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.

Ket vectors have 16 elements, one element for each of the 16 states represented by four qbits. Qbit order is $|q_3 q_2 q_1 q_0\rangle$. 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 a constant or balanced oracle such that $q_3 = f(q_0, q_1, q_2)$. Then the Deutsch-Jozsa algorithm is

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

where f is a 16×16 matrix.

Bernstein-Vazirani algorithm

Let f be an oracle (16×16 matrix) such that $q_3 = f(q_0, q_1, q_2)$. Then the Bernstein-Vazirani algorithm is

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