the state of one can affect the state of the other, and this entanglement can persist over any distance under certain conditions. This can be utilized for quantum information transfer or cryptography between qubits. Another feature of qubits is the preservation of quantum states and uncertainty in measurement. Before measuring whether a qubit is in a certain state, it can be in superposition, and its exact state may be uncertain. However, upon measurement, the state of the qubit is determined and observed as either 0 or 1. These characteristics distinguish qubits from classical bits and enable quantum computers to harness parallel computation capabilities and operate certain algorithms faster. Therefore, qubits can possess computational power and processing capabilities beyond what classical computers can achieve.

2. What is the fundamental difference between Classical Bits and Qubits?

- Classical bits are the smallest units of information that represent data as either **0 or 1** in the form of an electrical signal. A classical computer operates by manipulating these bits.
- Qubits, on the other hand, rely on the fundamental principles of quantum mechanics unlike classical bits. According to the principles of quantum mechanics, a qubit can simultaneously exist in both the 0 and 1 states.

3. Advantages of Qubits

- Qubits surpass classical bits due to features such as superposition and quantum parallelism. Superposition refers to a qubit's ability to simultaneously exist in both the 0 and 1 states. This enables the capability to perform multiple operations simultaneously, unlike classical bits.

- Additionally, qubits possess features such as quantum compression and quantum teleportation. These characteristics indicate the potential for computational capacities beyond what classical computers can access.

4. **Uncertainty and Measurement**
   - Classical bits have definite values; they are either 0 or 1. However, in qubits, the state is uncertain, and it cannot be precisely known which state the qubit is in before a measurement is made.
   - Measuring a qubit involves reducing the qubit in a superposition state to a definite state. The measurement outcome is obtained by determining whether the qubit is in the 0 or 1 state, but before measurement, it is uncertain in which state the qubit exactly resides.

5. **Quantum Parallelism and Computational Power:**
   - Due to the feature of quantum parallelism, qubits are much more powerful than classical computers. This feature allows a qubit to simultaneously explore many different computational paths. This means that quantum computers can perform certain computational tasks much faster.

6. **Preservation of Quantum States:**
   - Preservation of quantum states refers to the protection of the delicate quantum states of qubits against external influences. This enhances the reliability of quantum computations by ensuring the stability of qubits.

Feature	Classical Bits	Qubits
Fundamental Unit	0 or 1	0, 1, or in superposition (uncertain between 0 and 1)
Measurement of State	Definite	Uncertain; in superposition before measurement
Superposition	Absent	Present; can be in both 0 and 1 states simultaneously
Quantum Parallelism	Absent	Present; multiple computational paths can be explored simultaneously
Computational Power	Limited	Potentially much more powerful
Preservation of Quantum States	N/A (Classical states)	Present; delicate quantum states are protected against external influences

Table 1. A Brief Comparison of Classical Bits and Qubits