Quantum Teleportation

Quantum teleportation is a process in which the state of one qubit is transmitted from one location to another without physically moving the qubit itself. This process requires a pre-shared entangled state and a classical communication channel. The steps for quantum teleportation are as follows:

1. Alice and Bob share an entangled pair of qubits, such as the Bell state $\frac{1}{\sqrt{2}}(|00\rangle + |11\rangle)$.
2. Alice has a qubit in an unknown state $|\psi\rangle = \alpha|0\rangle + \beta|1\rangle$ that she wants to teleport to Bob.
3. Alice applies a CNOT gate to her qubit and the entangled qubit, and then applies a Hadamard gate to her qubit.
4. Alice measures both qubits and sends the results to Bob over a classical channel.
5. Depending on the results of the measurement, Bob applies certain gates to his qubit to reconstruct the original state $|\psi\rangle$.
6. Bob now has the qubit in the same state that Alice started with.

Qubits

A qubit is a quantum bit, which is the fundamental unit of quantum information. Unlike classical bits, which can only take the values 0 or 1, a qubit can exist in a superposition of both states. The state of a qubit is represented by a vector in a two-dimensional complex vector space, such as:

$$|\psi\rangle = \alpha|0\rangle + \beta|1\rangle$$

where α and β are complex numbers and $|0\rangle$ and $|1\rangle$ are the basis states of the vector space. The coefficients α and β must satisfy the normalization condition $|\alpha|^2 + |\beta|^2 = 1$.

Qubits can be manipulated using quantum gates, which are unitary operations that act on the state of the qubit. Examples of quantum gates include the Pauli-X gate, the Hadamard gate, and the CNOT gate.