

Building a Compiler for Quantum Computers

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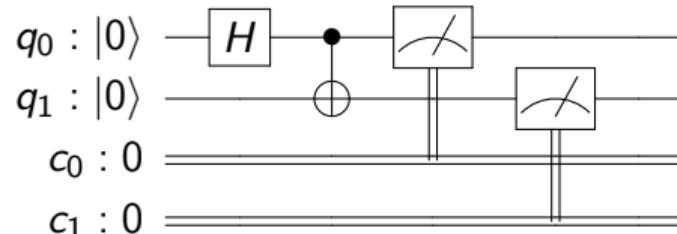
<https://github.com/mtreinish/quantum-compilers>

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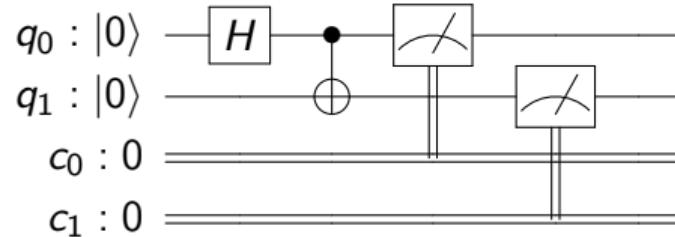
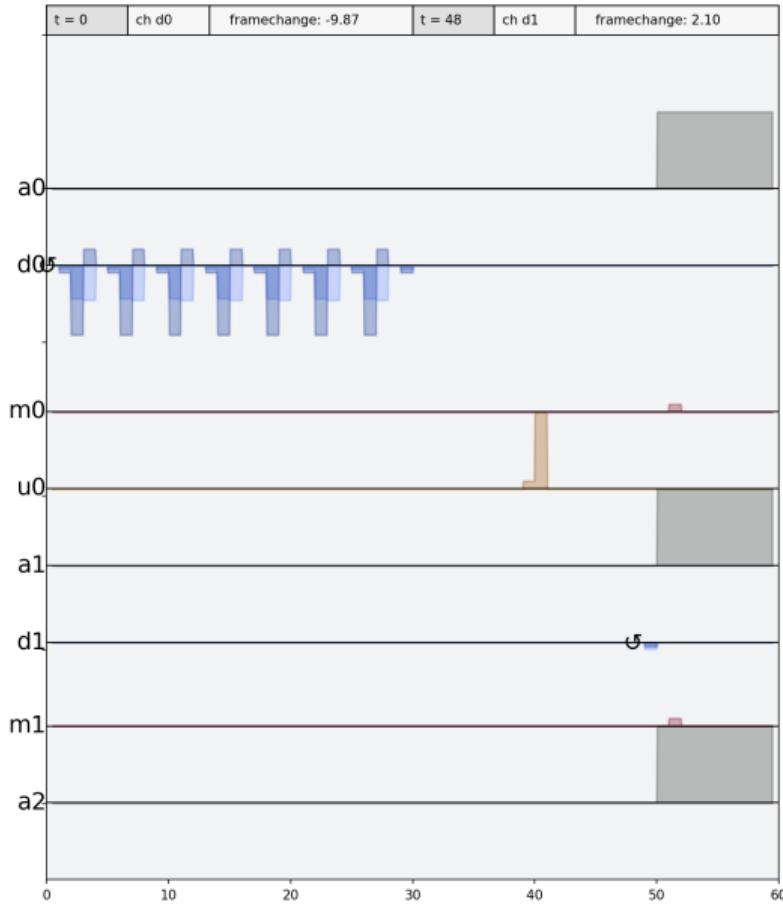
Quantum Circuits

OpenQASM

```
OPENQASM 2.0;
include "qelib1.inc";
qreg q[2];
creg c[2];
h q[0];
cx q[0],q[1];
measure q[0] -> c[0];
measure q[1] -> c[1];
```



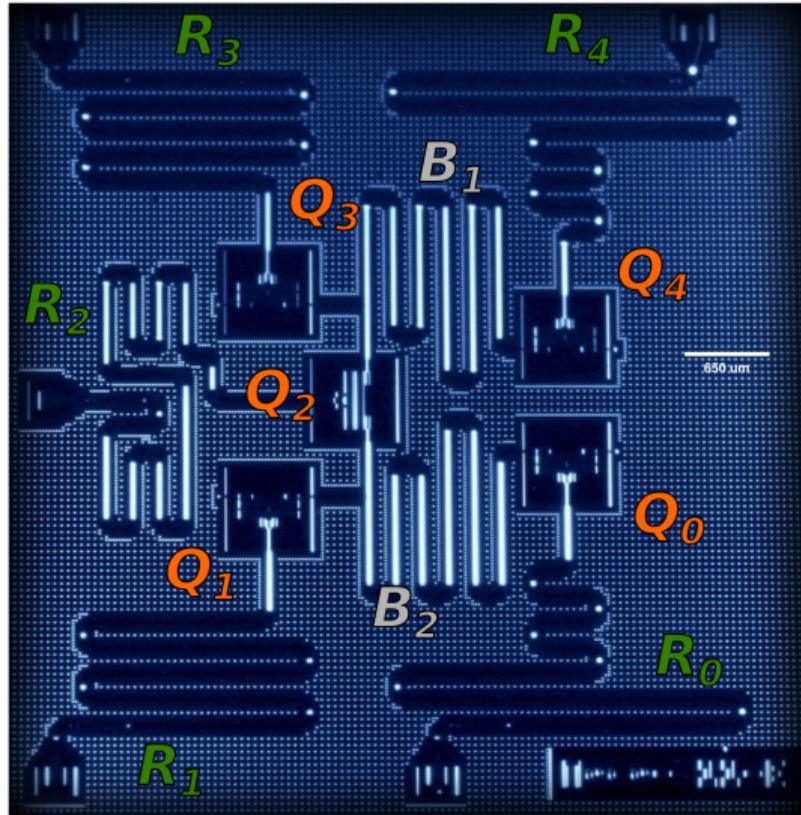
Pulse Level Programming



Qubit Connectivity

- ▶ Qubits in a device have limited connectivity
- ▶ For multi-qubit gates this means we can only run them between those qubits
- ▶ Need to use SWAP gates to move state around

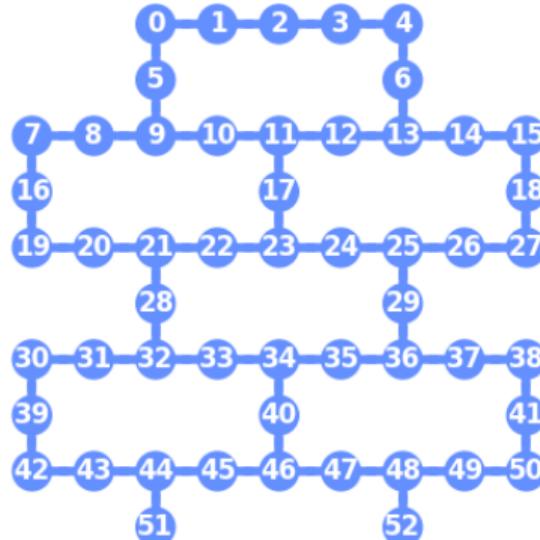
IBM Q 5 Yorktown



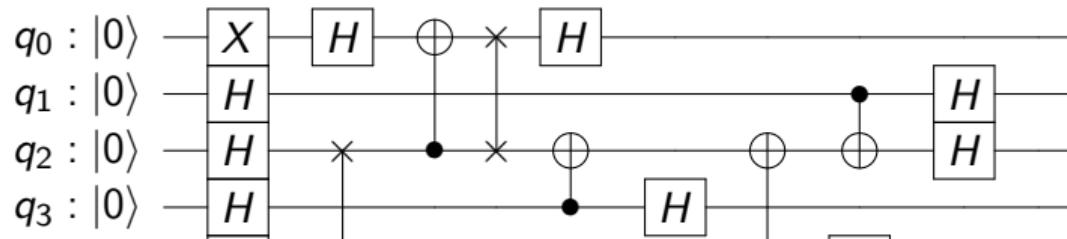
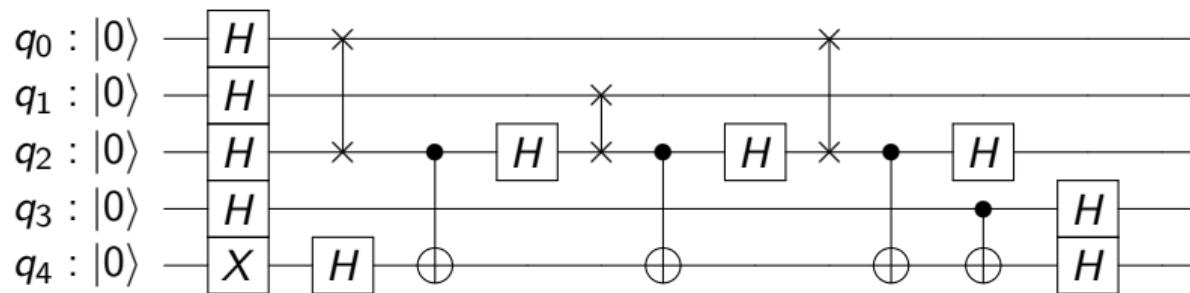
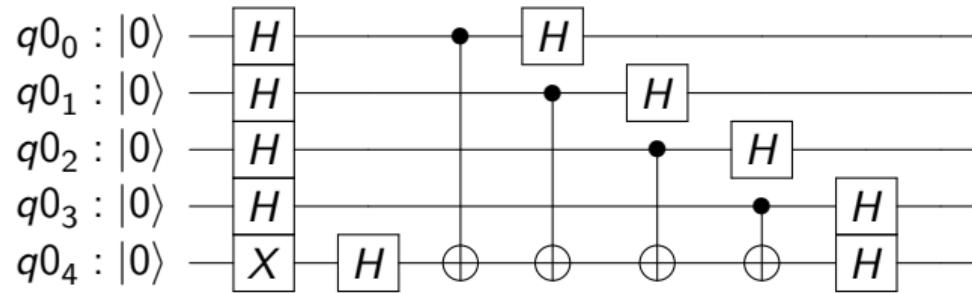
Qubit Connectivity

IBM Q 53 Rochester Coupling Map

- ▶ Qubits in a device have limited connectivity
- ▶ For multi-qubit gates this means we can only run them between those qubits
- ▶ Need to use SWAP gates to move state around



Mapping



Basis Gates

Unrolling

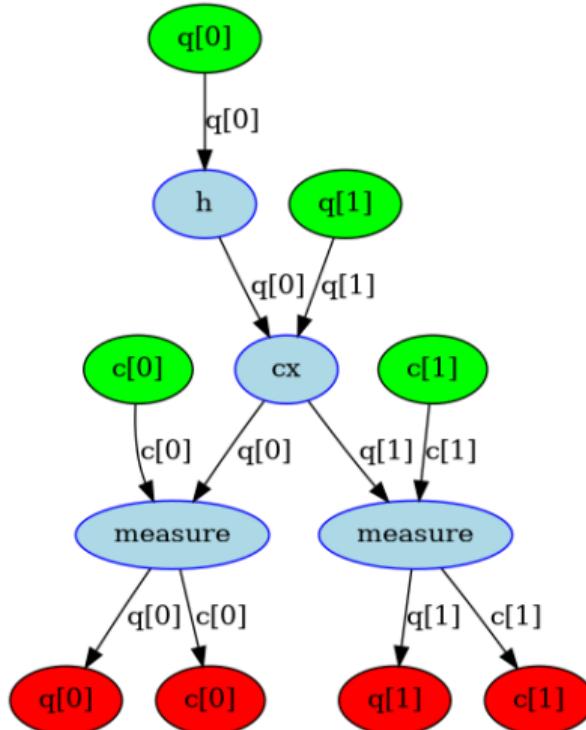
Qiskit Terra

- ▶ Is the base layer for working with quantum computers provides interface to hardware and simulators
- ▶ Provides an SDK for working with quantum circuits
- ▶ Compiles circuits to run on different backends
- ▶ Designed to be backend agnostic and work with any quantum hardware or simulator
- ▶ Written in Python

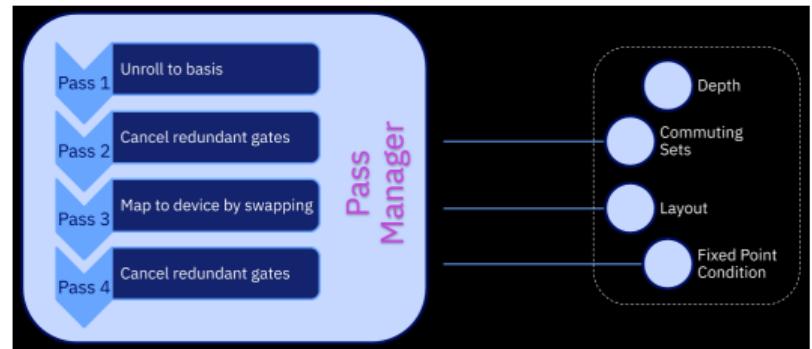


The DAG

- ▶ Compiler represents circuits as a DAG
- ▶ Each node in the DAG is an operation, an input, or an output
- ▶ Each edge corresponds to a qubit or classical bit



Pass Manager



Types of passes

Transformation Passes

- ▶ Can alter the DAG during execution
- ▶ Read-only access to the property set
- ▶

Analysis Passes

- ▶ Can alter the property set
- ▶ Read-only access to the DAG

The Unroller

Optimize 1Q Operations

Quantum Volume¹

¹<https://arxiv.org/abs/1811.12926>

Conclusions

- ▶ similar but different

Where to get more information

- ▶ These Slides: <https://github.com/mtreinish/quantum-compilers>
- ▶ Qiskit: <https://qiskit.org/>
- ▶ Qiskit Terra on Github: <https://github.com/Qiskit/qiskit-terra>
- ▶ IBM Q Experience: <https://quantum-computing.ibm.com>
- ▶ Tutorials on Quantum Computing and Qiskit:
<https://github.com/Qiskit/qiskit-tutorials>

BACKUP SLIDES