# sdMay23-24 Quantum Computing

Aug 2022 - May 2023

Mid / Late March Report

## Team: Quantum Computing

## Goal: Create a kilo-qubit scale (KQB) **design** for a quantum computer

## Team Members:

- Nicholas Greenwood
- Jacob Frieden
- Emile Albert Kum Chi
- Colin Gorgen (not present, no listed reason)
- Arvid Gusatfson
- Sam Degnan (late due to unknown reasons)

## Advisors:

- Gavin Nop (PhD student) (Late)
- Dr. Jonathan Smith
- Dr. Durga Paudyal

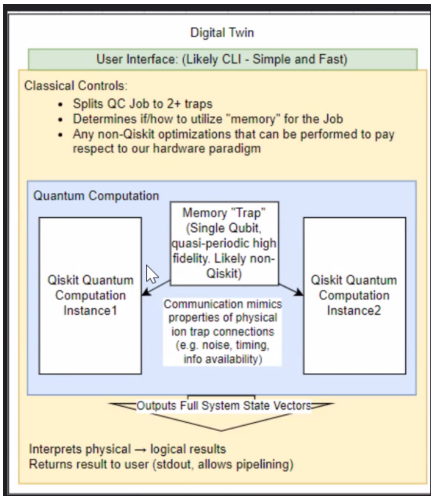
## Agenda: Virtual Meeting

- Software Side Updates **(took up whole meeting)**
    - Jacob
    - Arvid
    - Sam
- Hardware Side Updates (**never reached)**
    - Nick
    - Emilie
    - Colin
- Discuss mid-semester Presentation if time allows and interest is there

## Summary

- Weekly meeting summary, **including accomplishments, pending issues, and individual contributions**
    - Software team has done little in past 3 weeks due to wanting clarification on the following issues:
        - How are we pushing the needle here? How do we utilize the extra qubits to do so?
            - Johnathan's comment: We are thinking in node level, Qiskit (backbone) thinks at trap level
            - Having a dedicated memory trap
            - Parallel computing instances (3-4 traps doing the same thing)
        - Can qubits move physically between traps?
            - Yes, but we don't necessarily have to do that

            - Memory traps would probably need physical transfer in
            - Durga proposed not having the ions move and using different types of ions. Our project is hinged on the Honeywell design which uses YB though.
        - Would we need to produce a quantum circuit for each trap or each node? Do we have the ability to work with the Wiskit API in a multiple-trap sense or do we pretend 1 node = 1 Qiskit trap?
            - Arvid thinks we would need one per node, not one per trap
            - Overall the team is struggling to see how Qiskit maps onto our proposed design, as Qiskit proxies for what we are trying to do aren't well understood
            - 1 Trap = 1 Qiskit circuit
        - How do you propose traps and nodes will communicate with each other?
            - Traps: Physical transfer of ion from one trap to another with some noise added to imply accuracy
                - This could be done using "gates" to simulate the setting of ion values aka transferring
            - Node: transmit information in a physical sense
    - Arvid has made a readme file that lays out what some of the functions and variables of various classes would be
    - Arvid also worked on "NodeLiteral" and "Cycle" Class. A NodeLiteral is the manual version of a node where you describe all operations of the Node over time. Cycles allows you to adjust the time of the simulation
    - Arvid used his software to demonstrate the issue of transferring info (qubits) from trap to trap
        - Qubit can only be represented via tensor products
        - Arvid recommends having a combined tensor vector and treating the 1 Trap = 1 Qiskit circuit
        - Gavin is in favor of not modeling the internal circuit at all, just the ion transfer from circuit to circuit (which can be done classically)
        - Gavin thinks being able to observe the degradation of qubits through X number of gates is important
        - Gavin says Qiskit is not great for the physical transport problem because it deals more in abstract terms and not with physical computer architecture
    - Jacob showed his drawing that he made for the mid-semester presentation

- 

  - Johnathan said the memory should be simulated in Qiskit to, which was highlighted in a paper
  - Emile asked about swapping the states of two atoms, if we could do that that would seemingly solve most of our issues
    - Gavin said you could transmit states between any qubit and a qubit arbitrarily far away
    - A swap gate could be implemented to do exactly that, but the ions have to be adjacent to each other. At that point, you may as well physically swap the ions
    - After running the computer for some time and getting ions entangled, the physically swapping is the only way to transmit states

| **Name** | **Contributions** | **Weekly Hours** | **Total Hours** |
|---|---|---|---|
| Nick | Recorded and edited Mid-Semester slideshow, started looking into paper for relevant ancillary hardware info | 5 | 70 |
| Emile | Finished slides and presented Mid-Semester slideshow, worked on RF circuitry | 7 | 72 |
| Colin | Presented Mid-Semester slideshow, attempted Solidworks update | 3 | 68 |
| Sam | Presented Mid-Semester slideshow, developed question list | 5 | 70 |
| Jacob | Presented Mid-Semester slideshow and supporting materials | 6 | 71 |

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|---|---|---|---|
| Arvid | Presented Mid-Semester slideshow, worked on Readme and instance files | 8 | 73 |

    - Please note: We have not been keeping track of weekly or cumulative hours beforeEarly/Mid March. It seems very micro-manag-y and is not how we like to work. The only reason we have this table in here is to appease course requirements. All numbers are estimates.
- List of any decisions made
    - Look at work from the node level because there's not a good way to have traps communicate with each other via Qiskit
    - Pursue the ion-transfer angle at Gavin's behest
        - Noise + Physical movement
        - Can use linear trap tech to do this, vs having to use segmented rails (which are hard in real life)
        - This is more or less a scheduling problem
- Next steps for the project / Plans for the coming week(s)
    - Software side will flesh out node literal class
        - Look at work from the node level because there's not a good way to have traps communicate with each other via Qiskit
    - Hardware side will continue looking into ancillary hardware components and placement based on paper and Google