VIEW

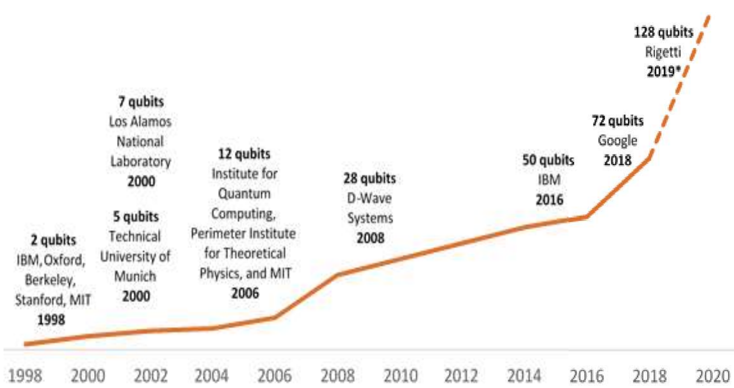
Will Quantum Computing Change the World?

Introduction

For many years, conventional wisdom has suggested that quantum computing may change the world by disrupting dominant industries including telecommunications, cybersecurity, manufacturing, finance, and healthcare. Recent news coverage and research and development by technology giants, including Google, Microsoft, Intel, and IBM has increased enthusiasm about the possibilities of quantum computing. Startup activity and venture capital investment has been on the rise, aiming to take advantage of a confluence of trends that may spur an entire quantum computing ecosystem. While quantum computing is highly promising, investors with potential exposure to the space must build an understanding of the technology and its challenges in order to optimally frame investment strategies.

Quantum computers, supercomputers equipped with advanced processing powers, can process massive and complex datasets more efficiently than classical computers. Quantum computing, the marriage of quantum physics and digital computing, uses the fundamentals of quantum mechanics to speed up solving complex computations. Unique to quantum computers is the ability to rely on two important states of matter, known as superposition and entanglement. These states can speed up the ability to perform immense computations.

Number of qubits acheived by date and organization 1998 - 2020*

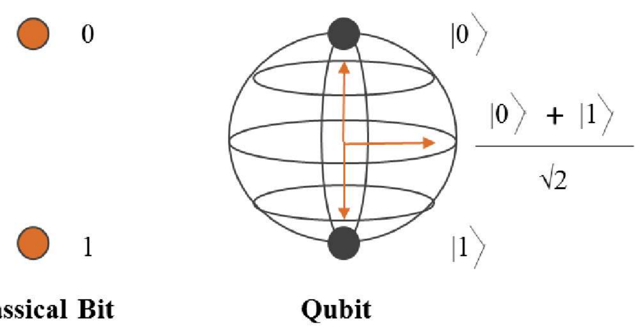


Source: CB Insights

Though theoretical concepts of quantum computing have been around for decades, we have recently witnessed significant advancements. Quantum computing power, as measured by qubits, has increased exponentially in recent years and has also contributed to the renewed enthusiasm.

Quantum Computing Explained

Quantum computers do not use transistors (or classical bits). Instead, they use qubits. Qubits are the basic units for processing information in a quantum computer. Quantum mechanics allows qubits to be in multiple states and levels simultaneously as opposed to bits which have



Source: CB Insights

to be in one state or another. To understand why quantum computers can process massive and complex datasets more efficiently than a classical computer, consider this example: Think about a large listing of patient data, randomly sorted, and then imagine you have a specific name to look up in that data. Without user-altered filtering, a classical computer will search each line of the dataset, until it finds and returns the match. In theory, a quantum computer could search the patient data set instantaneously, assessing each line simultaneously and return the result much faster than a classical computer.

At a high level, there are three types of quantum computing. The first, quantum annealing, is best for solving optimization problems. The second, quantum simulations, uses advanced modeling to account for greater combinations. Lastly, universal quantum computing is the most powerful and most applicable, but the technology doesn't exist yet as over 100,000 qubits are required.[1] Universal quantum computing has all the properties of quantum annealing and quantum simulation with the aim of efficiently solving massively complex computations.

Market Opportunity

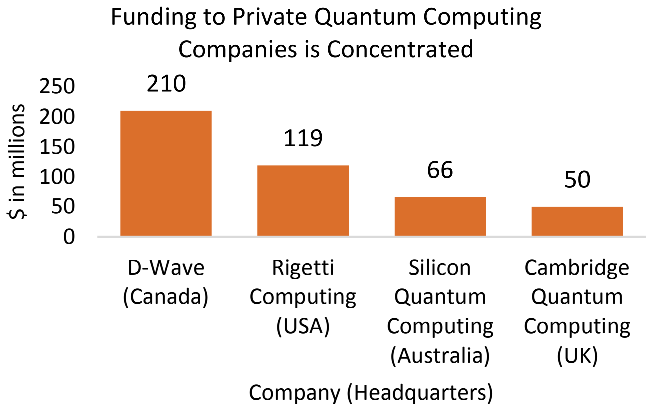
The global enterprise quantum computing market was valued at $650 million in 2017 and is projected to reach approximately $5.9 billion by 2025, growing at a CAGR of 31.7% from 2018 to 2025.[2] The hardware segment dominated the overall enterprise quantum computing market share in 2017 and this trend is expected to continue during the forecast period due to the increased investment in startups working on quantum computing hardware. Solving hardware-related problems in quantum computing is required to unlock the full potential of the technology. Conversely, the service segment is expected to attain the highest growth rate during the forecast period due to increased adoption and the availability of cloud services associated with quantum computing. Key opportunities within the services segment include allowing users to develop, test, and run their programs on quantum devices without a physical quantum computer.

Geographically, North America dominated the overall market in 2017, as the U.S. was a major contributor to the growth of the enterprise quantum computing market in North America. The dominance of this region is primarily driven by the U.S. Government, which recently announced a $1.2 billion initiative to fund activities promoting quantum information science over an initial five-year period. The bill includes creating new research centers that bring together academics from different disciplines, such as computer science, physics, and engineering, to help experiment and train future quantum researchers. Additionally, large companies and startups are incentivized to pool their knowledge and resources in joint research efforts with government institutes.[3]

Quantum computing is also generating enthusiasm outside of North America. In fact, Asia-Pacific is expected to witness the highest growth rate during the forecast period as it is one of the most opportunistic regions for the quantum computing market. For instance, the Chinese government is building a $10 billion National Laboratory for Quantum Information Sciences, which is expected to start its services by 2020. Though early in its development, the elements critical to a successfully growing market are seemingly taking shape.

Market Traction

Despite government support, an evaluation of private markets suggest that the commercial application of quantum computing remains incipient. There are only a few private companies in the industry that have been able to raise at least $50 million, and only four deals accounted for approximately 70% of the industry's total funding since 2013.[4]



Source: CB Insights

However, the number of new investments has accelerated in recent years. Total yearly deals increased over 200% to 24 in 2018 from seven in 2013.

Private company investments in quantum computing are driven by corporations and venture capital firms. On the corporate venture capital side, Google Ventures and Amazon have invested in ionQ, a developer of quantum computers which combines physical performance, qubit replication, optical networkability, and highly-optimized algorithms to support a broad array of applications for many industries. Notable is that Google Ventures co-led the Series B round in 2017. Perhaps more publicized are the efforts of large technology companies, including

[1] CB Insights, November 2018
[2] Allied Market Research, January 2019
[3] MIT Technology Review, December 2018
[4] CB Insights, November 2018

Microsoft, Intel, and IBM. Microsoft has been working on full-stack solutions, including hardware and software platforms and programming languages. Intel is focused on producing quantum processors and doing system-level engineering that target production-level quantum computing and IBM is focused on advancing the entire quantum computing technology stack and exploring applications to make quantum broadly usable and accessible.[5]

Traditional venture capital firms have also participated in the growth of quantum computing. In 2017, Quantum Circuits, a Connecticut headquartered company, raised $18 million of Series A venture funding in a deal led by Canaan Partners and Sequoia Capital. Quantum Circuits is a unique manufacturer of quantum computers that enable customers to make error free computation through solid-state quantum bits.[6] Another company in the quantum computing space is Bleximo, a startup that aims to build quantum processors in many industries. Noteworthy is that Bleximo is not building a general-purpose quantum computer, but rather Bleximo is building "quantum accelerators," special-purpose quantum computation systems, that will aid conventional computers in solving industry's hardest practical problems. Eniac led the $1.5 million seed round in 2018. Currently, Bleximo is mostly looking at speeding up simulations of new materials and molecules for drug development among other industries. D-Wave, the most well-funded privately held quantum computing company, utilizes technologies to solve optimization problems for commercial use across a diversified set of industries, enabling users to get customer support, site preparation, site installation, training packages, and on-site engineering services.

The majority of the venture capital industry's exposure to quantum computing comes through investments in three quantum computing manufacturers, Rigetti Computing, D-Wave, and Atom Computing. Aside from traditional venture capital firms, accelerators such as Y Combinator and Alchemist are investing in quantum computing. The overwhelming majority of investments have been early stage investments in the manufacturers. At this time, many venture capital firms are opportunistically investing in the category and do not represent substantial positions in funds. For expertise, professionals within venture capital firms are often engineers who have backgrounds in engineering, physics, and mathematics. Overall, many firms appear to be opportunistically investing in quantum computing and venture investments are not reflective of the entire stack.

Applications of Quantum Computing

Quantum computing is poised to impact many significant markets. The healthcare and financial sectors are the major industries anticipated to adopt this technology due to the rise in demand for effective medicines and an increased need for better financial portfolio optimization.[7] It takes at least 8-10 years to develop a particular drug due to billions of possibilities of its reaction on the human body. By using quantum computing, such possibilities and complexities can be reduced and solved efficiently. In addition, quantum computing has scope in determining the cures for several diseases by mapping proteins in DNA, which provides major opportunities for the medical and healthcare industries. Financial service firms are especially interested in quantum computing technology. For instance, Royal Bank of Scotland Group, Barclays, Goldman Sachs, Morgan Stanley, and other financial institutions focus on exploring the potential use of quantum computing in areas such as asset pricing, portfolio optimization, capital project budgeting, and data security.[8]

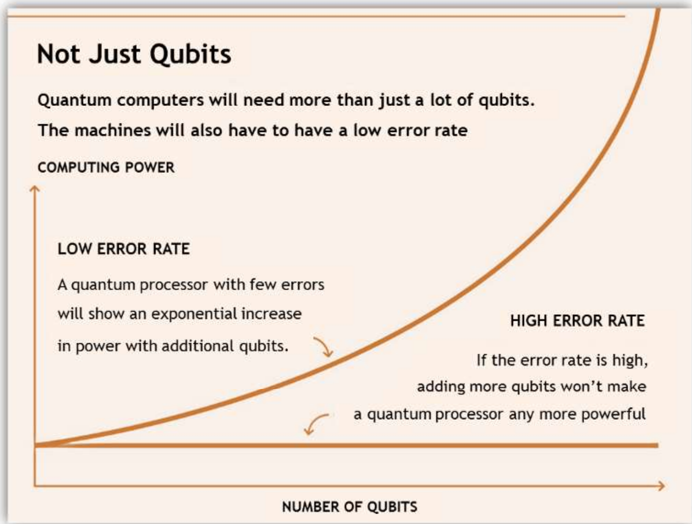
Other applicable industries include cybersecurity, cloud computing, and general advancements in artificial intelligence. One threat from quantum computers is that they can break cryptographic codes that society uses to keep sensitive data and electronic communications secure. However, quantum computers can also secure data from quantum hacking, termed quantum encryption. Quantum cloud platforms could simplify programming and provide low-cost access to quantum machines.[9]

Challenges

Quantum computing remains an evolving industry and challenges lie ahead. One challenge is the propensity to require highly talented individuals trained in quantum physics to advance the industry with limited visibility on

[5] Intel.com and IBM.com
[6] Pitchbook
[7] Allied Market Research, January 2019
[8] Allied Market Research, January 2019
[9] CB Insights, November 2018

commercialization. Another is the trend that hardware investing has become less attractive to venture capital investors primarily due to its capital intensity. Lastly, and most importantly, errors in quantum computing have limited the potential of the emerging technology. Though there has been exponential growth in qubit-powered computing, the quantum states are fragile and prone to collapsing or producing errors when exposed to the electrical "noise" from the world around them. However, many companies have developed code to reduce error rates with increasing success, a trend that bodes positively for the industry. Despite the challenges and advancements in quantum computing, it is likely that both classical and quantum computers will co-exist, with quantum computers complementing classical computers in solving specific complex problems.



Source: Quantamagazine.org, Fairview Analysis

Given this, quantum computers will need to be designed to be responsive to cloud-based applications, web services, and co-processing hardware.

Outlook

While quantum technologies are emerging, a true quantum computer with a proven value chain is still years away. When developed, quantum technologies will co-exist with classical computers. As the race for qubits continues to increase, companies must make sure the existing qubits perform efficiently with low error rates. As of now, the quantum computing industry is in the early days of investment and firms engaged are cautiously optimistic in their approach to investing, as evidenced by their selective approach. This is true in Fairview's portfolio as well.

Institutional Investors need to monitor advancements in the category and ensure that they have the appropriate approach to capitalize on the potentially disruptive trend. Private equity and venture capital investors have a unique opportunity to gain access to and impact the advancement of quantum computing. Quantum computing companies that emerge as winners will be able to capture a large market share and drive significant value creation to investors. However, as evident already, many are opportunistically investing in the space and a diversified approach is best.