Quantum-Ready Visualization Platform

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Domain: Quantum Annealing

Quantum annealing is simulated annealing that takes advantage of quantum properties for solving optimization problems. Specifically, problems in the form of a quadratic unconstrained binary optimization (QUBO).
This is a relatively new field, and very little information visualization work has been completed.

Task:

Visualizing the annealing process and/or results for classical and quantum annealers.

Dataset:

Simulated Quantum Annealing: Abundant data, and ability generate more. Data cardinality is adjustable.
DWave results: Provided by 1QBit. Order of ~1000 reads of results of ~1000 qubits.

Expertise:

Eight month internship with 1QBit. Extremely limited interaction with the quantum side of things, as my project was to create a visualization/abstraction algorithm, where some heuristics could be replaced by an exact quantum solver. My supervisor wrote the exact quantum solvers. Thus, while I have some knowledge of the field, I do not have a grasp of the underlying physics, and that may prove to be a substantial barrier. To overcome that, I will primarily be relying on expertise and consulting with 1QBit employees. In addition, since it is relevant to my interests and career, I will self-learning relevant information through papers and online resources.

Proposed solution:

An extendible quantum-ready visualization platform. This platform would consist of interlinked views, some of which may be applicable to many solvers, and some of which may be specialized to one solver.

Potential Views/Windows For DWave Results (some are general):

- A debugging mode, which would highlight errors.
- Correlations between qubits over multiple reads, contrasted with expected correlations, encoded by colour.
- Highlighting broken chains
- Consistency of qubit values over all reads, encoded by color
- Aggregation for clusters of qubits
- Aggregated per chimera cluster
- Energy landscape
- Energy Spectra
- Degeneracy graph
- Barcode graph of the sample
- Correlation of error
- Variance of energies
- A characterization/summary of how easy/difficult the problem is
- Show properties i.e. fit with boltzmann distribution, fair sampling
- Export feature for derived data
- Vector graphics export for visualizations created

For SQA Process Only:

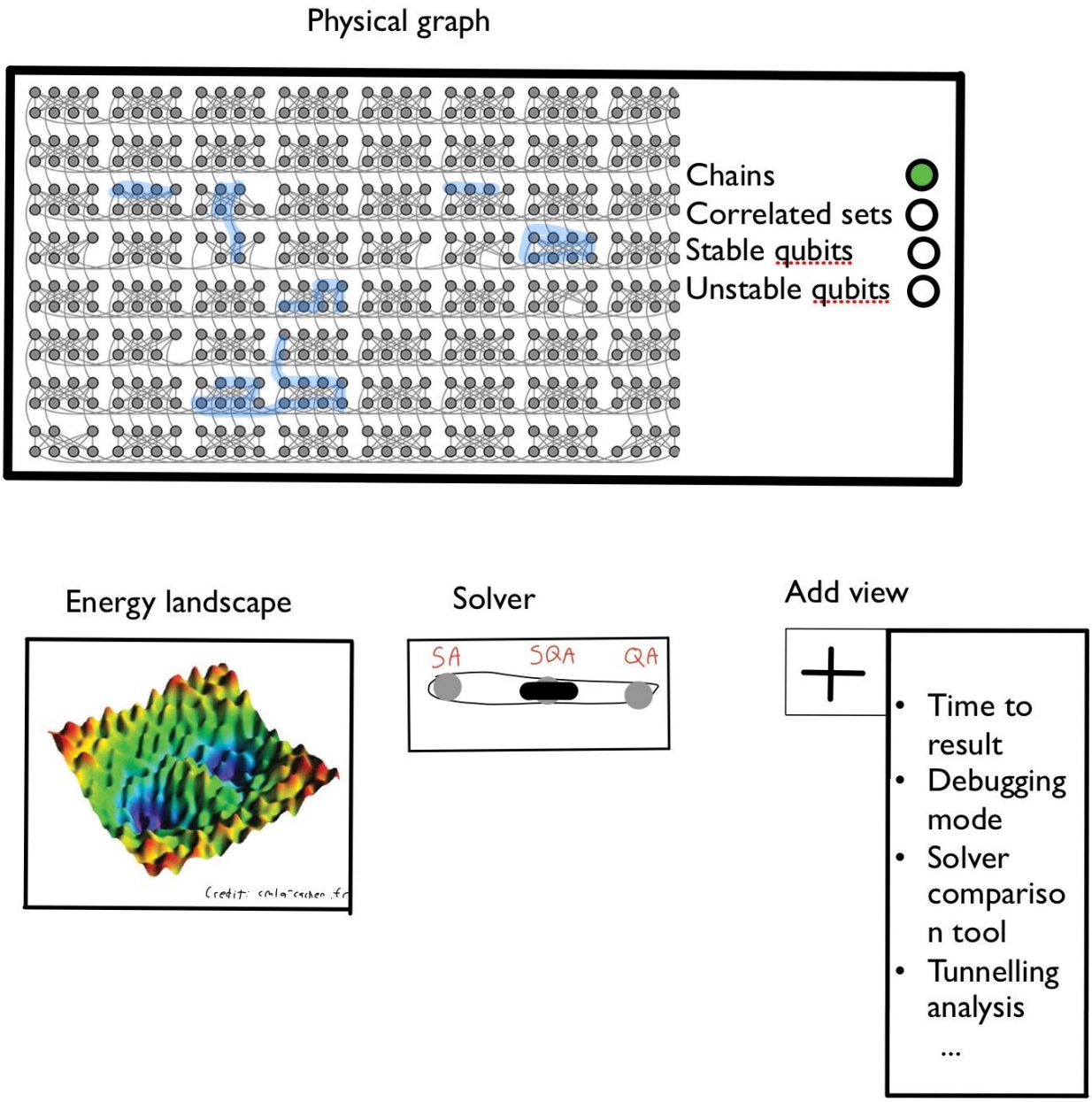
- Time series data, qubit values changing with time
    - Animation
- Highlight highly interactive/correlated cqubits
- Visualize the tunnelings that occurred
- Changing energy landscape

- Parameter adjustment for small problems

Scenario of use:

A user would load in their data, which would be the results of SQA, QA, and/or SA.
Based on the data and solvers supplied, a default set of views would be presented.
The user would then be able to add/remove views that are applicable to their data.
The user will be able to subselect qubits or qubit clusters to examine more closely, and that will be reflected through all views.
After debugging or exploring the data, the user would be able to export what they found.

Illustration:



Implementation:

To be determined:
Likely using D3JS, building upon pre-existing toolkits where possible.

Milestones:

March 8: Submit proposal

March 10: Close inital feedback form

March 15: Abstract tasks from form

March 17: Discuss form results with Jas, formulate long term plan

March 20: Complete task abstraction for final system

March 26: Peer reviews part 1

March 27: Complete review of past work for given tasks

March 31: Complete interim paper [I have Quidditch Canada National Championship as well, so the timing may be tight]

April 4: Peer reviews part 2

April 5: Finalize the system which will be written up

April 15: Finish first draft of formal paper

April 20: Finish good draft of paper

April 25: Present

April 28: Hand in paper

Previous work:

Multi view vis platform:

Yang, Yu, et al. "SNAMP: A multi-sniffer and multi-view visualization platform for wireless sensor networks." *Industrial Electronics and Applications, 2006 1ST IEEE Conference on*. IEEE, 2006.

Spatial heatmaps:

Yang, Yu, et al. "SNAMP: A multi-sniffer and multi-view visualization platform for wireless sensor networks." *Industrial Electronics and Applications, 2006 1ST IEEE Conference on*. IEEE, 2006.

Visualization of quantum annealing:

Boixo, Sergio, et al. "Evidence for quantum annealing with more than one hundred qubits." *Nature Physics* 10.3 (2014): 218-224.