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# Is quantum computing reaching commercial viability?

Recent advances in quantum computing will lead to commercial viability soon. Given the dollars, talent, number of companies and interest of various governments, the pace of development is accelerating. I recently interviewed Lawrence Gasman, the Founder and Principal Analyst at Inside Quantum Technology, about the latest developments, trends, and strategic insights in quantum computing technology. Here's a synopsis of our discussion.

## *Quantum progress in 2023*

"Unlike a year ago, real-world quantum computing applications are now more apparent," said Gasman. "Suitable applications involve vast volumes of data and complex calculations." Examples include:

- Modelling advanced material systems for aerospace, construction and automotive industries.
- Simulating complex chemical reactions to develop new pharmaceuticals.
- Optimizing complex systems, such as traffic flow or financial trading.

This paper in Nature, "IBM quantum computer passes calculation milestone," showed for the first time that:

- A 150-qubit quantum computer is sufficient to run these applications.
- A quantum computer larger than the range of 127 - 150 qubits is the point where a quantum computer is more capable than a classical computer.

In December 2023, IBM unveiled a quantum chip called Heron with 133 qubits. That development is significant progress in making some applications viable, but there's still some distance to decrypting public key encryption.

Still, the decryption of public key encryption, which much of today's cybersecurity depends on, by a quantum computer is closer than previously projected. For comparison, some researchers estimate it would take a classical computer 300 trillion years to crack an RSA-2048-bit encryption key. This year, researchers estimated that a quantum computer with 4099 stable qubits can do the same job in just ten seconds.

In 2023, quantum computing received over $2 billion in venture capital (VC) funding. Two years ago, it was well under $1 billion. One example is In-Q-Tel, a VC funding quantum development on behalf of multiple intelligence agencies. Other major VC funders include Airbus Ventures, Alumni Ventures, ICM Allectus, Mindrock Capital, Quantonation, Ridgeline Partners, and Salesforce Ventures.

## *Geopolitical dynamics*

“The global race for quantum technology dominance is ongoing and accelerating into 2024, said Gasman. “The competitors are increasing funding for quantum technology development.”

The Biden administration's focus on quantum impacts international relations and US national security. The CHIPS Act of 2022 allocated more than $150 million annually for quantum computing and networks research and development. China is developing quantum technology focusing on its military, including a quantum network for communications between satellites and ground stations. China was the first to launch a satellite for quantum communication in 2016.

The Europeans are also planning to launch a quantum communication satellite. Canada recently announced a multi-year investment of $360 million in the National Quantum Strategy to amplify Canada’s quantum research and achieve commercial success.

One area of global competition is quantum networks in space. Such a network is appealing because it transmits information at the speed of light and overcomes the current distance limitation on Earth. Equally important, any attempt to intercept the signal immediately severs the link, making hacking impossible.

## *Quantum devices and innovations*

“Several promising quantum sensors, communication, and hardware advances are poised to disrupt some product categories in 2024,” said Gasman. “The definition of who or what is dominant changes from year to year and press release to press release.”

Approximately 90 quantum computer companies are using about 40 different approaches in their quantum processing unit (QPU) designs. The companies include heavyweights such as Alibaba, Alphabet, the parent of Google, Amazon.com, D-Wave Systems, IBM, IonQ, Microsoft, and NVIDIA. There are also many quantum startups, such as Infleqtion, QC Ware, and Xanadu, and spinoffs, such as Quantinuum (from Honeywell) and SandboxAQ (from Google).

The most significant barrier to robust quantum computers is the errors caused by noise. Advancing error correction is a prerequisite to more reliable quantum computing.

The following QPU hardware approaches currently dominate quantum development work:

## Superconducting Qubits

Superconducting qubits leverage the principles of superconductivity to carry quantum information.

They've shown significant progress in recent years, with companies like IBM, Google, SEEQC and Rigetti leading the way. They are known for their relative ease of scalability and potential for error correction.

Maintaining the ultra-low temperatures required for superconductivity poses a substantial engineering and cost challenge.

## Trapped Ions

Trapped ions involve using individual ions as qubits. These ions are typically trapped using electromagnetic fields and manipulated using lasers to perform quantum operations.

Trapped ions are known for their long coherence times, which means they can retain quantum information for extended periods. The trapped ion approach is also appealing because it does not require much cooling. Leading developers include Alpine Quantum Technologies, Quantinuum and IonQ.

Constructing a stable and scalable system for trapping and manipulating ions can be complex.

## Topological Qubits

Topological qubits are based on anyons, exotic particles that exist in certain two-dimensional materials.

Topological qubits have the potential for robust error correction due to the inherent properties of anyons. Microsoft is the leading company associated with this technology.

Identifying suitable materials and creating stable conditions for manipulating anyons remain significant challenges.

## Photonic

Photonic quantum computing uses photons, particles of light, as qubits. The properties of photons are used to encode quantum information.

Photonic systems have the potential for long-distance quantum communication due to the nature of photons. Companies working on this approach include ORCA Computing, PsiQuantum and Xanadu Quantum Technologies. Other advantages are that they do not need cooling and can be built from off-the-shelf components.

Creating reliable sources of entangled photons and developing efficient photon detectors are ongoing challenges.

### Neutral cold atoms

Cold atoms quantum computing uses lasers to cool down atoms at very low temperatures and arrange them in space using "tweezers" made of light. Arranging many atoms builds a quantum register. Logic operations are performed by controlling the qubit's state with laser light.

Cold atom systems may lead to a more stable platform to perform more accurate error correction than competing technologies. Companies advancing this approach include Atom Computing, ColdQuanta, PASQAL, and ColdQuanta.

## *Quantum innovators*

“The danger in quantum computing and AI is the incredible hype we hear all too often,” said Gasman. “We’ll cure cancer on Monday and beat the Chinese on Tuesday.”

IonQ Inc. jumps out for Gasman as an innovator developing quantum computers based on the trapped-ion approach. While it’s relatively new, the company has customers and $100 million in revenue. Peter Chapman, formerly the Director of Engineering for Amazon Prime, is the President/CEO.

Quontinium, a Honeywell spinoff, is progressing with the trapped ions approach. The company focuses on cybersecurity, computational chemistry and quantum natural language processing (QNLP).

## *Looking into the future*

“Today, AI and quantum computing are separate technologies that are both rapidly developing,” said Gasman. “I expect connections between AI and quantum computing will develop soon.”

For example, we know AI needs voracious amounts of computing power to train and respond to end-users. Some quantum computing observers forecast it will dramatically reduce the cost of computing power and lift this cost constraint on AI applications and further development.

Similarly, the Internet solved the constraint of near-instant access to vast amounts of digital data that AI needs as training data.

We can expect rapid advances in quantum computing that will lead to commercial viability based on the dollars, talent, and number of companies focused on this work. The competition among various governments for leadership and control will maintain interest and pace.