
Simulating Quantum Computing with Linux and FOSS

By Kiran Thakur

Presented remotely on 10/21/2020 for Boston Linux & Unix User Group.

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Introduction

Undergraduate Research Assistant at the Wearable Biosensing Lab under Professor Kunal Mankodiya

Research with smart prosthetics, 3D printing, haptic feedback systems, and applications of machine learning

Special Topics research study under Professor Leonard Kahn, Professor of Theoretical Physics

Research in linear optics, photonic band gaps, physical implementations of quantum systems, and quantum computing

Computation Will Guide The Sciences

“...the computer will do exactly the same as nature. If this is to be proved and the type of computer is as I've already explained, then it's going to be necessary that everything that happens in a finite volume of space and time would have to be exactly analyzable with a finite number of logical operations”



-Richard Feynman, American Theoretical Physicist

“As soon as an Analytical Engine exists, it will necessarily guide the future course of the science. Whenever any result is sought by its aid, the question will then arise by what course of calculation can these results be arrived at by the machine in the shortest time?”

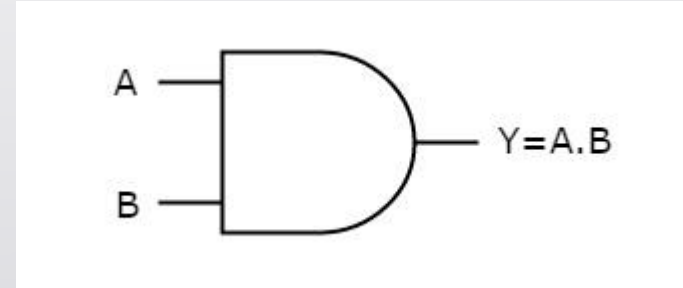
-Charles Babbage

What is Quantum Computing?

- Application of Quantum mechanics to perform logical operations
- Performing calculations based off the probability of the state
- Parable of the Sock

Going Beyond Classical Computing

- cBits
 - (Classical) Bits are referred as cbits
 - Boolean algebra applied to perform operations
 - Calculations are DETERMINISTIC
- quBits
 - Whats next???






Quantum Computers... and Quantum Logic?

- Quantum bits, or Qubits, can be represented as a 0 , 1, or the superposition of the two
(ie. $|0\rangle$, $|1\rangle$, $|\psi\rangle = \alpha |0\rangle + \beta |1\rangle$)
- Quantum “logic” → linear operators (represented by matrices)
- Superposition allows for NONDETERMINISTIC problems to be solved

Bernstein-Vazirani Algorithm

- SPECIFICALLY for determining an unknown or secret number
- Utilizes two universal gates, Hadamard gate and Pauli-X gate
- Hadamard gate puts qubits into superposition, Pauli-X gate inverts the qubit (CNOT gate entangles the qubits)
 - Application of Quantum teleportation (No Cloning Theorem)

Gate	Notation	Matrix
NOT (Pauli- X)		$\begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix}$
Hadamard		$\frac{1}{\sqrt{2}} \begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix}$

CNOT (Controlled NOT)		$\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & 0 & 1 & 0 \end{bmatrix}$
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Using FOSS To Simulate Quantum Computing



- Qiskit
 - Python code in a Jupyter Notebook
 - Able to run on classical computers in simulation and (with the hardware) real quantum computers
 - Apache 2.0 Licensed

<https://github.com/Qiskit/qiskit.git>
<https://qiskit.org/>

qiskit 0.23.0
see release notes

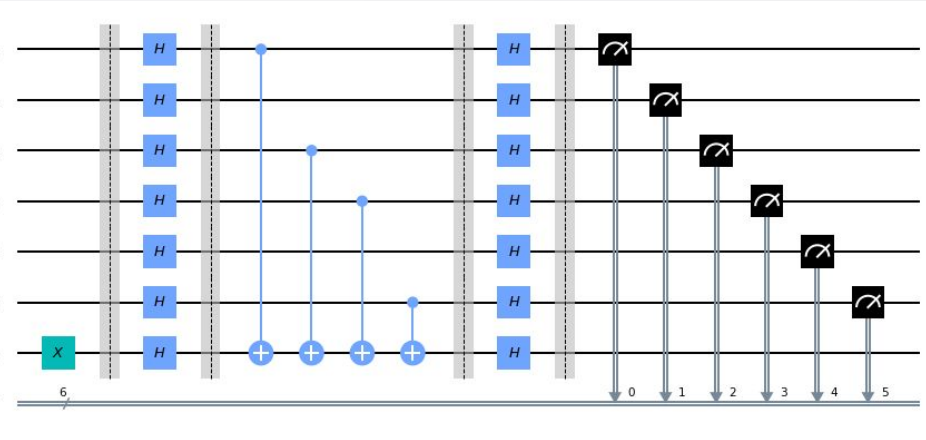
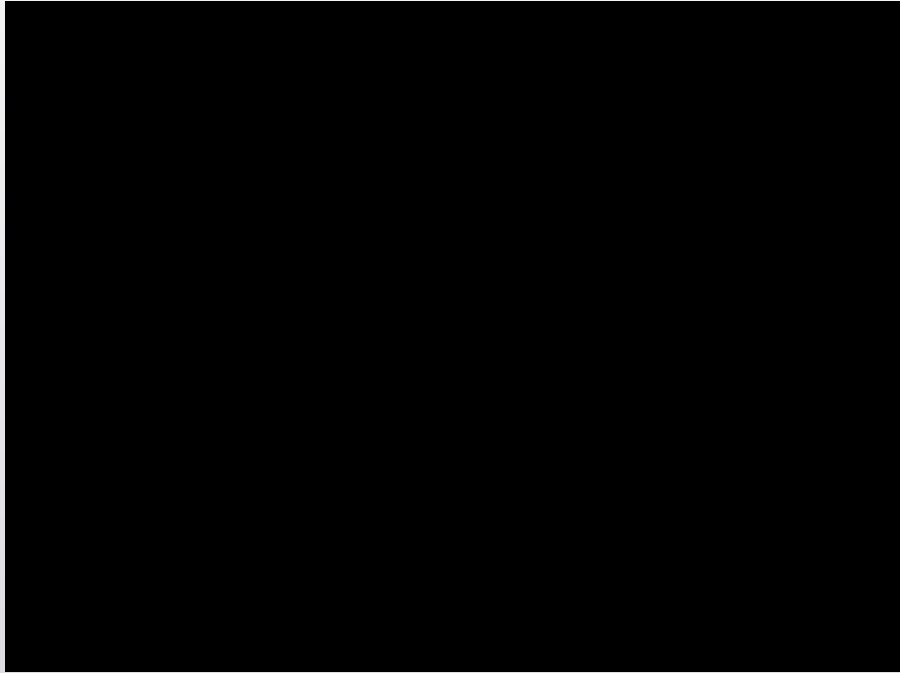
Open-Source Quantum Development

Qiskit [kiss-kit] is an open source SDK for working with quantum computers at the level of pulses, circuits and algorithms.

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Demo



Applications and Hurdles

- Quantum cryptography for encryption/decryption (Shor's Algorithm)
- P vs NP problems
- Machine learning and neural networks
- Decoherence is still problematic → any wave interferes with computation!
- Physical system limitations → Quantum optics? Superconductors?

Contact



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Research Areas :

Quantum optics, superconducting quantum computing, quantum algorithms and cryptography methods