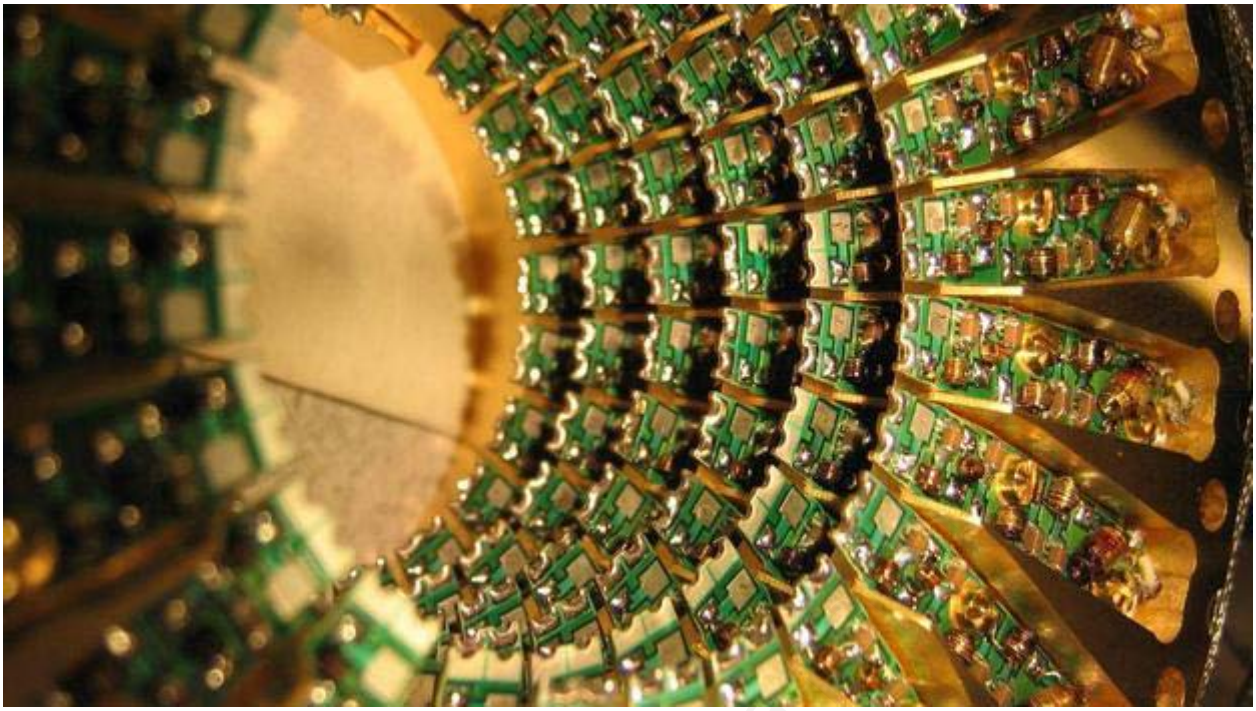
Why Google and the Pentagon want 'quantum computers'
Sharon Weingerger



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The search giant and the US space agency are the latest high-profile backers of an experimental machine that could transform computing. But what do they want it for?

Imagine a computer that can teach your mobile phone to recognize any object it sees, or one that can instantly find optimal travel routes for thousands of planes to avoid a snowstorm and deliver their passengers safely to a destination, or even one that can trawl through millions of social media posts to identify a potential terrorist.

Traditional computers, including supercomputers, require substantial time to crunch that kind of big data. But scientists have long theorised that a computer that harnesses the often-peculiar principles of quantum mechanics could perform these kinds of calculations in a flash, and even solve problems that would take years for a normal computer to churn through.

The scientific community is still debating whether a true quantum computer can ever be built. But one quantum computing company, D-Wave, is forging ahead. It has already won over the Pentagon's biggest weapons builder and has now received another huge endorsement: a three-way collaboration between the US space agency Nasa, search giant Google and the Universities Space Research Association (USRA) that it will buy the second D-Wave Two computer.

D-Wave Systems, a Canadian-based company, came to prominence in 2007 when it stunned the scientific community by announcing that it had built the world's first quantum computer. That claim was also met with scepticism and critics, particularly from scientists who wanted peer-reviewed, published proof of the claims, rather than just a public announcement.

Since that time, however, D-Wave has not only published in the scientific literature, it's also won important customers. The first was Lockheed Martin, the world's largest defence company, which announced earlier this year that it was buying the upgraded version of its computer, the D-Wave Two, a 512 qubit quantum computer (it had bought an earlier version of D-Wave two years ago).

That a defence company would be interested in a quantum computer is not surprising: the Pentagon and US intelligence community have long been the leading funders of quantum

computing in the United States. The spy world, in particular, has looked to quantum computing for its use in encryption and code breaking – a mainstay of the intelligence business.

Weapon software

The interest from the national security world also suits D-Wave. “Frankly, we don’t want thousands of customers, we want a handful of really deep collaborative customers to work on how they can harness this kind of technology, so in the initial phase it’s relatively low volume, low number of customers that we are selective about,” says Vern Brownell, CEO of D-Wave Systems. “On the that list are the DOD and the intelligence community.”

What makes a quantum computer valuable to the military and spy world is the way it makes calculations. A classical computer does useful calculations by processing bits that represent ones and zeroes. But a “standard” quantum computer uses the idea of quantum entanglement – whereby information can exist as both a one and a zero or an infinite number of “superpositions” of the two states at the same time. Effectively these "quantum bits", or qubits as they are known, can work in parallel rather than sequentially, allowing quantum computers to solve certain problems orders of magnitude faster than its classical counterparts.

There are, however, different approaches to quantum computing: D-Wave’s computer is a special type of device based on a technique known as adiabatic quantum computing, which involves using loops of superconducting metal to cool the system. If this is done in a precise way, the machines qubits seek out a low-energy state that represents the answer to a given problem.

However, unlike most computers, D-wave’s machines, cannot answer any old question. Instead, it is only able to solve so-called “optimisation” problems, where there are a series of criteria all simultaneously competing to be met, and where there is one optimum solution that satisfies the majority of them – for example, the optimal route for a delivery truck to drop off packages, minimising the time and distance travelled.

Lockheed, according to Brownell, hooked up with D-Wave out of a mutual interest in the types of calculations that a quantum computer could perform. “They had algorithms that were applicable to our technology,” he says. “Their particular focus is software verification.”

Software is increasingly at the heart of what defence companies do. For example, the Lockheed Martin F-35 Joint Strike Fighter has what is described as the most complex software system of any modern weapon system, with over 24 million lines of code, according to a 2012 report by the Government Accountability Office. Quantum computing could be used to verify this huge amount of code to ensure the aircraft will operate reliably and safely.

A quantum computer would also be good for a variety of other applications that involve machine learning, says Bo Ewald, the president of D-Wave’s recently launched US business. That may involve what Ewald calls “finding the essence of complex data structures”, something which could be useful for mining social media data or pattern recognition in imagery.

Ewald says that the quantum computer will be able to learn the key characteristics of a particular shape, say a car, by showing it lots of pictures of cars. Once it learns the key characteristics of that shape, it should be able to recognise them more readily than conventional systems. In addition, he says, once it has figured out the characteristics of what make a "car" recognisable, it can be used to "train" conventional computers – such as your mobile phone – how to more easily recognise a car, something which could interest the likes of Google.

Other applications which may interest the Nasa-Google-USRA collaboration range from improving web search and robotics to hunting for exo-planets and optimising air-traffic control. That computer, which will be installed at what is being called the Quantum Artificial Intelligence Lab, will be located at Nasa’s Ames Research Center in California, and is expected to be ready for use later this year.

Bits and bets

But in most cases, proving that a quantum computer will actually perform these sorts of functions faster than a classical computer is still in the realm of theory. As it is, not everyone is even convinced yet that the D-Wave computer is actually using quantum mechanics to make the calculations.

Christopher Monroe, a quantum information researcher of the Joint Quantum Institute and University of Maryland, has expressed doubts in the past about D-Wave's claims and now says that although the company has made progress in demonstrating its computer's abilities, it has still not offered proof that it is operating in a quantum state. "I'm not convinced at all it's a quantum computer," he says. "But maybe it doesn't matter."

What Monroe means is that the D-Wave computer may indeed be able to solve some optimisation problems better than classical computers, as was shown in recent tests, even if the way it works doesn't involve quantum mechanics. "Given the dearth of publishing from the group, it's hard to know from all the details whether what they're observing is a quantum phenomenon," he says.

But even some former D-Wave critics have been won over – at least in part. Seth Lloyd, a professor of mechanical engineering at the Massachusetts Institute of Technology who has long been involved in quantum computing, says that when Lockheed Martin first got interested in D-Wave, he tried to dissuade them from buying it. Lloyd himself had been involved in developing the principles behind the adiabatic quantum computer, but says his group didn't patent the idea because they didn't think a practical machine could really be built. "I was probably wrong, and [Lockheed and D-Wave] were probably right," he now says. "The D-Wave device is doing something quantum, but it's not clear yet what that something is."

Perhaps the bigger question then is whether Lockheed's multi-million dollar investment is a signal that the company really believes in D-Wave's quantum computer. At least one theory suggested by those in the quantum computing world is that Lockheed's gamble is less a bet on the reality of quantum computing, than a bid to win favour with the Canadian government, a key investor in the F-35 Joint Strike Fighter.

"I think from a technology perspective I'm somewhat agnostic to that [idea]: It's great technology, and it's a unique capability… and that would have got our attention under almost any circumstance," says Brad Pietras, vice president of technology for Lockheed Martin. "The fact that the Canadian government is an F-35 partner, and we work closely with them as industrial partners and allies is just a fantastic added bonus to the relationship."

Pietras also isn't too worried about whether the D-Wave computer has won over all its scientific critics. "In the short-term, my concern is, what is its utility? What problems can we solve?" he says.

As for whether the computer is truly "quantum," Pietras' answer is simple: "It really isn't a question that concerns me that much."

Fonte: BBC International [Portal]. Disponível em: <http://www.bbc.com/future/story/20130516-big-bets-on-quantum-computers/1>. Acesso em: 16 maio 2013.