Quantum
4TH YEAR ON THE LIST

Quantum Computing

KEY INSIGHT

Quantum computing uses the properties of quantum physics to store data and perform computations using specialized machines.

EXAMPLES

In short, quantum computers can solve problems that are computationally too difficult for a classical computer, which can only process information in 1s or 0s. In the quantum universe, those 1 and 0 bytes can exist in two states (qubits) at once, allowing computations to be performed in parallel. So, if you build two qubits, they can hold four values at the same time: 00, 01, 10, 11. Scientists have theorized about the possibilities of quantum computing for decades and only built the first working system in 1998. The challenge, however, has been proving that a quantum machine is actually carrying out quantum computations. That’s because in a quantum system, the very act of observing information in transit changes the nature of that data.

DISRUPTIVE IMPACT

Quantum computers are becoming more powerful and available. Equity deals for quantum startups surged in 2020, nearly doubling from the previous year. Most activity is aimed at transforming health care, logistics, and finance. But a persistent fear is driving much of today’s research: Quantum computers could break today’s encryption protocols at a speed and scale beyond anything we’ve ever seen.

EMERGING PLAYERS

• U.K. National Quantum Technologies Programme
• European Union’s Quantum Flagship
• U.S. National Quantum Initiative Act
• National Institute of Standards and Technology
• Google AI Quantum
• Rigetti Computing
• IBM Q Network

Google’s Sycamore performed a challenging calculation in 200 seconds.
Watch Closely Informs Strategy Act Now

Named Sycamore, calculated something that an ordinary computer—even a very powerful one—simply could not have completed. Sycamore performed a challenging calculation in 200 seconds. On the world’s current fastest traditional computer, that same calculation would have taken 10,000 years. In February 2021, researchers from Google and quantum computing company D-Wave Systems solved a real-world challenge 3 million times faster than a classical computer.

Global Quantum Computing Race

The global quantum computing race is underway. Several nations, including the U.S., France, the U.K., and China, want to become the global leader in quantum computing. Governments are setting the stage now to attract talent and investment, ahead of the first real-world quantum use cases. The U.S. passed the National Quantum Initiative Act in 2018, earmarking $1.2 billion for quantum research. Last year, the U.S. launched five new quantum computing centers, including one at the Lawrence Berkeley National Lab to codesign algorithms, quantum devices, and engineering solutions; a center at the Fermi National Accelerator Laboratory to make it easier to deploy quantum systems; and a center at Brookhaven National Laboratory to build new nuclear, chemical, and physics applications. Some would say that the U.S. showed up a day late and a few billion dollars short. The U.K. National Quantum Technology Program kicked off in 2013 and is now in its second phase, with $1.3 billion in investment. Germany’s program is funded at $2.4 billion. A team of researchers from the University of Science and Technology of China published a paper in the journal Science describing their quantum computer achieving speeds that were 10 billion (yes, billion) times faster than Google’s Sycamore.

Quantum Boosts for Classical Computers

New kinds of processors are being designed to add on to existing equipment, to give classic computers a quantum boost. The end result isn’t a complete quantum computing system, but more of a hybrid. Rigetti Computing is building small quantum processors that integrate with the cloud. Pharmaceutical company Merck is experimenting with the processors for faster drug development and production.

Quantum Computing Trends

Updating Post-Quantum Cryptography Standards

U.S. National Institute of Standards and Technology will recommend new guidelines in 2021 to help organizations transition to new cryptography standards. In the U.K, the National Cyber Security Centre published recommendations for any organization using secured transactions. Today’s encryption standards could quickly become outdated as quantum computers improve, and the complexity of upgrading IT systems in large organizations will take years to complete.

Quantum Supremacy

In October 2019, Google researchers published a paper in the journal Nature as well as a blog post on the company’s website explaining that they had achieved “quantum supremacy” for the first time. It was a significant revelation. Physicists said that their 53-bit quantum computer, named Sycamore, calculated something that an ordinary computer—even a very powerful one—simply could not have completed. Sycamore performed a challenging calculation in 200 seconds. On the world’s current fastest traditional computer, that same calculation would have taken 10,000 years. In February 2021, researchers from Google and quantum computing company D-Wave Systems solved a real-world challenge 3 million times faster than a classical computer.

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