HM ◆ Hochschule München University of Applied Sciences

Assignment 01: Introduction

Objectives

- You will get a first impression about Quantum Computing and how it can be used
- You will be a Consultant showing our client how to benefit from Quantum Computing
- You will learn how Quantum Computing can contribute to sustainability
- You will learn how to set up an IBM Quantum account

Requirements

- Notebook or Desktop Computer with access to the internet
- E-Mail account

Solution Steps

Why do we need Quantum Computing?

You are curious about Quantum Computing and its potential to change the world?

Please watch the following video:
https://youtu.be/i4Z3Bb6ObSA

[1]

With increasing data our world is getting more and more complex. As we are facing several large and global problems like climate change, scarcity of resources and food shortages in some regions of the world, we need more powerful computers to address these challenges for example with innovations, simulations and scientific models.

However Classical Computers are limited in computation power as transistors in the devices are already as small as they can be built. Therefore, solving complex and large problems is sometimes not possible as it would take too much time. Quantum Computers are able to provide the required computing power to solve certain problems within a day, for which Classical Computers would need several hundred years.
[2]

The faster calculation time of Quantum Computers also improves the energy efficiency and becomes a game changer in terms of energy consumption relative to computation power.

In contrast to Classical Computers, Quantum Computers do not work on the basis of electrical states (bits), but quantum mechanical states (qubits). As nature speaks the language of quantum mechanics, we are now striving to build computers that are able to do the same. When technology of Quantum Computers is built on the same foundational principles as nature, we will be able to mimic its behavior and harness that power to make an impact on the world around us. In short, quantum mechanics enables us to compute closer to how nature computes. By this means we have the opportunity to revolutionize fields and unlock capabilities to help save our planet [1]. In this context early generation Quantum Computers can contribute to technologies like carbon capture as well as green hydrogen power for combating global warming [4].

You want to figure out how those capabilities can look like in practice? Let's get started with our consulting project.

As part of this Learning Lab you are working as a consultant for the Co-Innovation Lab (www.co-inno-lab.org). Our client, a leading Bavarian car manufacturer, wants to examine business opportunities of Quantum Computers especially in the context of sustainability and CO2 emissions.

General Note: This Learning Lab is designed to be solvable by all individuals regardless of prior knowledge. To have a better idea of the scope of the task, you are provided with an suggested time frame for each task. If you can't come up with a solution in the estimated time, please ask the tutor for help.

Task 1: Climate Case (20 min.)
As the client currently has no experience and limited knowledge about potential use cases for Quantum Computing in his industry, your task is to do a first research for our client to make the topic more tangible. Your research should focus on the use of Quantum Computing (QC) to improve sustainability in the automotive industry.

Please go through the following sources and answer the questions to demonstrate the need of adapting quantum technologies in the automotive industry.

Sources + Questions
Topic 1: Improving Navigation
Article:
> Innovating and optimizing navigation algorithms with help of Quantum Computing; Volkswagen Lisbon Case:
> https://www.volkswagenag.com/en/news/stories/2019/11/where-is-the-electron-and-how-many-of-them.html

Questions:
- How were Quantum Computers used to avoid traffic jams in Lisbon during the WebSummit in 2019?
- For which kind of navigation use cases is Volkswagen currently developing solutions with quantum algorithms?

Topic 2: Developing better batteries
Article:

Quantum Computing innovating automotive industry from a tech company's sight:
https://mediacenter.ibm.com/media/See+how+Mercedes-Benz+is+using+quantum+computers+to+design+better+batteries/1_dm6myi14

Questions:
- Why are we facing obstacles when improving batteries at the moment?
- How can Quantum Computers contribute to solving those problems?

Before we can demonstrate our client how QC works in the real world, we need to get access to IBM Quantum.

Task 2: Creating an IBM account
IBM Quantum is a platform, allowing users access to cloud-based Quantum Computing services. It provides tools for creating and manipulating quantum programs in order to run them on real quantum devices.

To register, please open Quantum Lab in your browser and create an "IBMid":
https://quantum-computing.ibm.com/

Please note: It is suggested to use Google Chrome or Mozilla Firefox for all upcoming tasks, as technical problems occurred when using Safari.
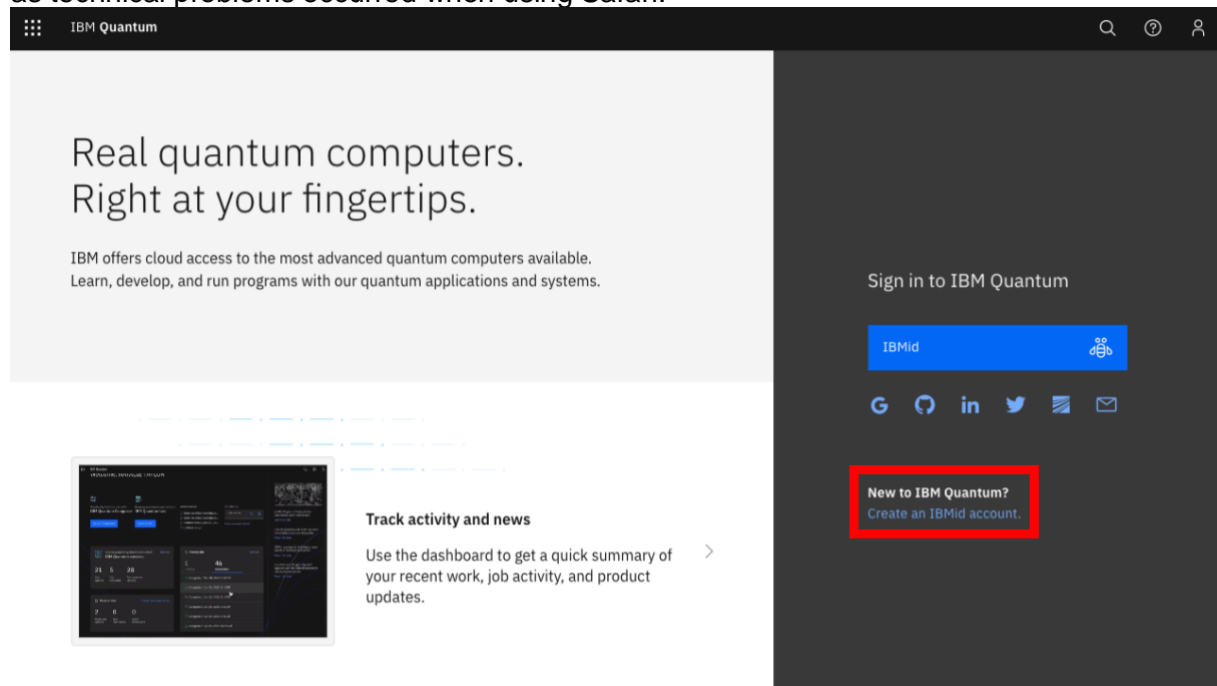
2. Please provide your personal data (name, e-mail address and your password) until the registration is completed.

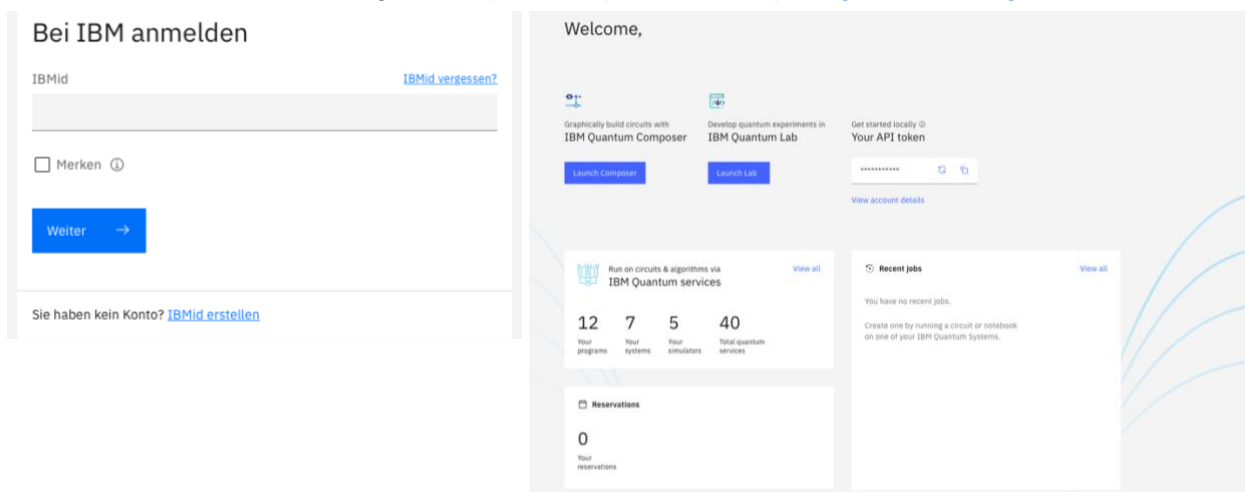3. Please enter the security code if you get asked. IBM has submitted it to your e-mail account.
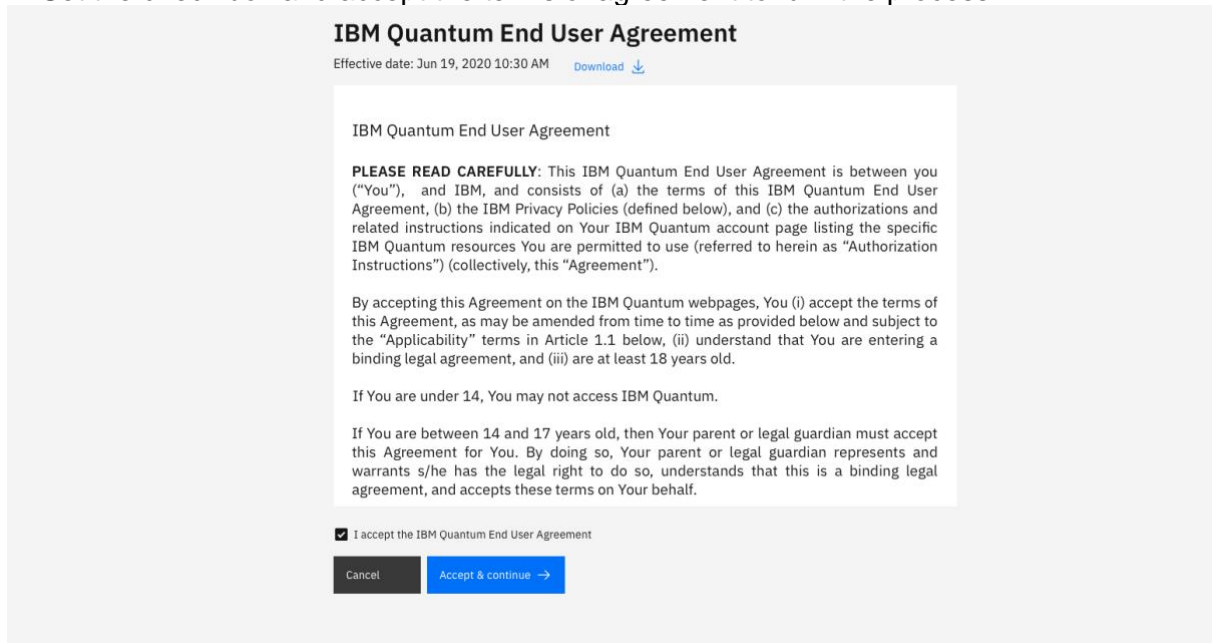
4. Set the check box and accept the terms of agreement to fulfil the process.

5. Congratulations! After setting up your IBM account successfully, you can now access IBM Quantum Lab at the following link: https://lab.quantum-computing.ibm.com/login

Useful Resources for Own Research

1) Economic Impact Quantum Computing in the Automotive Industry

Will quantum computing drive the automotive future?
https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/will-quantum-computing-drive-the-automotive-future

Quantum Computing and battery research from an OEM's point of view:
https://group.mercedes-benz.com/magazin/technologie-innovation/quantencomputing.html

<u>2) General Quantum Computing sources</u>

Why Quantum Computing?: https://news.mit.edu/2020/explained-quantum-engineering-1210

Impact of Quantum Computing to better understand how nature works:
https://www.youtube.com/watch?v=GXZHzjUyAZg

Summarizing the impact of Quantum Computing:
https://www.youtube.com/watch?v=ba88EwG5b0Q

A Quantum Advantage in Fighting Climate Change:
https://www.bcg.com/de-de/publications/2020/quantum-advantage-fighting-climate-change

How quantum computing can help tackle global warming:
https://www.mckinsey.com/business-functions/mckinsey-digital/our-insights/how-quantum-computing-can-help-tackle-global-warming

Retrospective

Please answer the following questions:
1. What are the limitations of Classical Computers?
2. What are the advantages of Quantum Computers compared to Classical Computers?
3. How can Quantum Computing contribute to sustainability in the automotive industry?

Sources

[1] https://www.ibm.com/case-studies/jsr-mitsubishi-keio/
[2] https://www.avg.com/de/signal/cpu-stress-test
[3] https://www.youtube.com/watch?v=GXZHzjUyAZg
[4] https://www.bcg.com/de-de/publications/2020/quantum-advantage-fighting-climate-change