

Ralph's teleportation

Ralph is interested in furthering his understanding regarding the impact of science on society and the economy. Ralph believes the idea everything is information is compactly and richly illustrated by quantum teleportation and recognizes quantum entanglement (rich interactions among components) is a central feature.

Required:

1. Create an entangled state by $CnotH_1|00\rangle = |\beta_{00}\rangle = \frac{1}{\sqrt{2}}(|00\rangle + |11\rangle)$. The first qubit of the entangled pair resides with Alice, the second qubit resides with Bob. Alice and Bob may be separated by considerable distance.

2. Combine an unknown state $|\psi\rangle = \alpha|0\rangle + \beta|1\rangle$ with $|\beta_{00}\rangle$ to form $|\psi\rangle|\beta_{00}\rangle$ or $\frac{1}{\sqrt{2}}(\alpha|000\rangle + \alpha|011\rangle + \beta|100\rangle + \beta|111\rangle)$. Neither Alice or Bob knows what state $|\psi\rangle$ is in. The first two qubits, $|\psi\rangle$ and the first qubit of the entangled pair, reside with Alice.

3. Apply H_1Cnot to Alice's pair of qubits. (Alice can only operate on the qubits residing with her.)

4. Measure Alice's two qubits via the observable
$$\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 2 & 0 & 0 \\ 0 & 0 & 3 & 0 \\ 0 & 0 & 0 & 4 \end{bmatrix}.$$

If the measurement reveals 1, Alice knows the eigenstate is $|00\rangle$ and Alice communicates the measurement result to Bob. What transformation does Bob apply to the cubit in his residence based on Alice's report to recover $|\psi\rangle$?

If the measurement reveals 2, Alice knows the eigenstate is $|01\rangle$ and Alice communicates the measurement result to Bob. What transformation does Bob apply to the cubit in his residence based on Alice's report to recover $|\psi\rangle$?

If the measurement reveals 3, Alice knows the eigenstate is $|10\rangle$ and Alice communicates the measurement result to Bob. What transformation does Bob apply to the cubit in his residence based on Alice's report to recover $|\psi\rangle$?

If the measurement reveals 4, Alice knows the eigenstate is $|11\rangle$ and Alice communicates the measurement result to Bob. What transformation does Bob apply to the cubit in his residence based on Alice's report to recover $|\psi\rangle$?