

Python quantum programming languages

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Overview

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References

- Python based quantum programming libraries
- Tried programming the common programs (e.g. Grover's, Shor's, etc.)
- Tried compiling a simple program for different hardware platforms (i.e. with gate restrictions, etc.)
- We've written a programming guide – we're currently reviewing it

```
# Do quantum stuff
qvm = QVMConnection()
qprog = Program()

# do X on q1, q3, q7
# remember HZH is X
qprog.inst(H(1), Z(1),
           → H(1))
qprog.inst(X(3))
qprog.inst(X(7))
# do measurement over
#   all 8 qubits
for i in range(0, 8):
    qprog.measure(i, i)
```

Short comparison

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What is there

- Focussed on quantum circuits
- Apply gates to specific qubits
- Classical control in the same source code
- Python syntax is beginner friendly
- Simulators are available
- Hardware compilers are available

What is lacking

- Some languages target specific hardware
- Some simulators are cloud based and require accounts
- Lack of support for custom unitaries
- Compilers are not highly developed
- No real quantum programming constructs (e.g. quantum if etc.)

Cloud based quantum computing

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References

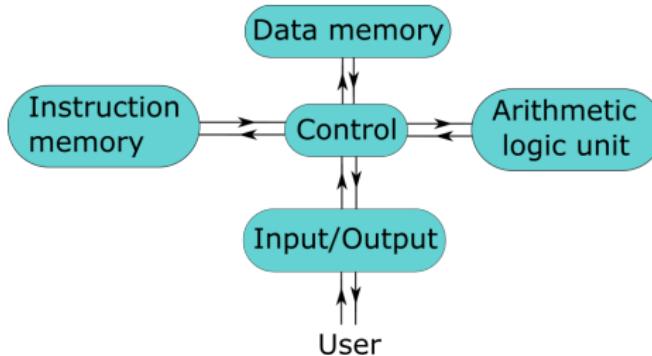
- The superconducting qubit developers (IBM, Rigetti, Google, etc.) have made their hardware accessible through the cloud.
- Released software written in Python for use on their simulators and hardware.
- We found the connection would time out for moderate sized quantum circuits.

Structure of classical computers

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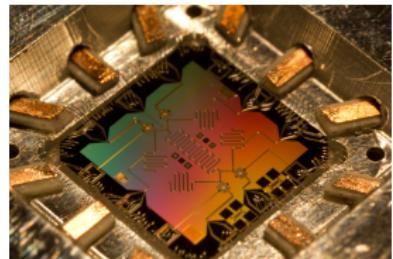
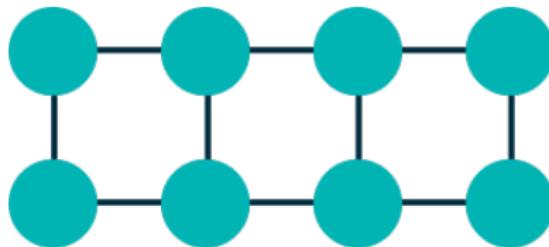
- Classical computers have a lot of internal structure – they are not just a collection of addressable bits.
- Classical computers are controlled using an instruction set, which has elementary operations for arithmetic, control, moving data around, etc.

Structure of quantum computers

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- Quantum processing units (QPUs) currently comprise a lattice of qubits which can be manipulated and measured.
- The only 'instructions' which can be performed are qubit initialisation, gate operations, and measurement
- Will QPUs eventually involve higher level structures like in the classical case? This will determine the type of languages that will control the devices

Conclusion: long term programming languages

- The structure of long term languages depends on the structure of long term quantum computers
- We need a quantum instruction set that isn't just listing gates. We want to see coherent **addition**, **multiplication**, **exponentiation**, etc. Possible also coherent **branching?**
- Don't see Python being the long term quantum language – there's no need to wrap assembly language in high level syntax.
- Existing Python libraries not built to be scalable languages. Heavy focus on quantum circuits, not useful for new algorithms.

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