When open source meets quantum computing

Mark Fingerhuth

FOSDEM 2019
Brussels, Belgium
February 2-3, 2019
Quantum computing is happening and it’s happening open source!
Plenty of quantum hardware ("QPDs") available today...
Plenty of quantum hardware ("QPU")s available today...

Google

IBM

D-Wave

IonQ

Intel

Xanadu

Rigetti
There even is a incubator program for quantum software startups!

Quantum Machine Learning Program

Mission

By 2022 the QML Program will have produced more well-capitalized, revenue generating quantum machine learning software companies than the rest of the world combined. The majority of these will be based in Canada.

Applications are open now!
In QC everyone is chasing exponential speedups over classical algorithms

Calculating the Thermal Rate Constant with Exponential Speed-Up on a Quantum Computer

Daniel A. Lidar and Haobin Wang
Department of Chemistry, The University of California, Berkeley, CA 94720

Exponential algorithmic speedup by quantum walk

Andrew M. Childs,1,* Richard Cleve,2,† Enrico Deotto,1,‡ Edward Farhi,1,§ Sam Gutmann,3,¶ and Daniel A. Spielman4,**

Eigenvector Approximation Leading to Exponential Speedup of Quantum Eigenvalue Calculation

Peter Jaksch and Anargyros Papageorgiou
But there is large amounts of software engineering outstanding in order to enable useful real-world applications that harness these speedups.
There is already a mesmerizing diversity of quantum open source projects and there is a curated list:

https://github.com/qosf/os_quantum_software
We set out and did an extensive review of the current state of quantum open source software...

and here is what we found.
Quantum project selection criteria

- We checked >60 quantum software repositories

26 quantum software projects were selected based on these criteria.

Main reason for exclusion was contributor count and lack of external interest.
Results: Open source licences

- >90% of the projects used permissive (open) licences
- 65% of the projects chose the permissive Apache-2.0 licence
- Only two projects are released under copyleft licences

Community seems open with respect to commercial use of their software.
Results: Documentation analysis

- Most projects have good source code documentation and README files
- **Major shortcomings** in changelogs, extensive per-feature user documentation
- **Lack of hands-on tutorials** that show application of the software
Static analysis of quantum software

Writing high-quality code and testing is crucial.

- 23 out of 26 projects used automated test suites
- Average code coverage was found to be 75%
- Median code coverage was 87% (standard: >85%)
Static analysis of quantum software

Responding to issues and pull requests is important for building a healthy ecosystem.

- Issues and pull requests without answer for 30 days are considered ignored
- We measured attention rate for all projects
  \[ \text{AR} = 1 - \frac{\text{unanswered I & PRs}}{\text{total I & PRs}} \]
Static analysis of quantum software

Responding to issues and pull requests is important for building a healthy ecosystem.

- Issues and pull requests without answer for 30 days are considered ignored.
- We measured attention rate for all projects
  \[
  AR = 1 - \frac{\text{unanswered I & PRs}}{\text{total I & PRs}}
  \]

Commercial backed project are not better at replying to issues and pull request than community efforts!
Results: Community analysis

- **GitHub’s community profile** is a quantitative measure for best practices within a project.
- Only 4 projects scored 7/7 on this metric.

**Code review is important to maintain quality code.**
- 10 out of 26 projects do **not review the code** of core contributors.

**Support & discussion channels:**
- We identified a **lack of developer-centric discussion forums** to drive design decisions.
- Qiskit is the only project with a **public roadmap**.

<table>
<thead>
<tr>
<th>Checklist</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>✔ Description</td>
<td></td>
</tr>
<tr>
<td>✔ README</td>
<td></td>
</tr>
<tr>
<td>✔ Code of conduct</td>
<td></td>
</tr>
<tr>
<td>✔ Contributing</td>
<td></td>
</tr>
<tr>
<td>✔ License</td>
<td></td>
</tr>
<tr>
<td>✔ Issue templates</td>
<td></td>
</tr>
<tr>
<td>✔ Pull request template</td>
<td></td>
</tr>
</tbody>
</table>

Screenshot of GitHub community profile
This type of research gets outdated quickly...
This type of research gets outdated quickly...

...so we decided to automate the evaluation process and continuously publish the results online:

https://qosf.org
Physicists are great with equations but not necessarily with code.

One bad programmer can easily create two new jobs a year.

The field needs skilled software engineers like you to come in and help build the software for future quantum computers!
ONE DOES NOT SIMPLY
LEARN QUANTUM MECHANICS
ONE DOES NOT SIMPLY LEARN QUANTUM MECHANICS

WHEN YOU HEAR SOMEONE SAY THEY UNDERSTAND QUANTUM MECHANICS
ONE DOES NOT SIMPLY

IF YOU TRY TO UNDERSTAND QUANTUM MECHANICS

YOU WON'T UNDERSTAND QUANTUM MECHANICS

When someone says

Quantum mechanics is easy.

When you hear someone say

I think I can safely say

they don't understand quantum mechanics

That nobody understands quantum mechanics
ONE DOES NOT SIMPLY

WHEN YOU HEAR SOMEONE SAY

Is quantum mechanics really that hard?

YOU WON'T UNDERSTAND QUANTUM MECHANICS

Quantum mechanics is easy.

THAT NOBODY UNDERSTANDS QUANTUM MECHANICS
You can learn how to program a QPU in less than a day!

We are hosting a quantum workshop @ FOSDEM tomorrow!

https://qosf.org/fosdem-19-qc-workshop
The elephant in the quantum room
The elephant in the quantum room
The elephant in the quantum room
The elephant in the quantum room

standardization?
Unifying frameworks are key

Eclipse XACC

+ ProjectQ

IBM QPU
Rigetti QPU
D-Wave QPU
TNQVM Simulator

https://github.com/eclipse/xacc
Quantum Open Source Foundation - QOSF
Quantum Open Source Foundation (QOSF)

"Supporting the development and standardization of open tools for quantum computing."

This is a community effort between academia and industry and we’re looking for advocates, advisors, contributors, partners and funding!
Conclusions

- With NISQ devices becoming available, **quantum software engineering** is becoming increasingly important
- Abundance of academic and commercially-backed open source projects
- **Most projects lack proper documentation** making it hard for newcomers to start with quantum software engineering
- **Lack of public development roadmaps** with most decision being made internally
- **Shortage of quantum compiler projects** (either proprietary or within full-stack libraries)
Conclusions

- With NISQ devices becoming available, **quantum software engineering** is becoming increasingly important
- Abundance of academic and commercially-backed open source projects
- **Most projects lack proper documentation** making it hard for newcomers to start with quantum software engineering
- **Lack of public development roadmaps** with most decision being made internally
- **Shortage of quantum compiler projects** (either proprietary or within full-stack libraries)

Overall, there is a **lack of standardization** with each hardware player developing their own full-stack solution. Both, users and developers, would profit immensely if **open standards were developed**.
There is a second FOSDEM day on quantum open source tomorrow!

- Community-built quantum software
- Quantum applications built on top of today’s frameworks
- Quantum hackathon

Find the Sunday schedule for the quantum dev room here: https://qosf.org/fosdem/
Thanks for listening and see you tomorrow to hack quantum!

Find the Sunday schedule for the quantum dev room here: https://qosf.org/fosdem/