The NextGen Computing

Skeptics question their concept of quantum computing, but the company feels that it is redefining the computing world with its quantum technology. Is it a real revolution or just wishful thinking? In an interview with Geintelligence, Vern Brownell, CEO, D-Wave Systems, tells us why they are here to stay.

Can you tell us about quantum computing? What are its advantages?
A quantum computer is radically different from a conventional computer. Its promise lies in the ability to offer an unprecedented speedup for certain types of application over existing classical computers. Problems that would take these classical computers a lifetime to solve may become solvable in minutes with a quantum computer. Furthermore, with classical methods, regardless of how big a supercomputer you build, there will always be applications that can’t be solved. Quantum computing offers an entirely new type of computational capability.

There is a lot of research going on in quantum computing, and it’s really one of the most interesting things going on in science today. Our mission is to build something that is practical and useful for solving real world problems. Some of the early verticals that we’ve focussed on include defence and intelligence. Our first customer was Lockheed Martin, and we have sold systems to Google and NASA as well. We’re working with the intelligence community, and that’s a real focus area for us.

How are you commercialising this technology? Do you also have some hardware products?
We offer a few different services. Our main business model is based on providing subscription services to our computers. Customers can sign up for a three-year contract to gain access to a D-Wave computer through the cloud. Along with that, we work with each particular customer to find the best use of our software. This type of collaboration with our partners, where we work with them to determine how we’re going to use this capability to solve problems, is the most important business for us. For example, one of our partners is Lockheed Martin. Since they understand our system quite well, they can help customers who want to have a system integration partner provider capability. We’ve been working with them as integrators on several projects for the past three or four years now.

We do have a model where a customer can purchase a machine, but most customers opt for a leasing model. We expect a number of purchases in the next few years for those customers who want to have their own secure...
machine. As for hardware, the fundamental capability of D-Wave is driven by hardware. A D-Wave computer is a large machine, and there are three racks of equipment that go along with it. The hardware is very complex, but we are developing more software tools and capabilities to go along with it. That’s a big growth area for us.

This is a new technology. Interoperability with the legacy systems and existing systems might be a big challenge. How do you overcome this challenge?
There are a number of levels of operability. First, to make the interface easy, we’ve developed APIs (Application Programming Interfaces) that are really quite easy to use - in C++, Java, Python, and MATLAB - all the environments that most computer scientists are used to. Right now, it’s almost a web-based transactional service and a great computing resource for all our customers. For example, Google tested our computer remotely before purchasing it, successfully running millions of problems across the internet.

We are also able to install our system in traditional data centers - one is installed at NASA Ames in California and the other at USC in California. For hardware installation, there are just a few simple requirements. Quantum computers have to be shielded from all radiation and magnetic activities, and they need 15 kilowatts of available power. The system also requires a minimum of vibration on the floor, so we conduct testing before we conclude that a particular site is suitable. The computers will fit in most data centers but as it is a little bigger than most cabinets, there are some size constraints. However, over time, we’ll make it smaller, so that it will be just a couple of racks, or standard data center racks, which would be good for any data center. In general, we see our computer being used in several ways, like being integrated into existing computing environments.

You said that the primary advantage is the accuracy of computing. What kind of applications would this be capable of, especially, in the defence sector?
There are three main categories of applications that we focus on. One is machine learning, which teaches algorithms to do certain tasks that are very difficult to programme. This application is very popular in big data analysis. Examples of this kind of task include image matching, and searching through videos for patterns.

Another category of problems involves optimisation, or looking for an optimal solution to a very complicated logistics problem. In the defence department and at NASA, there are very complex missions that need optimisation, and they’re always looking for better tools to do that. Optimisation problems can be found in many kinds of applications, from pattern matching to finding inferences in data.

The third main category is called sampling. This involves looking through data, often through a certain filter, very quickly, for changes in the data. For example, if you’re trying to defend against a missile attack, and you’re trying to draw some conclusions about what to
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don very quickly, our quantum computer would be helpful.
There will be other categories as the power of our machine grows. Right now, it is a second generation processor, so it is still in the very early stages of development.

Skeptics have questioned your concept of quantum computing. What do you have to say to them? How do you try and create awareness about this technology?
Quantum computing in general, and also quantum mechanics, which are the fundamental laws of the universe on which this technology is based, are not all that well understood. It has only been a hundred years since scientists came up with the theories, and there are still a lot of things unknowns around this science.

More specifically, there are many different ways to build quantum computers. At D-Wave, we use a technique that was originally devised at MIT in 2000. This is different from what most researchers focus on, which is the gate model of quantum computing — it is very difficult to implement and scale right now. At D-Wave, our focus is on figuring out what kind of quantum computing we can deliver as quickly as possible, so that we can solve problems.

The other difference is that we have chosen, from the beginning, to build this processor as a semi-conductor, whereas most other efforts in quantum computing are around laboratory experiments. For example, Dave Wineland, who won the Nobel Prize in Physics last year for quantum computing, is working on building ion traps, and using lasers to manipulate ions. It is very complex, but incredible science. However, it would be difficult to scale something like that to thousands of qubits, to make it commercially useful science. So from the very beginning, we decided to work on building a quantum computer from a chip, as a semi-conductor. I know it sounds kind of obvious, but we are the only ones who are doing that. It’s hard to do. It’s hard to build any kind of new semi-conductor because it involves new metal, and a new kind of process.

The third difference is that we’re a commercial company. We’re trying to solve real customer problems. We’re not just doing our research for the pure science, although we have published dozens of peer-reviewed articles that have contributed to the literature on quantum computing. We are very much engaged with science, but our primary mission is to build something which is useful.

Are you also trying to develop some kind of solutions for customers or do you just provide the hardware and software?
We are becoming more and more solution focussed. For example, Lockheed Martin has a software verification and validation system, which enables it to test flight control systems in an efficient way. But this is a very expensive process for the company. So, although we have this kind of capability, we don’t have off-the-shelf tools for carrying out verification and validation. But through our partnership with Lockheed Martin, we are able to deliver such capabilities. Lockheed Martin is providing the framework, and we are providing the computational resources for it. This is an example of the type of solution that’s emerging. We can collaborate with our customers to achieve advantageous results, and build specific solutions that fit their needs.

Can you tell us about your association with other organisations, like Google?
Google is a visionary organisation in many fields, and we’re thrilled to be working with them. They’re particularly interested in using our technology in the machine learning space.

Another organisation we work with is NASA. Although we’ve taken up different kinds of work together, we’ve mainly been involved with projects related to image recognition. One project we’re working on with them is mission planning. Another is the search for exoplanets, that is, planets outside our solar system. For this project, they’re analysing massive amounts of data collected from its Kepler and other spacecraft. So we’re working with NASA on several cutting edge applications.

You are fundamentally operating in the US. Are you also trying to explore the global market?
We’ve just started exploring the global market. Right now, however, 90 per cent of our efforts are in the US. There is huge demand for our software capabilities and solution expertise in the US, so we’re trying to expand that business very quickly and grow in this capability. Soon, we want to expand our operations in North America and Asia as well, and we’ve recently hired someone to begin outreach in Asia. There is a significant interest in the quantum computing market, so we are exploring business opportunities all over the world.