

# Python quantum programming languages

John Scott, Oliver Thomas

Quantum Engineering CDT  
University of Bristol

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# Overview

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programming  
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Oliver Thomas

References

- Python based quantum programming libraries
- We tried to program the common programs (e.g. Grover's algorithm, Shor's algorithm, etc.)
- We tried compiling a simple program for different hardware platforms (i.e. with gate restrictions, etc.)
- We've written a programming guide - under an internal review

```
# 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

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

# Cloud based quantum computing

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References

IBM recently introduced their new API [1] which uses JSON files to control runs. They have added pulse shaping.<sup>1</sup>

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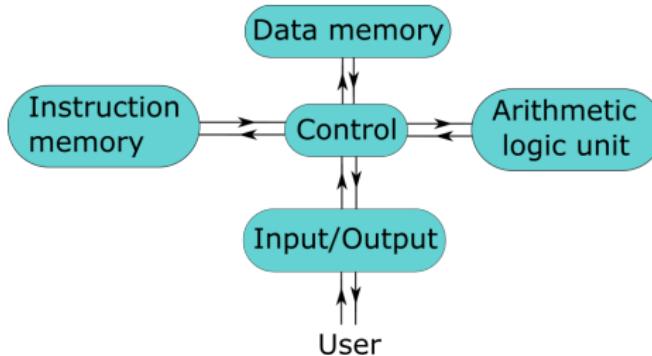
<sup>1</sup>way to specific and the examples look incredibly confusing

# Structure of classical computers

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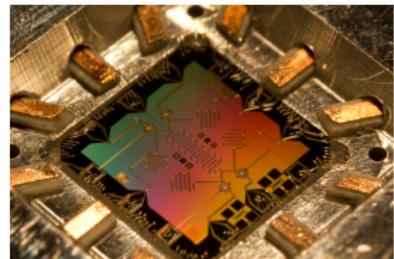
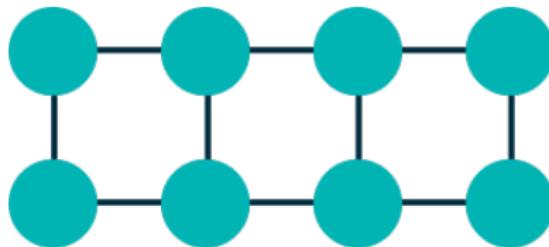
- Classical computers have a lot of internal structure – they are not just a collection of addressable bits.
- Classical computers are controlled using an instruction set, which has elementary operations for arithmetic, control, moving data around, etc.

# 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

# Long term programming languages

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References

- The structure of long term languages depends on the structure of long term quantum computers
- Don't see Python being the long term quantum language
- Existing Python libraries not built to be scalable languages. Heavy focus on quantum circuits <sup>2</sup>
- Need a quantum instruction set that isn't just listing gates

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<sup>2</sup>I don't think thinking in terms of quantum circuits is useful for new algorithms

# The

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References

# References

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References

- [1] David C McKay, Thomas Alexander, Luciano Bello, Michael J Biercuk, Lev Bishop, Jiayin Chen, Jerry M Chow, Antonio D Córcoles, Daniel Egger, Stefan Filipp, et al. Qiskit backend specifications for openqasm and openpulse experiments. *arXiv preprint arXiv:1809.03452*, 2018.