Computing's quantum shift

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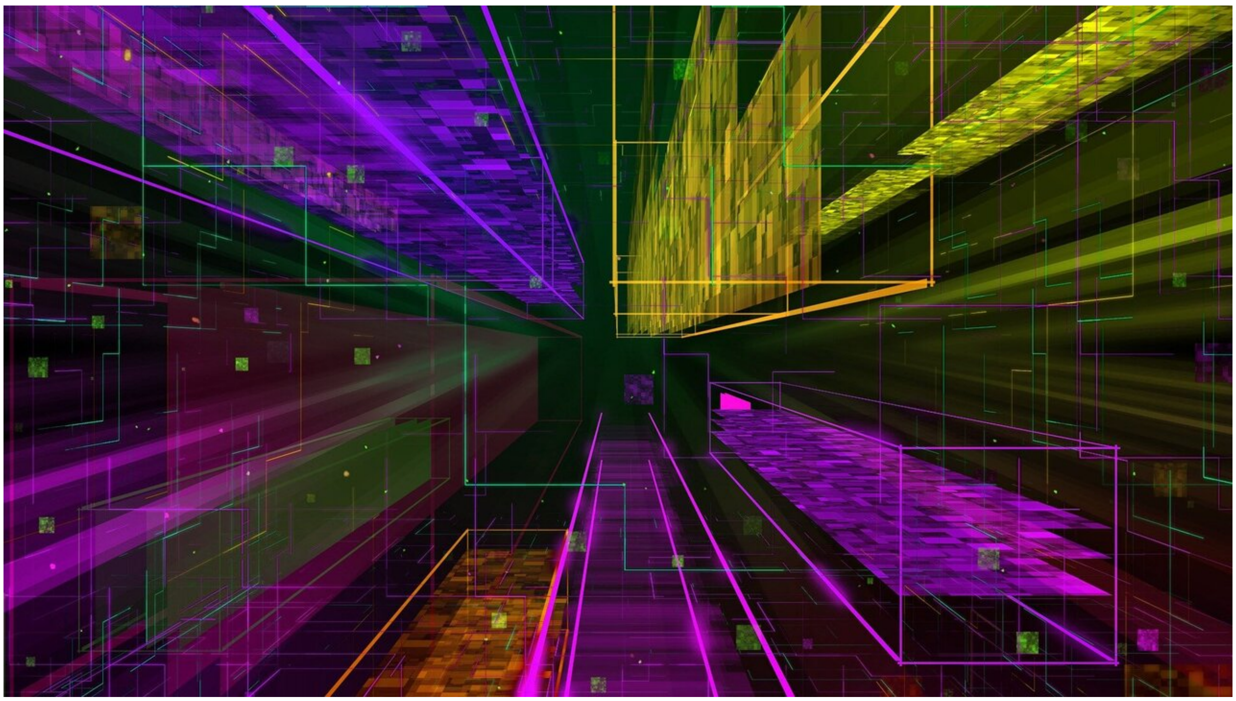

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With the race to build a new generation of computers heating up, European companies are eyeing the game-changing opportunities.

At some point in the future, the medicines that people take for everything from a simple cold to a complex disease like Parkinson's might result from a discovery made using quantum computers.

These machines, which rely on the principles of quantum physics to outperform the fastest classical computers, are widely expected to spur the development of new drugs with the potential for major improvements in health care.

New frontier

"Classical computing is facing its limits in a range of fields such as drug discovery," said Dr. Cyril Allouche, head of quantum computing at Eviden, a French advance-computing company. "We hope that quantum computing can break this barrier. That would mean new drugs and less disease."

Welcome to the global race for the next generation of computers—a hunt that Allouche is part of as head of a research project that received EU funding to explore the wide range of possible uses for quantum computing.

While big-name U.S. companies have grabbed headlines by investing billions in a bid to be the first to build a full-sized quantum computer, European businesses and scientists have exhibited the same determination largely out of the spotlight.

For all involved in the quest, deciding whether or not to invest in research now could mean the difference between being on the front line of cutting-edge technologies for health, energy and cybersecurity or lagging behind.

Zeroes, ones and more

If the stakes for society are clear, the nature of quantum computing itself is less so.

A normal computer uses a binary code to operate and make calculations. At its core, today's computing code is nothing more than large amounts of zeroes and ones, with the computer reading either the zero or the one at any single moment.

But in a quantum computer something special occurs: a "superposition" of the zero and the one. That means the operating system can occupy the two states at the same time.

It is this ability to do two things at once that could drastically speed up the time it takes for computers to perform certain calculations.

But no one is there yet. Existing quantum computers are low-powered machines that offer few advantages over regular computers.

What apps?

"Quantum computing, for now, is still theoretical," said Allouche.

That is proving no discouragement to researchers, however.

Allouche's EU-funded project is called NEASQC—an acronym for Next Applications of Quantum Computing. It began in September 2020 and runs until the end of November 2024.

The project has brought together universities in countries such as Germany, Ireland and the Netherlands as well as businesses like pharmaceutical developer AstraZeneca in Sweden, utility Electricité de France, Latvian language-technology company Tilde and U.K.-based HSBC Bank.

"Now is the time for industry to get interested," said Allouche. "It would be a very bad idea to wait for the technology to mature before we develop applications. We need to look at use cases now."

NEASQC is exploring nine use cases. The potential applications are being kept confidential for competitive reasons.

Emulator exercise

Allouche said researchers can already test whether a technology that is not yet fully operational, like quantum computing, might be better in certain scenarios than a technology that is already in use.

An emulator is used. It's a regular computer configured to simulate a quantum computer without the power a real one would have.

"You try to infer some properties from the theory," said Allouche. "Here we simulate what a quantum computer would look like."

With these simulations, researchers can determine whether quantum computing is able to make advances such as finding combinations of molecules for new medicines or enhancing renewable-energy output based on solar cells.

Quantum computers won't outperform regular computers for all applications. So finding the applications in which quantum computers would excel is a prime research focus.

"We need to see where the frontier of classical computing lies and where quantum computing might offer a solution," said Allouche.

Better together

A second EU-funded research project is looking at another way to promote quantum technologies in Europe. Rather than funding actual research, the project is uniting disparate initiatives across the continent.

Called QUCATS, the three-year initiative runs until the end of April 2025. It is led by Professor Philippe Grangier, research director at the French National Center for Scientific Research, or CNRS.

"We in Europe don't have big companies that concentrate quantum computing research in them," said Grangier. "Europe's research is very scattered. We want to unscatter that."

QUCATS is undertaking some of the coordinating functions that big technology companies provide in the US.

The project does this in a range of ways. It writes strategy documents on what direction quantum research needs to take, such as a new roadmap to position Europe as a "Quantum Valley" of the world. It helps researchers file patents. It coordinates research across borders. And it even informs the public.

QUCATS includes as a partner the European Quantum Industry Corsortium, or QuIC, gathering private companies that hope quantum computing can provide them with future benefits.

Dr. Thierry Botter, executive director of QuIC, echoed Allouche in saying it's not too early to focus on such matters.

"Quantum is still young," said Botter. "Yet businesses need to understand how quantum computing can impact their business today. Early movers are already making gains. Late movers will find it difficult to catch up."

He said that European companies are already looking at what quantum computing can offer them.

Opportunities and risks

Plane manufacturer Airbus, for example, wants to examine how quantum computing can help in the design of better aircraft and the modeling of air flow and fuel efficiency.

Another urgent area for quantum research is cryptography.

Today, much online communication and data is encrypted using mathematical puzzles. Solving these with current computers is impossible in practice without knowing the encryption keys.

But quantum computers will be able to solve these puzzles without the keys. Once operational quantum computers exist, online communications could become vulnerable.

Grangier said that European companies are working to avert such trouble. For example, Spanish telecommunications-equipment supplier LuxQuanta and other players have found ways of honing and deploying a type of "quantum cryptography" that could prevent a widespread breach of privacy.

Money matters

Meanwhile, the jury is out on how Europe will ultimately perform in the quantum race—in part because of investment needs.

"Europe has a very strong research environment in quantum from which many startups have emerged," said Botter. "But there are still gaps. One of those is funding."

A 2022 study by the European Investment Bank found that, while

Europe has a similar number of quantum companies as the U.S., a lack of private investments on the continent means American companies receive 10 times more funding.

Botter said the EU and its Member States must act urgently to make more capital available for European companies in the field.

"A lot of things might happen in the next 10 years," he said. "What today are startups might become large companies in the future. Fifty years ago, Europe came together to create Airbus, now a leading aerospace company. I dream of an Airbus for the quantum world."

The science of qubits

A quantum computer manipulates not the binary bits of classical computing but rather quantum bits, or qubits. Qubits have additional properties as a result of two quantum mechanical phenomena: superposition and entanglement.

A qubit can represent combinations of zero and one at the same time—superposition. Qubits can also be entangled—two separate ones can exist in a single state, which will change when acting on one of them. This creates correlations between the qubits.

These quantum features can be controlled by scientists and could drastically speed up the time it takes for computers to perform certain calculations.

More information:

- NEASQC

- QUCATS

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