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Benchmarking Near-term Adiabatic Quantum Computation

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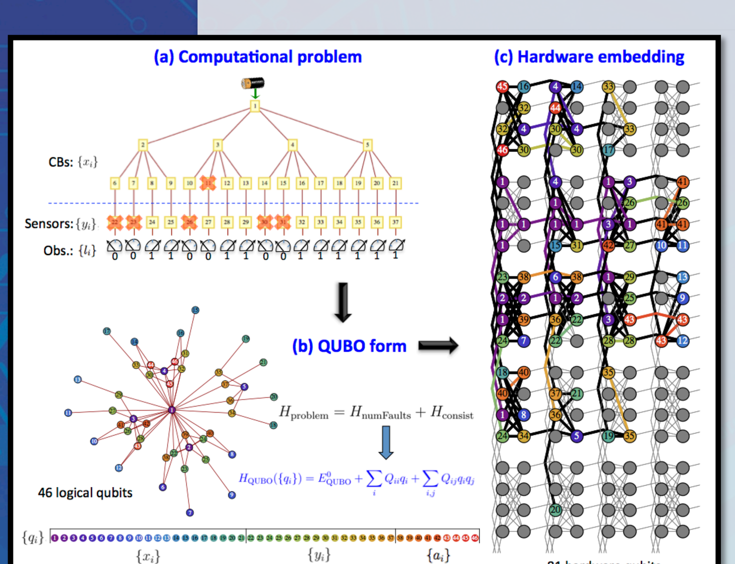
Problem



Fair benchmarking is challenging

How does one fairly compare different algorithms running on vastly different types of computational devices?

Adiabatic Quantum Computing

What is the near-term potential of adiabatic quantum computing, such as D-Wave's systems?

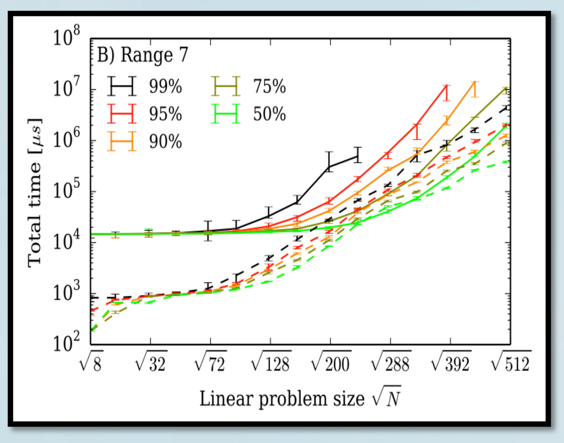
Algorithms, hardware architectures, and underlying physics differ from classical.

Approach

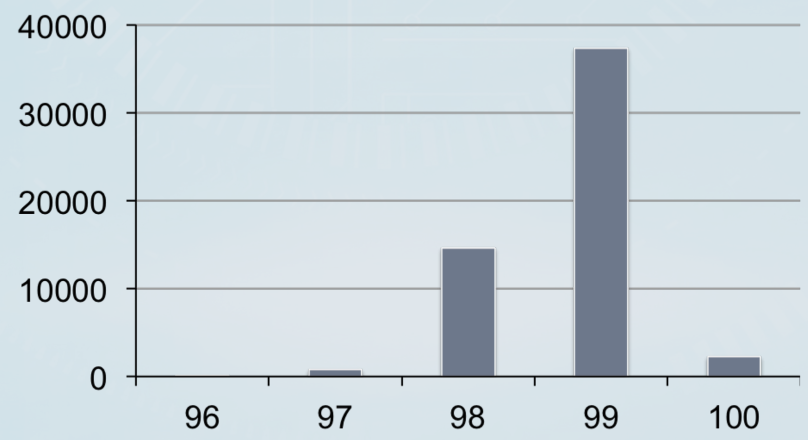
Adopt black-box benchmarking when possible and scrutinize routine assumptions

Example: Which of the two below is a "better" objective for hard discrete optimization problems?

Finding an optimal solution 99% of the time	Finding a solution within 99% of optimal all the time



Hard: exponential scaling



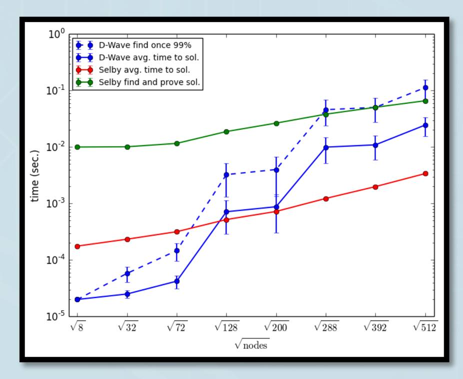
Easy: within 96% of optimal!

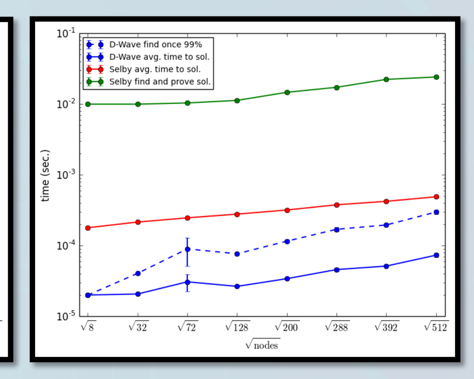
- What is an appropriate measure of success? Which are of practical significance and which lead to good science?
- What classical algorithm(s) should be used for comparison? How should they be configured?
- How should one select appropriate benchmark instances? Bridge the gap between random and real-world instances?

Results

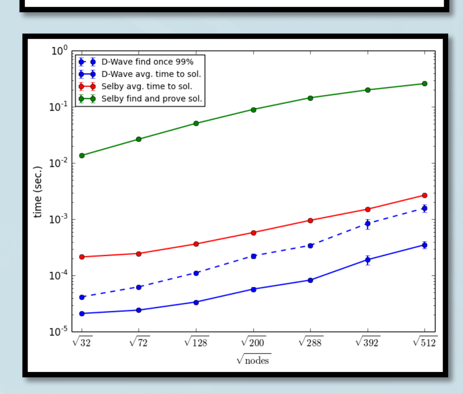
No clear "quantum" speedup

Some problem instances are easy/hard for D-Wave and some are easy/hard for other (classical) heuristics. Empirical complexity varies widely, even for closely related problems.

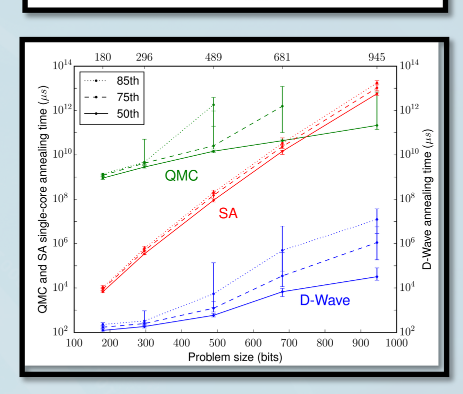




Striking variance in D-Wave performance on two "easy" related graph analysis problems.

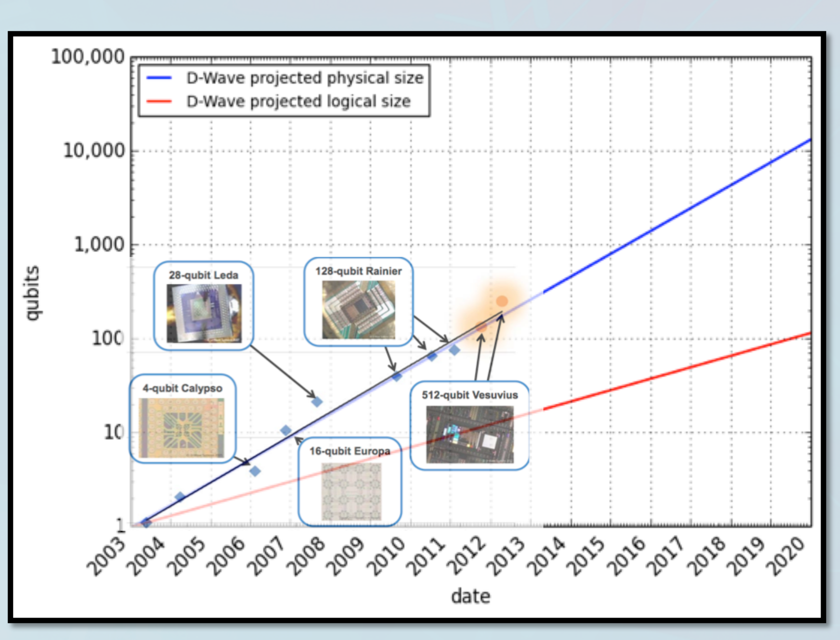


Instances where D-Wave outperforms selected classical algorithms; however, state-of-the-art discrete optimization techniques remain to be compared.



Recent "100-million" speedup by Google is only for a particular classical algorithm, not the best known.

Significance



Most significant hurdles to solving real-world problems: must "compile" logical problem-domain variables to physical qubits and limited-precision couplers.

We give mathematical evidence that worst-case $O(N^2)$ overhead is unavoidable for current D-Wave architecture.

Algorithmic tools for "compiling" real-world problems on emerging quantum architectures are critical!

U.S. DEPARTMENT OF ENERGY

NNSA National Nuclear Security Administration

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