ALICE & BOB

Case Study
Alice & Bob

Written by Audrey Woods

Even though the quantum computer industry is still in its infancy compared to that of conventional computers, global excitement around quantum is rapidly gaining momentum. Funding for research is ramping up, startups are growing, and legacy companies are forming branches dedicated to solving problems in the quantum space. Perhaps most importantly, governments around the world are beginning to make quantum a priority because of the cybersecurity implications and the need to stay competitive. With the exciting potential to be at the forefront of a second computer revolution, enterprising companies are working to solve the challenges of quantum and bring a functional quantum computer to market.

One such company is French startup and CSAIL Alliances Startup Connect Plus member, Alice & Bob, who believes their self-correcting cat qubit could be the key to bringing about the useful and widely applicable quantum computers of tomorrow.

ABOUT THE COMPANY
One of the biggest open challenges in quantum computing is error correction. Due to the nature of quantum mechanics, it is very easy for qubits, or the logical part of a quantum computer, to be affected by outside noise, such as temperature fluctuation or electromagnetic radiation. When noise disrupts the qubit, its state can change in either a bit-flip (which can roughly be understood as going through the equator of the qubit sphere to end up on the opposite side) or a phase-flip (roughly, turning the sphere around). Both bit-flips and phase-flips erode the information stored in a qubit in a process called decoherence, ruining the integrity of whatever computational output the user is expecting.

A common method of combating such errors is through redundancy, where hundreds of physical qubits can stand in for a single logical qubit. This is the approach most quantum computer designers are taking, but this is an expensive and inefficient answer to an inevitable natural problem. Therefore, a different and promising solution is to use cat qubits, which can be stabilized so that they are only prone to one of the two classes of errors. Named after Schrodinger's Cat, the cat qubit was originally introduced in a 2020 Nature paper which Alice & Bob co-founders Raphaël Lescanne and Théau Peronnin helped write. Realizing the potential of their discovery, Peronnin and Lescanne created the company in 2020 with the promise of building quantum computers based on the cat qubit. Alice & Bob Chief Product Officer Blaise Vignon says, **"based on those qubits, we believe we can build efficient error correction for quantum computers, and we believe error corrected quantum computers can change the world."**

Alice & Bob has since grown to over 95 employees, 35 of which have PhDs, and has locations in both Paris and Boston. Getting funding is hard for any startup, particularly for one whose main product is still at least five years away from development, but Vignon explains how Alice & Bob has enjoyed strong support from the French government, who wants to encourage deep tech entrepreneurship and investment in quantum. Vignon says that the public support "gave a lot of credibility to the project to the point that [Alice & Bob] then could raise private money."

Alice & Bob has also been working to road-test the technology whenever possible and prove its promise for investors. For example, with Boson 4, their latest chip available on Google's marketplace, they reached up to 7 minutes bit-flip protection.

However, Vignon admits that it's not just fundraising that makes the long tail of their business roadmap difficult. "Keeping in contact with the market when you're looking so far ahead is a very big challenge," he says, explaining how Alice & Bob engineers have to think deeply about how a theoretical quantum computer might be applied when there are still major uncertainties about where the quantum value will be. It's still an open scientific question what kind of algorithms will work on a quantum computer—one reason Shor's algorithm, a quantum algorithm for finding the prime factors of an integer, is so famous—and without algorithms, it's hard to know where quantum computers will be needed. One area that quantum engineers are confident will benefit is biotech, which inspired Alice & Bob to open an office in Cambridge. But another reason they wanted a location in the Boston area was to connect with CSAIL, which Vignon believes is "the right place for us to explore this quantum algorithm question."

CONNECTING WITH CSAIL: FINDING VALUE IN PREVIOUS EVENTS & BUILDING A QUANTUM COMMUNITY

Having worked in computer science for much of his career, Vignon says that he's always been aware of CSAIL. But he first heard of the CSAIL Alliances sub-program Startup Connect Plus when he ran into CSAIL Alliances Associate Director Glenn Wong at a CSAIL seminar on quantum. They got into a conversation about Vignon's hope to explore quantum algorithms with the help of the bright minds at CSAIL and Glenn introduced how CSAIL Alliances could provide that connection. Vignon says, "it made sense to [become a member] at that point."

Right away, Vignon made use of the video archive of previous events available through the members-only CSAIL Alliances web portal, focusing on those related to quantum. He was excited to discover the recordings for **Convergence: The Promise and Reality of AI & Quantum**, a 2022 event that brought together intradisciplinary experts, local companies, and quantum startups to discuss the current state and future potential of AI and quantum. He says that the speaker lineup was particularly impressive, noting "all these markers—like Peter Shor being at this Convergence event—are very reassuring for us that we're in the right place."

Being located in Cambridge means that Vignon can attend CSAIL events and seminars in person, which he says has been very important for making connections and establishing a strong foundation to the relationship Alice & Bob plans to have with CSAIL. They've also hosted quantum-focused gatherings in Cambridge, such as their June 17th event Collaborations in the Quantum Space, which CSAIL Alliances Client Relations Coordinator Christiana Kalfas helped promote. Vignon says that her support "was invaluable in driving awareness of the event," for which 120 people registered. He hopes that this event will be the first of many.

Fundamentally, Vignon wants to see a community for quantum research at CSAIL, similar to what has happened with AI. With the boom of generative AI and related technologies, CSAIL has become a hub of research, discussion, and networking for AI. As the field of quantum computing begins to hit its own stride, Vignon would like to see an equally robust quantum community sprout around CSAIL, specifically in the area of quantum algorithms. "If there is one place on Earth," he says, "that can crack this question of what are the right quantum algorithms in general, and what are the right quantum algorithms for cat qubits, it's probably CSAIL." Beyond writing algorithms, which is critical for the functionality of future quantum computers, Vignon explains how important it will be to learn how to use and apply quantum computers once they're available. This is both an academic and industry question, or as he puts it a "hardware, user, research trifecta." In his experience, this is a trifecta that CSAIL has modeled in the AI realm, so he hopes to take part in a similar model built around quantum research.

He concludes, **"CSAIL is very key in my mind to unlocking the value of quantum computing."**

LOOKING AHEAD: QUANTUM CHIPS & BEYOND
As they continue to prove what their cat qubit is capable of, Vignon says Alice & Bob is focused on "building the quantum computer and making sure it's used." Because designing the chip is just the first step in the process; once the hardware has been created, then it will be important to craft a value chain around it, including coding, electronics, and both low- and high-level software. An interconnected, quantum-educated group of computational thinkers will be necessary for this future quantum ecosystem, and Alice & Bob hopes to play a pivotal role in such a network.

Overall, excitement is high at Alice & Bob. When asked what makes him enthusiastic to be in this space, Vignon jokes, "We're making a quantum computer. Didn't you hear?" Quantum computers have the potential to affect society on the same scale as the computer revolution of the 50's and 60's which forged the world we live in today. "We are reinventing the processor," Vignon says, and Alice & Bob is ready to leverage the CSAIL community to help do so.

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