

The file q4.txt defines kets, operators, and a measurement function for simulating a four qbit quantum computer.

Ket vectors have 16 elements, one element for each of the 16 states represented by four qbits. The following basis kets are defined in q4.txt.

$$\begin{aligned}
|0\rangle &= |0000_2\rangle = (1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0) \\
|1\rangle &= |0001_2\rangle = (0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0) \\
|2\rangle &= |0010_2\rangle = (0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0) \\
|3\rangle &= |0011_2\rangle = (0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0) \\
&\vdots \\
|15\rangle &= |1111_2\rangle = (0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1)
\end{aligned}$$

Operators are 16×16 matrices that rotate kets. The following operators are defined in q4.txt.

Cmn Controlled not (CNOT) operator, m is the control qbit, n is the target qbit.

Hn Hadamard operator on qbit n .

Xn Pauli X (NOT) operator on qbit n .

Yn Pauli Y operator on qbit n .

Zn Pauli Z operator on qbit n .

Function M measures the final state by drawing a graph of the probability for each of 16 states.

$$M(\psi)$$

Quantum algorithms are expressed as sequences of operators applied to the initial state $|0\rangle$. The operator sequence should be read backwards, from right to left, although the direction makes no difference mathematically.

Deutsch-Jozsa algorithm

Let f be the oracle function. Then the Deutsch-Jozsa algorithm is

$$\psi = H_2 H_1 H_0 f H_3 X_3 H_2 H_1 H_0 |0\rangle$$

Bernstein-Vazirani algorithm

Let f be the oracle function. Then the Bernstein-Vazirani algorithm is

$$\psi = H_2 H_1 H_0 f Z_3 H_3 H_2 H_1 H_0 |0\rangle$$