A quantum leap in computing

January 4 2012

The the D-Wave One 128 qubit "Rainer" processor will be used by researchers in USC Dornsife and USC Viterbi to help advance the understanding of quantum computing. Photo by Ziva Santop/Steve Cohn Photography.

When American physicist Richard Feynman in 1982 proposed creating a quantum computer that could solve complex problems, the idea was merely a theory scientists believed was far off in the future.

A few decades later, USC Dornsife researchers are closing in on harnessing quantum computing, a system that takes advantage of computational quirks such as quantum coherence. In the past, quantum decoherence had hindered researchers' attempts to construct a durable quantum computer because the process interferes with quantum properties and renders the system no better than a classical computer. Once a deterrent, decoherence has become an obstacle that can be overcome using quantum tricks developed by USC researchers.

USC scientists can now vet their theories on the world's first commercially available operational quantum computer.

In October, USC founded the USC-Lockheed Martin Quantum Computing Center, which houses the D-Wave One, worth about $10 million and owned by Lockheed Martin. USC and Lockheed Martin will work together to explore the potential of the groundbreaking technology. The center and the adiabatic quantum computer that uses quantum annealing to solve optimization problems operating on a 128 qubit chip-set are located on the USC Information Sciences Institute campus in Marina del Rey, Calif.

“We have been strong in quantum computing for years but this development really is a ‘quantum leap’ for us,” said Daniel Lidar, a professor of chemistry in USC Dornsife with a joint appointment in USC Viterbi School of Engineering, who serves as the center's scientific and technical director, and who initiated the efforts culminating in the arrival of the D-Wave One.

“We believe the ‘Rainier’ processor can pave the way toward solving some interesting algorithm issues such as optimization problems — problems such as machine learning automatic image recognition, and software validation.”

Lidar is separately leading a team conducting research with the support of a $6.25 million Department of Defense Multidisciplinary Research Initiative (MURI) grant issued to five academic institutions under USC leadership. The USC award is part of a $151 million MURI program involving 27 institutions.

“The D-Wave chip is not uncontroversial: many researchers in the community are skeptical regarding its quantum powers,” Lidar said. “An important aspect of the USC research effort will be to settle this controversy.”

Stephan Haas and Paolo Zanardi of USC Dornsife, USC Viterbi faculty members and researchers on the Marina del Rey campus, along with scholars from several universities are working with Lidar.

The center’s findings could lead to designs for superfast computers.

“This center is very big for the quantum information community,” said Zanardi, professor of physics in USC Dornsife and a newly elected fellow of the American Physical Society. “Rather than just writing our theories on the board we can finally check them on a real concrete system.”

Fifteen USC Dornsife and USC Viterbi researchers, along with USC graduates and postdoctoral students are collaborating through the center, trying to better understand the perplexing questions of quantum systems. The group is part of the USC Center for Quantum Information and Science and Technology (CQIST), which serves as the umbrella organization for quantum computing at USC.

Unlike a classical computer, which encodes either a one or a zero using traditional bits, quantum computers rely on qubits, a unit of quantum information associated with the quantum properties of a physical atom. Quantum mechanics can encode the one and zero digits simultaneously — greatly speeding up the system. This property known as superposition — coupled with the quantum states ability to “tunnel” through energy barriers — allows the computer to perform optimization calculations far faster than classical computers. By taking advantage of these properties, a quantum computer in theory could process every possible answer at the same time rather than one at a time.

Researchers will utilize the D-Wave processor to develop methods to construct new quantum optimization algorithms, study the fundamental physics of entanglement and lead experiments in adiabatic quantum computing.

They will also focus on managing decoherence. The same ingredient that drives quantum computers to operate at fast speeds can also be a troublesome stumbling block that kicks quantum particles off superposition, knocking the quantum system back down to that of a classical computer. Envision the quantum system as a point in space and you want the point to follow a precise trajectory. Simple enough except the quantum system's continuous interaction with the environment randomly kicks the points around and off the trajectory. The key is to protect quantum information and control decoherence.

"In order to allow us to outperform classical information processing devices, quantum components have to be very stable," Zanardi said. "It turns out this quantum weirdness is the extra ingredient that gives us computational speedups, compared to classical algorithms that are very fragile."

The development of optimization algorithms can help detect bugs in computer programs. In addition, optimization has the power to find a needle in a haystack, said Haas, professor of physics and astronomy, and vice dean for research in USC Dornsife.

"A model has countless solutions but only one of these is optimal," Haas said. "The optimal solution can be one in a billion. If you have a classical computer it would take forever to find the optimal solution. With a quantum computer the search is very much accelerated."

Haas and Tameem Albash, a postdoctoral research associate in the department of physics in USC Dornsife, are addressing how to control a quantum computing system — or manipulating the inputs to a system to obtain the desired effect on the system's output. By manipulating the magnetic field surrounding the device, the researchers are attempting to find the lowest-energy state of a specific quantum mechanical system, or the ground state property of a specific problem of interest.

"This chip gives us a new opportunity to flex our theoretical muscles," Albash said. "The most interesting aspect of the chip is using it to solve problems we have never been able to answer."

USC researchers are studying the various challenges associated with constructing a quantum computer, so it can be more easily built in the future. The new center paves the way for scholars to advance knowledge in a potentially revolutionary field.

"This technology is going to be a great testing ground for our theories and will enable us to develop our theories in new directions," Zanardi said. "I expect great things out of the processor. We are all excited."

Provided by USC College

Citation: A quantum leap in computing (2012, January 4) retrieved 27 April 2024 from https://phys.org/news/2012-01-quantum.html