

Qubits 2017: LANL Site Report – “Ising”

Motivation and machine activity

Experience with D-Wave

Future plans



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Operated by Los Alamos National Security, LLC for the U.S. Department of Energy's NNSA

LANL's D-Wave 2X System

- “Ising” operational since Aug. 2016
 - Our first full-year report
 - LANL Technical POC: Scott Pakin
- We’re excited that community is growing



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- Continuing LANL’s long tradition of taking big risks with supercomputing architectures
 - History of procuring large-scale, first-of-their-kind systems
 - Small testbeds sometimes not enough to deeply evaluate a new technology



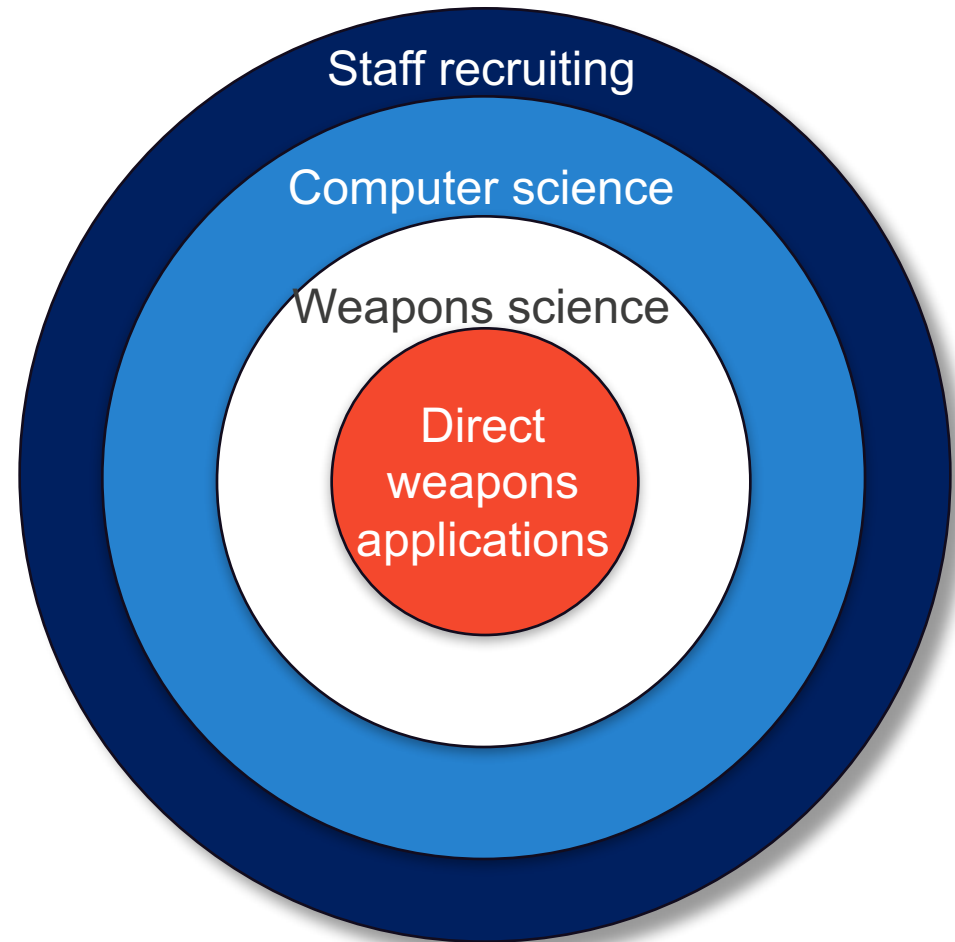
Why LANL Procured a D-Wave 2X System

- **Paid for by NNSA's ASC program**
 - Supports most supercomputer work at LANL, LLNL, and SNL
- **Concern about the end of Moore's Law**
 - How will we get more performance?
 - Considering alternative computing paradigms (primarily quantum and neuromorphic) as possibilities
- **Forward-thinking approach**
 - Invest in new technologies now, *before* the situation becomes dire
 - Perhaps even influence the development of these new technologies
 - For the D-Wave, even if 1K qubits isn't enough to be useful, we want to be ready for future generations that *do* have enough qubits
- **Thanks to Mark Anderson (HQ); Bill Archer, Mike Lang, Jim Lujan (LANL)**



What LANL Hopes to Get Out of Its D-Wave System

- **“Circles of influence”**
 - Outer to inner = more desirable but more challenging and less likely to achieve
- **Representing aspects of weapons physics as optimization problems**
 - Sometimes an approximate answer fast is better than an exact answer eventually
- **Accelerating classical steps**
 - Optimizing data layout to minimize communication
- **Emphasis on workforce and skill sets of the future**



Educating the LANL Workforce

- **Want the D-Wave to be a practical tool**
 - ...not just an apparatus for physics experiments
- **How to get people up to speed?**
- **Internal D-Wave info Web site**
- **Mailing list for discussions**
- **Embedded D-Wave staff**
- **On-site tutorials**
 - Beginner, intermediate, advanced
 - Mostly hands-on but did one in a large auditorium, broadcast it over the Internet, and recorded it for offline viewing
- **Strategic funding investments**
 - Laboratory Directed Research and Development, Directed Research (LDRD-DR): ~\$4.8M for an interdisciplinary investigation of quantum annealing (not just D-Wave)
 - Information Science and Technology Institute (ISTI), “rapid response” calls: ~3 person-weeks for each of a large number of “learn to use the D-Wave” projects, G&A funded



D-Wave “Rapid Response” Projects (Stephan Eidenbenz, ISTI)

Round 1 (June 2016)

1. Accelerating Deep Learning with Quantum Annealing
2. Constrained Shortest Path Estimation
3. D-Wave Quantum Computer as an Efficient Classical Sampler
4. Efficient Combinatorial Optimization using Quantum Computing
5. Functional Topological Particle Padding
6. gms2q—Translation of B-QCQP to D-Wave
7. Graph Partitioning using the D-Wave for Electronic Structure Problems
8. Ising Simulations on the D-Wave QPU
9. Inferring Sparse Representations for Object Classification using the Quantum D-Wave 2X machine
10. Quantum Uncertainty Quantification for Physical Models using ToQ.jl
11. Phylogenetics calculations

Round 2 (December 2016)

1. Preprocessing Methods for Scalable Quantum Annealing
2. QA Approaches to Graph Partitioning for Electronic Structure Problems
3. Combinatorial Blind Source Separation Using “Ising”
4. Rigorous Comparison of “Ising” to Established B-QP Solution Methods

Round 3 (January 2017)

1. The Cost of Embedding
2. Beyond Pairwise Ising Models in D-Wave: Searching for Hidden Multi-Body Interactions
3. Leveraging “Ising” for Random Number Generation
4. Quantum Interaction of Few Particle Systems Mediated by Photons
5. Simulations of Non-local-Spin Interaction in Atomic Magnetometers on “Ising”
6. Connecting “Ising” to Bayesian Inference Image Analysis
7. Characterizing Structural Uncertainty in Models of Complex Systems
8. Using “Ising” to Explore the Formation of Global Terrorist Networks

LANL folks at this meeting span the diversity of our D-Wave activities

- **Quantum Computing Environment**
 - Edif2qmasm – Scott Pakin
 - BQPJSON & Friends – Carleton Coffrin
 - Panel: Dan O'Malley
- **Quantum annealing approaches to graph partitioning on the D-Wave system – Sue Mniszewski**
- **Unsupervised machine learning and facial recognition – Dan O'Malley**
- **Opening the D-Wave quantum box: hidden multi-body interactions and the echo of the chip architecture – Andrey Lokhov**
- **Programming models for the D-Wave system – George Stelle**
- **D-Wave benchmarking made easy: open source tools... - Carleton Coffrin et al.**
- **Tuning Hamiltonians by genetic algorithms – Marcus Daniels**
- **Denny Dahl (LANL^{***})**

Future Directions/ “Advice”

- **A “Broad, not necessarily deep” approach is working for us**
 - Technical diversity is a strength of our user community
 - And our folks are making meaningful contributions to the literature
- **Be patient**
 - It takes time for people to build momentum
- **No alternative to getting people on the machine**
 - Using any and all mechanisms that arise
- **Balance investment in people and hardware**
 - But it is important to stay on the bleeding edge