What Google's 'quantum supremacy' means for the future of computing

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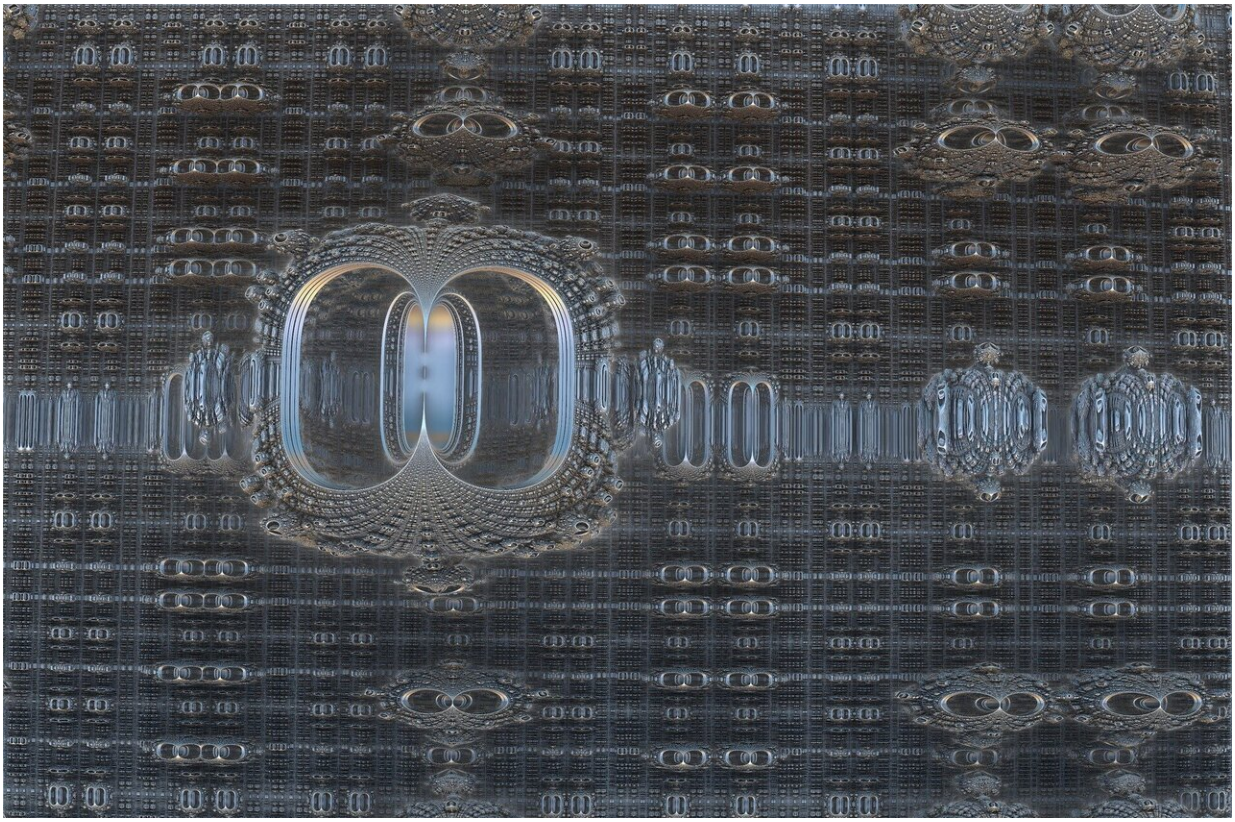

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For the first time ever, a quantum computer has performed a computational task that would be essentially impossible for a conventional computer to complete, according to a team from Google.

Scientists and engineers from the company's lab in Santa Barbara announced the milestone in a report published Wednesday in the journal *Nature*. They said their machine was able to finish its job in just 200 seconds—and that the world's most powerful supercomputers would need 10,000 years to accomplish the same task.

The task itself, which involved executing a randomly chosen sequence of instructions, does not have any particular practical uses. But experts say the achievement is still significant as a demonstration of the future promise of quantum computing.

William Oliver of MIT compared the feat to the first successful flight by the Wright brothers. "It is what the event represented, rather than what it practically accomplished, that was paramount," he wrote in a commentary that accompanied the study.

Google's scientists are hailing the achievement as the first demonstration of what's known as "quantum supremacy." The phrase was coined in 2012 by John Preskill, a theoretical physicist at Caltech, to describe the point at which quantum computers can do things that classical computers simply can't.

Not everyone agrees that Google's announcement represents true quantum supremacy. Computer scientists at IBM have countered that their most powerful supercomputer, called Summit, could complete the same task in 2.5 days rather than 10,000 years.

Still, Google's success is a noteworthy steppingstone on what will probably be a long and winding road to quantum supremacy, Preskill said.

"It won't change anything overnight, but it is significant that quantum computers are now at the stage that at least in some arena, they can

outperform the best computers on Earth," he said.

Preskill spoke to The Los Angeles Times about where quantum computing stands today and what types of big problems it may help us solve in the future.

But be forewarned: This is brand-new technology with a whole lot of unknowns.

Q: How did you become interested in quantum computing?

A: Around the mid-1990s it was discovered that if you had a quantum computer, you'd be able to solve some really hard problems. The one that made the biggest splash was that you'd be able to break widely used cryptosystems that were considered unbreakable because they required too hard a computation.

I thought that was the most interesting thing I'd ever heard—this idea that whether you can solve a problem or not depends on whether the world is described by quantum mechanics instead of ordinary classical physics.

Q: How is a quantum computer different from a conventional computer?

A: The language that classical computers speak is all about manipulating strings of zeros and ones, but the language of quantum physics is quite different. This is more of a metaphor than a technically accurate statement, but in a quantum computer you have a qubit, which can be a 0 and 1 at the same time. That's a way of describing how they speak a completely different language.

The potential promise of quantum computing is that a quantum computer does something that we could never do with ordinary digital computers. And whether we can turn that into something useful is very much a topic of current research.

Q: What kinds of problems would you need to have a quantum computer to solve?

A: Where the applications are most obvious is when we want to figure out how some big quantum system is going to behave. For example, chemists try to describe very precisely what happens when you try to build a big molecule.

They try to put that on the computer, but when the molecule gets big it's just too hard because quantum mechanics is really important in a molecule, and you just can't describe what it is doing in terms of ordinary bits. But on a quantum computer, you could describe it very well.

Q: Does that have real-world applications?

A: We think in quantum chemistry there will be a big impact, which could be important in agriculture and human health. It could help with the development of new pharmaceuticals, new energy sources, new ways to collect solar power, and new materials.

That might be quite a ways down the road, but it's part of what gets people excited about the potential applications.

Q: Are scientists currently using quantum computers to solve problems?

A: People are experimenting, but there isn't anything spectacular to report along those lines yet. I don't think anybody has done anything with a quantum computer so far that you couldn't do much better with existing digital, classical computers.

But people are kind of gearing up, figuring the technology will mature, and they want to be ready. Exactly when we will see real economic impact from quantum computing, nobody really knows.

Q: What led you to coin the phrase "quantum supremacy" in 2012?

A: I suggested this term thinking we should take note that something kind of special is happening in the history of technology. As quantum computation advances, we will reach the point where we are doing things with quantum computers that we think go beyond what we can do with current or foreseeable digital computers.

Q: But not everyone likes that term, right?

A: Some people think it is hyping the state of the current technology too much and that it feeds unwarranted or unrealistic expectations of what the near-term implications are going to be.

I understand that concern. We don't want to overclaim. Google has this machine, but whether it can do anything useful that anybody cares about over the next few years—nobody knows.

We are in an era where we have this powerful device and don't know what to do with it. We have to experiment with it and try different things. We have to drive it around the block and see what we can we do.

Q: Would you say Google's announcement is a big deal?

A: It depends on what you think is a big deal. I would say it is an incremental step, but we might as well sit back and enjoy it as an indication that the technology of quantum computing is marching forward and we are getting to the point where potentially we can do things with quantum computers that we couldn't do with classical ones.

Q: What steps still need to be taken in order for quantum computers to become a reality?

A: More qubits, less noise. That will make the quantum computer more powerful. Presumably, both of these will continue to happen.

Q: Any thoughts on when quantum computers might become more useful?

A: It could be decades, but nobody can say for sure. There are a lot of different ideas out there, and with a breakthrough, the technology could take off.

Q: Do you think that one day quantum computing will be the standard?

A: Based on our current understanding, I think quantum computers will have very specialized applications. But we can't say for sure how far-reaching those will be. It seems unlikely that you will want to do your email on a quantum computer.

But it's actually not so crazy to say that in the future, we might have a

quantum internet which sends quantum information around because that could have advantages for encryption. It is very hard to eavesdrop on information that is encoded in quantum states. Whether that will happen or not, nobody is really sure.

(This interview has been edited for length and clarity.)