The file q4.txt defines kets, operators, and a measurement function for simulating a four qbit quantum computer. See eigenmath.org/q.c for the program that generates q4.txt.

Kets are unit vectors in $\mathbb{C}^{16}$. The dimension is 16 because four qbits corresponds to 2^4 basis states. Qbit numbering is $|q_3q_2q_1q_0\rangle$. 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 ket vectors. (A ket always has unit length.) The following operators are defined in q4.txt.

C_{mn} Controlled not (CNOT) operator, m is the control qbit, n is the target qbit.

H_n Hadamard operator on qbit n.

X_n Pauli X (NOT) operator on qbit n.

Y_n Pauli Y operator on qbit n.

Z_n 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 an operator (16×16 matrix) that operates on q_3 in a manner consistent with a constant or balanced oracle. 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 an operator (16×16 matrix) that operates on q_3. Then the Bernstein-Vazirani algorithm is

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