The Quantum Leap
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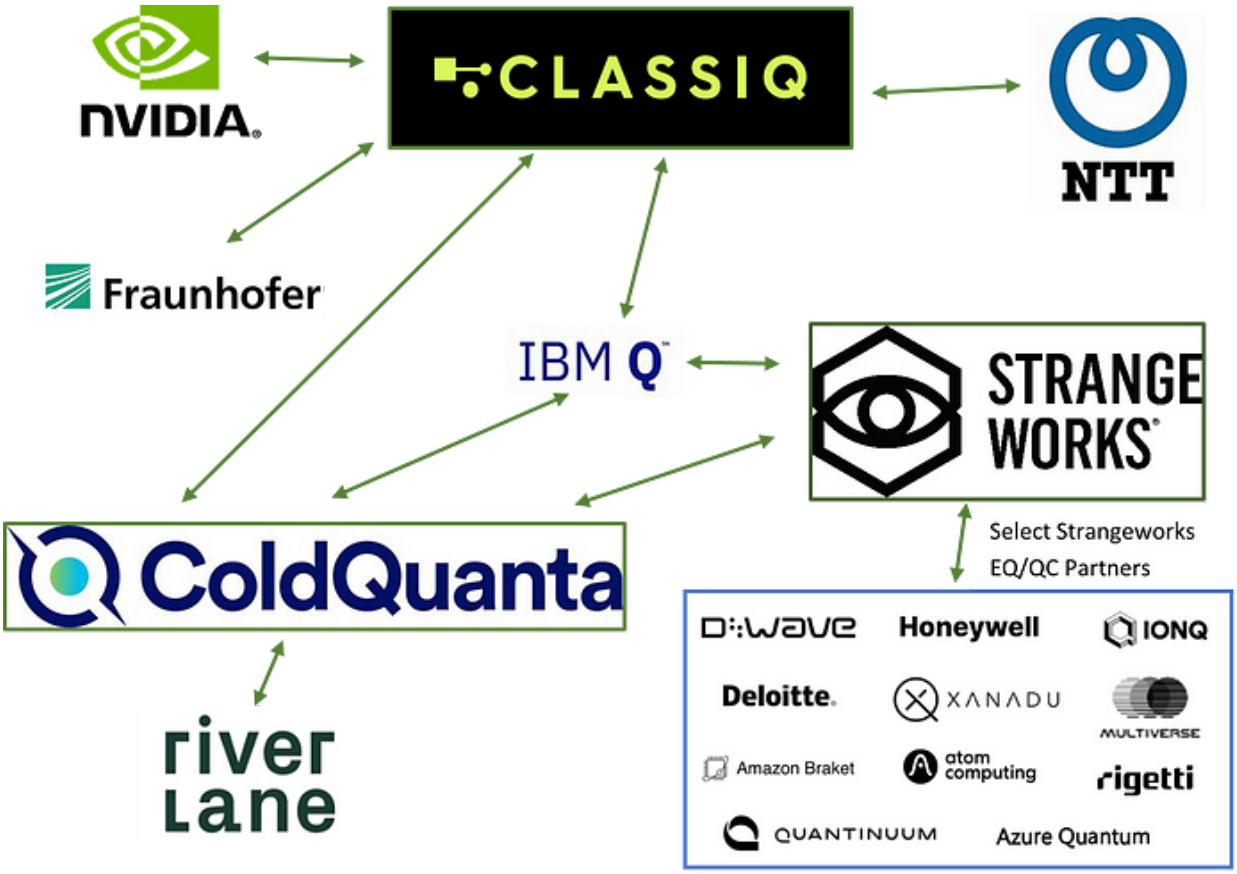
Collaboration is Dominating Quantum Computing

Nearly every day we see headlines about players in the Quantum Computing industry announcing new collaborations and partnerships. On a technical level this seems logical given the unique requirements of the various components such as the physical qubits, cryogenics, lasers, microwaves, controllers, compilers, error correction, various software layers, etc. And remember, we are talking about tiny, tiny size and time scales where things are measured in microseconds or shorter, and the tiniest imperfections or noise can throw off an entire calculation. Operating at the cutting edge of technology, many of these components require intense specialization, so it makes sense it would be difficult for one company to have the required expertise and resources to create best-in-class solutions for all these disparate components. Collaborations would seem inevitable as the industry attempts to power forward as rapidly as possible. In fact, as Paul Lipman, President of Quantum Information Platforms at ColdQuanta recently told me, "to really have the kind of multi-trillion dollar impact on the economy that we all believe quantum computing could represent…we only get there through really deep collaboration." And while the focus on this post is on commercial businesses, as Paul further noted "it's going to require innovation on a fairly broad basis. Not just collaborations between companies, but collaborations between governments and companies, between nonprofit organizations, academia, and others…collaborations in all directions."

Recently, Xanadu and NVIDIA announced a collaboration to provide native GPU support and high-performance computing (HPC) capabilities to Xanadu's open-source PennyLane software. Pasqal, the atom-based quantum hardware business announced a merger with Qu&Co., a quantum algorithm and software developer and Quantum Machines, a QC cloud infrastructure company is acquiring QDevil, a quantum hardware and auxiliary electronics firm. Quantum Computing Inc (QCI) announced a marketing agreement with QPhoton, Inc. to combine QCI's Qatalyst software with QPhoton's photonic quantum technologies. Q-CTRL has a collaboration with Quantum Machines, IBM has a partnership with Quantinuum, and Rigetti, Deloitte and Strangeworks have a three-way collaboration. In fact, Strangeworks has collaborations with seemingly everyone in the Quantum Computing (QC) space. There are dozens and dozens of additional examples.

Rather than try to describe all the many QC collaborations, I wanted to drill down on a few, partly to help emphasize the nature and benefits of such arrangements, and to introduce readers to a few companies moving fast and making important advances in Quantum Computing.

The following graphic gives a sampling of the inter-connected web being built in the industry:



Before I describe some of these partnerships and collaborations, I want to provide further details on some of the featured players noted, so the following are brief descriptions of Strangeworks, ColdQuanta and Classiq. I am also drafting deeper dives on each of these companies which I'll post as separate blogs in coming weeks.

Strangeworks, Inc.

Headquartered in Austin, Texas, Strangeworks is comprised of experienced serial entrepreneurs, enterprise software developers, and quantum physicists with an aim of making QC accessible to everyone and helping accelerate the integration of QC in corporations, universities, and government agencies. Strangeworks was founded by its CEO William Hurley, affectionately known as "whurley." Whurley has quite the resume including being co-founder and general partner at venture firm Ecliptic Capital, a former managing director at Goldman Sachs and he began his career as a R&D Engineer at Apple. In between he founded a number of companies including Chaotic Moon Studios (software, mobile development and design studio) which was acquired by Accenture and Honest Dollar (a retirement savings plan provider) which was acquired by Goldman. He is also an Eisenhower Fellow, the first Ambassador to CERN and Society, and co-founder of EQUALS (the Global Partnership for Gender Equality in the Digital Age), among other activities and achievements.

He admitted to me that the current Strangeworks website doesn't do a great job at conveying its business model, which is partly by design as the team builds out the platform and ecosystem.

Currently it is targeted at technical users but a web redesign is underway which should expand the target audience. Presently, there are a few ecosystems on the website including the following:

- **Strangeworks QCTM**: A platform used by thousands of researchers, developers, and companies around the world to learn, teach, create, and collaborate on QC projects. It is hardware agnostic, software-inclusive and extremely collaborative. Per the website, it has "all of the quantum tools you'll ever need, delivered in a single user interface. It is free to use (within certain project size limitations).
- **Strangeworks EQTM**: The enterprise version of Strangeworks QC with unlimited project size and added features and customizations.
- **Strangeworks QSTM** (Quantum Syndicate): A compendium of hardware, software, education, and cloud service resources and providers.
- **Backstage Pass:** Strangeworks has attracted tens of thousands of software developers and programmers from around the world, enabling users to test-drive pre-release features and functionality in exchange for feedback. While anyone can apply to participate, it is targeted at quantum researchers and developers. It's a great win-win arrangement where users get access to the latest and greatest tools and Strangeworks is then able to offer feedback to QC companies to help them improve their systems and programs.

In addition to the programs and features noted above, Strangeworks also acts to help its consultancy and global governmental agency clients behind the scenes, enabling "white label" platforms that users can leverage to enhance their QC capabilities and educational materials for themselves and their own customers and collaborators.

Given whurley's front-row seat to nearly the entire QC community, I asked him what sorts of problems QC's might solve. He responded that "I don't believe we should be focused on applying quantum computing to the problems of today…we should be focused on what happens post-quantum and the trillions of dollars of opportunity. And it's not just computing, it's sensors and communications too. I see trillions and trillions of dollars of opportunities nobody can even fathom today because they're going to come out of mistakes made on quantum computing experiments or experiments done by unlikely people. And that's why it's important to me to distribute this technology as wide and far and freely as possible." Given Strangeworks' large and growing ecosystems and vast numbers of partners and collaborators, it was a natural company to feature in this post, and given its exciting and evolving model, I look forward to providing additional details and color in a future post.

ColdQuanta

Based in Boulder, Colorado, ColdQuanta traces its roots to Drs. Eric Cornell and Carl Weiman who created the first ever Bose-Einstein Condensate (BEC) at UC Boulder in 1995, a feat for which they were awarded a 2001 Nobel Prize. BEC is a new form of matter, which is created when atoms are cooled close to absolute zero. ColdQuanta uses lasers to arrange either cesium atoms (cooled to a few microKelvin, or millionths of a degree for qubits) or rubidium atoms (cooled to nanoKelvin or billionths of a degree to make BEC, where the atoms act as a single quantum object and are used most notably in sensing) and hold them in place. Since temperate is a measure of kinetic movement, locking these atoms in place reduces their movement and hence,

reduces their temperature. ColdQuanta uses this cold atom method across multiple quantum applications including gate-based quantum computers as well as a variety of quantum sensing and signal processing applications such as High Precision Clocks, Quantum Positioning Systems (QPS), Quantum Radio Frequency Receivers (QRF) and Quantum Networking and Communications. While Quantum Computing steals most of the "quantum" headlines these days, these other quantum-enabled devices bring enormous advances in their fields.

ColdQuanta is on target to release its 100-qubit cloud-based quantum computer called Hilbert, sometime this year. Hilbert promises superior error correction, high qubit connectivity (4:1), long coherence times, and high gate fidelity, among other features. And most importantly, despite the super-cold atoms, the device itself operates at room temperature. In addition, because atoms do not have an electrical charge, they can be packed close together making this method of qubit construction highly scalable and compact. In fact, there is a ColdQuanta sensing device operating on the International Space Station, and while that is not a Quantum Computer, it reinforces ColdQuanta's ability to deliver highly stable and compact devices even in the most extreme environments.

ColdQuanta has entered a number of collaborations which I'll highlight below. Also, the breadth and depth of ColdQuanta's capabilities and its unique method of qubit creation, are quite fascinating, as are some of its customers which include NASA and DARPA, so look to this blog for an upcoming feature on ColdQuanta where I will describe more of these details.

Classiq

Classiq is a quantum algorithm design company based in Tel Aviv, Israel, developing software for tackling urgent and complex challenges in Quantum Computing development. Classiq's software increases the level of abstraction and permits developers to implement programs without the need to design the specific gate-level quantum circuits, enabling programmers to accelerate the development of algorithms without the need and expense of manually coding every step and function.

In these early days of QC, where machines have dozens or maybe 100's of qubits, many early users are able to write the code themselves, although there are few people that can manually create, test and maintain an efficient circuit with more than 25 qubits. And as QC's scale to 1,000 or 10,000 qubits or more, manually writing code for every qubit and every function will be practically impossible, so the Classiq algorithm design platform will be increasingly vital to users of QCs. And on top of the general efficiencies that Classiq can provide, their platform searches for solutions over a huge design space, meaning it can explore many more configuration options than a human can (see more details here). This leads to circuits that are more compact and efficient and results that are more accurate since fewer gates can but used. Another unique and constructive feature of the Classiq platform revolves around their allowing customers to use the platform to build their own modular functional blocks, which they can reuse together with blocks provided by Classiq. This enables/allows customers to build and own their own IP without needing to risk IP leakage to external providers. As companies build proprietary quantum software applications, enabling this IP protection will be essential.

Their Quantum Algorithm Design (QAD) platform is the quantum equivalent of computer-aided design (CAD) enabling quantum software engineers and scientists to produce algorithms much faster than ever. As quantum circuits become increasingly larger and more complex, it becomes difficult or impossible to design them manually. The QAD automatically synthesizes complete quantum circuits from high-level functional models in seconds and does so in an elegant and easy to utilize visual framework. It is platform agnostic so can work with any gate-based QC, most major quantum cloud providers and can output its code in various quantum languages including Qiskit, Q#, Cirq and others. And while some development tools provide certain templates, such as VQE (variational quantum eigensolver, used for things like preparing the ground state of a given molecule to aid in drug discovery among many other uses), they are very difficult to customize. Similarly, search algorithms require an oracle function which is nearly impossible to create manually but very easy with QAD. Look to this site for a future feature post about Classiq, but in the meantime, I encourage you to visit their website and sign-up for updates. They offer frequent webinars and informal demonstrations and other ways to learn more about their products. They also host "The Qubit Guy's Podcast," an excellent weekly discussion led by CMO Yuval Boger, which you can access here or wherever you listen to your podcasts.

Select Collaborations

Now that you have a general understanding of these three profiled companies and their businesses, I want to describe a few of their collaborations to emphasize the interdependence and cooperation that is spurring advances in Quantum Computing.

ColdQuanta/Strangeworks

This past December, ColdQuanta and Strangeworks announced the addition of the forthcoming Hilbert Quantum Computer to the Strangeworks Ecosystem. Hilbert will be available for early access by select members of the Strangeworks Backstage Pass program with general available later this year. As noted above, the Backstage Pass program is a vital tool for early development and evaluation of new QC capabilities, and ColdQuanta is benefiting from important feedback in advance of its broader public release. Think of it as a beta release which is accessible to an optimal set of users and therefore able to provide deep insights on strengths and weaknesses of the system.

Classiq/ColdQuanta

In January of this year ColdQuanta and Classiq announced a partnership to make 100-qubit quantum circuits a reality for companies and researchers seeking quantum computing solutions. The partnership combines ColdQuanta's cold atom quantum computers and Classiq's quantum algorithm design software. They aim to provide customers with the ability to create, simulate and execute unique quantum circuits to address a wide range of finance, material science, supply chain, and machine learning challenges. As Nir Minerbi, CEO of Classiq noted, "as the industry moves from toy problems solved by toy circuits running on small quantum computers to solving real problems that require complex circuits on larger quantum computers, there is an acute need for a high-level platform to develop these circuits quickly and efficiently." By entering into this

partnership now, the companies should be well aligned to scale together as ColdQuanta releases larger QCs in the future.

Classiq/NVIDIA

Last month Classiq announced a collaboration with NVIDIA to bring large-scale quantum circuits to customers intended to enable the exploration of the benefits of larger quantum circuits before the actual quantum hardware is available. To create and debug the next generation of quantum algorithms, customers need to simulate larger and more sophisticated quantum circuits. NVIDIA has developed the cuQuantum software development kit to speed up quantum circuit simulations based on state vector and tensor network methods. By combining with Classiq, NVIDIA hopes that cuQuantum users can write more sophisticated solutions which can be created, debugged, stress-tested and scaled in preparation for eventual availability of quantum hardware that can execute them.

Classiq/NTT

Late in 2021 Classiq announced a collaboration with NTT DATA to implement novel credit risk analysis algorithms using quantum computers. Credit risk analysis is vital in determining the creditworthiness of borrowers or vendors to quantify and limit the risk of loss to the lender. As Shunichi Amemiya, Head of R&D for NTT DATA noted "we are interested in applying quantum computer technology to financial engineering…Classiq's platform enables us to effectively generate and run quantum algorithms for the issues in applying to our use case." This is important in that it represents a collaboration between a QC company and industry, with very specific use cases in mind. As more and more companies consider QC applications for their industries, I expect to see more of these types of collaborations and believe Classiq offers a unique value proposition for accelerating QC engagement by industry.

ColdQuanta/IBM Q

In May of last year, ColdQuanta announced that it had joined the IBM Quantum Network and would be integrating IBM's Qiskit open-source software development kit (SDK). ColdQuanta plans to make its Hilbert QC available via IBM Q, IBM's quantum network, and combined with its integration with Qiskit, will enable ColdQuanta customers to accelerate their quantum computing initiatives. The companies also noted that they will pursue joint development opportunities with the goal of accelerating the adoption of other quantum technologies.

Summary

Based on the open-source nature of many of the aspects of the QC ecosystem and as this post highlights, 'collaboration' is the *modus operandi* in Quantum Computing at present. While some companies may enter such arrangements largely for the press release, there are many advantages in uniting best-in-class players to create synergies between areas of expertise. I am certain we will see more and more such collaborations in the future, not to mention more formal M&A activities. As the market matures and these companies begin generating meaningful revenues, I expect this spirit of openness to begin to fade as companies compete for customers. But in the meantime, I

look forward to following the various collaborations, partnerships, and other alignment arrangements.

***Disclosure**: The author has no beneficial positions in stocks discussed in this review, nor does he have any business relationship with any company mentioned in this post. The views expressed herein are solely the views of the author and are not necessarily the views of Corporate Fuel Partners or any of its affiliates. Views are not intended to provide, and should not be relied upon for, investment advice.*

References:

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Lipman, Paul. Interview. Conducted by Russ Fein, March 9, 2022.

Hurley, William. Interview. Conducted by Russ Fein, March 29, 2022.

"ColdQuanta and Strangeworks Announce Addition of Hilbert Quantum Computer to Strangeworks Ecosystem," PR Newswire, December 21, 2021.

"CLASSIQ and ColdQuanta Partner to Provide a Complete Solution to Creating and Executing 100-Qubit Quantum Circuits and Beyond," Businesswire, January 25, 2022.

"CLASSIQ Collaborates with NVIDIA to Accelerate the Path to Quantum Advantage,"Businesswire, March 24, 2022.

"CLASSIQ, NTT Data Collaborate on Quantum Algorithm Design for Financial Modeling," Businesswire, December 1, 2021.

"ColdQuanta Joins the IBM Quantum Network, Bringing Cold Atom Quantum Technology to Growing Ecosystem," Global Newswire, May 26, 2021.

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