BCG

Weekly Brief

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Quantum Computing Is Coming to Life

I wrote to you a few years ago about the transformative power of quantum computing. Its potential is now truly within reach. The UN, marking 100 years since the advent of quantum mechanics, declared 2025 the International Year of Quantum Science and Technology. And in just the past couple weeks, two major innovators in quantum made important announcements.

Google says it has reached "quantum advantage" with an algorithm that runs 13,000 times faster on the company's proprietary quantum chip than the fastest supercomputer, suggesting true business advantage is likely in this decade. And IBM announced a way to address quantum computers' tendency to lose their connectivity too fast to perform large-scale calculations. Its new error correction code can run on classical computers, pulling forward the timeline to quantum wins by at least a year.

I recently checked in with BCG's Matt Langione, one of our quantum experts, to find out more about the latest innovations and what they mean for business.

An Exponential Advantage

First, a quick overview on why quantum computing is so powerful. Unlike classical computers, which process information using a binary system of bits and tackle tasks sequentially, quantum computers follow the principles of quantum mechanics. Quantum bits, or qubits, can exist as both 0 and 1 at the same time, speeding

up problem solving exponentially. And those qubits can become linked, affecting one another even if far apart.

Put mathematically, it takes 2^N bits to do the work of N qubits. For example, to simulate penicillin, which is made up of 41 atoms, a classical computer would need 10^{86} bits—more bits than there are atoms in the entire universe. A quantum computer can do the work with fewer than 300 qubits, roughly the number of bits it takes to power a single pixel on a laptop.

For business, quantum can solve puzzles related to simulation, machine learning, cryptography, and optimization of supply chains, operations, pricing, and much more.

Fast Solutions, Business Gains

Business has already gained billions of dollars in value this decade through quantum integration. More than 100 global companies across sectors have begun learning, experimenting, and achieving results. Matt and his team predict value creation of more than $800 billion as the technology scales to major industrial applications through 2045.

Here are five examples of challenges that businesses are hoping to address with quantum computers in the next ten years—some within three to five years. Each will bring transformative change and tens of billions in annual value creation potential:

- **Simulating Fertilizer.** Fertilizer production uses around 2% of the world's total energy and costs up to $200 billion each year. Quantum simulations would radically lower costs while reducing energy use and environmental impact.
- **Discovering Drugs.** Piecing together the right compound for a new drug is like finding a needle in a haystack. Using the tools at hand, we've been able to discover about 10,000 drugs. With quantum, that number could grow to about 10^{60}. The technology offers the possibility of cures for every disease and even the potential of personalized medicine.
- **Unlocking Better Materials.** Almost all hydrogen used today—worth $205 billion to $285 billion—is produced from fossil fuels. Quantum computing could help discover new

processes that would radically improve our energy options, including better catalysts for producing and storing hydrogen, enhanced photovoltaic efficiency, and improved battery chemistries.

- **Optimizing the Grid.** Today, 5% to 10% of all energy, worth up to $400 billion, is lost each year because of inefficiencies. Broader under-optimization of energy networks leads to an estimated $4 to $5 trillion in economic losses and leaves more than 1.5 billion people without reliable access to energy. Quantum can improve how power is generated, transmitted, and distributed.
- **Managing Financial Risk.** Banks hold about $4 trillion in capital reserves to guard against rare but catastrophic market risks, such as major economic crashes. Improved risk modeling using quantum technology could make financial systems more resilient and efficient.

Challenges remain. Right now, the needed talent is scarce and computing resources remain limited. Even with all the resources lined up, the solutions that quantum offers are customized and will take time to build.

Despite the obstacles, continuing advances have put quantum's massive potential within reach, and business leaders need to invest now to build capabilities, onboard talent, and partner with the right providers. You can't just turn the lights on when the tech matures. For those that are ready, quantum will bring an exciting shift that could truly upend possibilities for competitive advantage and be a major new source of value creation.

Until next time,

Rich Lesser
Global Chair

Further Insights

How Quantum Computing Will Upend Cybersecurity

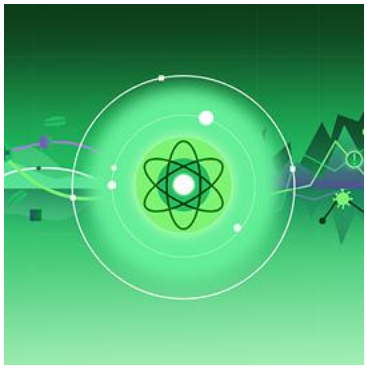
Current cryptographic standards could soon be vulnerable to attacks from quantum computers. To protect critical systems, companies should begin the transition to post-quantum cryptography now.

PREPARE FOR QUANTUM RISK

A New Era of Quantum Computing

On CNBC, BCG's Matt Langione explains how technical advances and increased funding are paving the way for practical applications.

WATCH WHAT'S EMERGING



Imagine This: When Quantum Computing Brings Breakthroughs ... or Chaos

Quantum computing has the power to drive breakthroughs across industries, but it also raises profound security and ethical concerns. BCG's Antoine Gourévitch explores the quantum age.

LISTEN TO THE PARADOX