QCi | Ready-to-run Quantum Software

Three Ways To Make Your Business Quantum Ready

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The hype around quantum computing is real. As is the potential for quantum to transform the way we use complex computational techniques to fuel more informed business decisions.

But what can you actually accomplish with quantum today? Especially given that current quantum hardware can't scale to contain the volumes of data needed to solve the complex, real-world problems it's designed to solve?

Is it all or nothing? Do you really have to wait until Quantum evolves to replace classic systems to run that big complex supply chain optimization? Is there something you should be doing now to shift toward quantum for the future?

The answers are No, No, and Absolutely.

What is the State of Quantum Computing, Right Now?

Quantum is at an early stage in its evolution. We already know it's going to change the computational world as we know it. The economic benefits are enormous. That's why an estimated $22B is being plowed into developing quantum technologies worldwide. It's all about achieving faster, better solutions to really hard computational problems.

For instance:

- Your supply chain optimization has become so complex, with such large variable sets and interrelated constraints, it's nearly impossible to know if you are optimizing every step, or even the best steps.
- Compared to today, identifying the best candidates for potential security breaches used to be straightforward. Not anymore. The complex interactions, combined with the vast number of devices, makes security vulnerability assessment a complex, constantly moving target.
- On-time delivery is critical to your customers' satisfaction. Yet Covid has geometrically increased the volume of orders and potential delivery options. How can you keep up?

All of the above are examples of problems that quantum computing can and will solve. Easily.

But only once quantum hardware is ready for production scale.

When is that going to be?

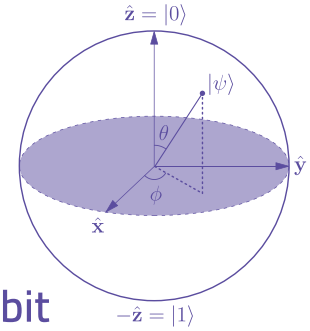
Well, that's the 22 billion-dollar question. Vendors have different answers, as do experts in various industries and disciplines.

We all agree on one thing. It's not ready right now.

So, does that mean you should wait until then? How do you do prepare for this coming quantum advantage?

First, let's review a few key fundamentals about quantum computing.

Quantum Fundamentals Everyone Should Know



Qubit

/ˈkjuːbɪt/

Basic unit of quantum information

Quantum is expected to be able to solve today's problems faster and better, and to efficiently solve currently unsolvable problems, and larger and larger future problems.

One reason for this promise is the difference between classical computing's serial data analysis vs quantum's multi-dimensional analysis.

With classical computing, today's data volumes limit the performance and results that a classical application can achieve. As data grows, the volumes overload classical resources.

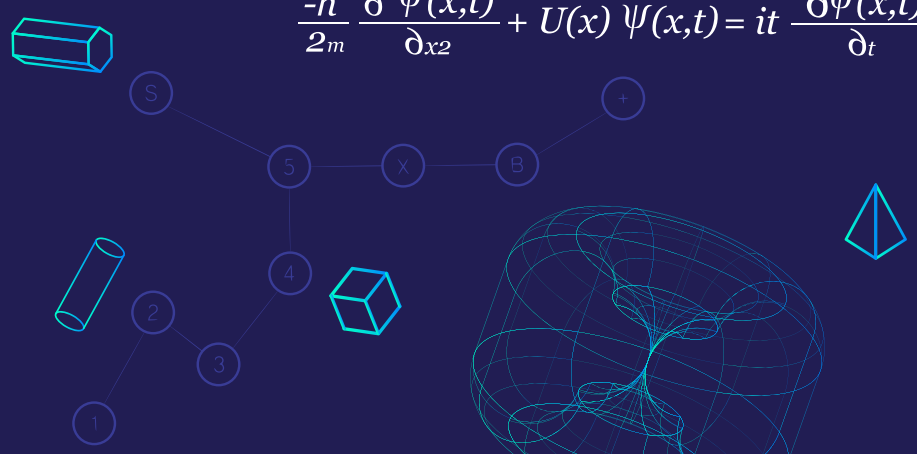
Serial processing in a binary space can't handle the large data volumes of many problems. That limits the size and validity of analytics. This forces SMEs and programmers to compress/reduce and limit the data that is processed, resulting in a lower quality solution. Plus, classical computers generally return one result, limiting the range of potentially powerful decision insights.

Quantum computers, on the other hand, utilize multi-dimensional, simultaneous analysis. Data is structured to accelerate performance, better mirroring the natural multidimensional state of most problems. Consequently, quantum computers, once they reach production levels, will be able to return a diversity of results, offering more and better opportunities to find the best possible solution in different business situations.

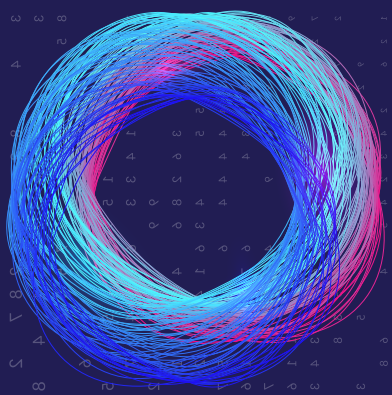
It's important to keep in mind that quantum computing is a completely new paradigm. Not only does it require entirely new "hardware," it also demands a new and highly technical set of skills to create the software that will drive processing quantum problems and results. For example:

- With classical computing, a programmer writes software, using binary elements of one and zeros (abstracted by app dev software), that are serially processed.
- Quantum problems are not programmed. Instead, a matrix of multiple elements is presented to a quantum computer in a format that is already pre-optimized for a QPU (quantum processing unit) to resolve. For example, a Quadratic Unconstrained Binary Operation (QUBO) is used to create the quantum lattice for annealing machines, while that QUBO is converted to a quantum circuit using the Quadratic Approximation Optimization Algorithm (QAOA) for a gate model machine.
- To create these packages, math, physics and quantum experts need to program complex circuits, algorithms and more to create the problem submission to the quantum system. They also have to program low level hardware configurations for each Quantum Processing Unit (QPU) type, and again for all upgrades or expansions.
- The difference between linear binary programming and sequential, multi-dimensional presentation and optimization means that quantum requires highly trained quantum experts to define the problem and its processing to extract full benefit from the quantum computer.

$$\frac{-\hbar^2}{2m}\frac{\partial^2\psi(x,t)}{\partial x2} + U(x)\,\psi(x,t) = it\,\frac{\partial\psi(x,t)}{\partial t}$$



$$\hat{H} = \sum_{n=1}^{N} \frac{\hat{p}_n^2}{2m_n} + V(x_1, x_2, \ldots x_N)$$



These experts are expensive. And the quantum software development kits that are available today are complex beyond measure. You literally have to be a math or physics genius to understand how to use them. One quantum programmer recently noted that it took over 8 months to begin to understand how to begin to program a very simple problem using a popular quantum software development toolkit.

The bottom line? Quantum computing has huge potential. It's also a new, complex paradigm that organizations need to thoughtfully and thoroughly plan for as part of their near-term computational infrastructure.

3 Practical Steps for Quantum Computing, Right Now

The power of quantum is obvious. The only question is, "How do we get there?"

That's not a simple answer. It depends on where you are today, what computational problems you need to solve, your inclination toward risk (e.g., build vs buy), budgets and more.

That said, we believe there are three steps you can take, right now, to move into the power of quantum performance and accuracy. Your business can and will reap value from quantum when you apply these practical approaches to leveraging this powerful technology.

1. Set the appropriate expectations for how you can and will use quantum computing.

Much of the information about quantum computing is really complex. It's also confusing as to what's real and what's not, what quantum can do and when it can do it. Here are a few quantum truths to consider as you begin to explore how it can benefit your organization.

We think it's important to set the expectations for your business correctly. Consider this first: While it's rightly garnering a lot of attention, Quantum computing will not replace classic computing. Quantum computers are not meant to do what classic computers do. The idea that quantum will process transactions, manage databases, run accounts and more is simply not feasible.

Thanks to its multi-dimensional processing, a quantum computer can test several possible solutions to a problem at the same time. Again, this is the biggest difference to classical computers: They process data step by step. It takes time for the final result to be achieved. And there is only one solution at a time.

Quantum computers are inherently designed to solve complex computations that require multi-dimensional analysis of diverse and changing scenarios, like a dynamic supply chain or logistics problem. A quantum computer will be able to perform calculations on a far greater order of magnitude than traditional computers … a concept which has serious concerns and applications in the realm of cryptography & encryption, supply chain, logistics, pharmaceuticals, finance and more.

The best expectation for quantum computing, for the foreseeable future, is to view quantum computers as providing powerful assistance to classic computers for complex computations. Our workflows today are usually designed to send a computational problem to a specific software for constraint optimization, then return that result to the workflow for continued processing.

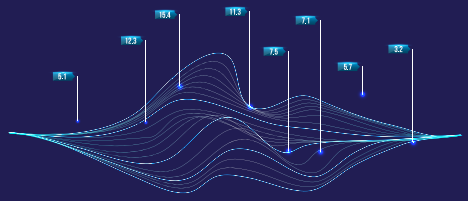
We see the initial and near-term value from quantum coming from the same type of integration with classic workflows. A workflow or application would simply call the quantum computer for specific computational processing needs, as it's needed—a sort of quantum kicker or assist. The results from quantum processors are returned as part of the overall workflow, with classic computers continuing to drive the processing leveraging the quantum insights for faster and more excellent results.

2. Evaluate how you'll most effectively program quantum software applications

As you would expect given the dramatic differences in hardware architectures, quantum software requires a dramatic shift from classic software. You literally have to create every single circuit, gate, algorithm, action and process. Using new quantum programming calls.

For example, the programming to configure and access QPUs is low level and extremely complicated. This coding is proprietary to each vendor's QPU requirements, not to mention unique to the specific count and version of QPUs in the system, right now. When the system is expanded or a QPU upgraded, all the code has to be rewritten. It makes the days of old when we were writing assembly code for individual devices seem really simple.

How do you prepare to understand this new programming paradigm? And the options available to you? Here are some recommendations.



- Take some time to have your more technical folks review the Quantum software development kits that are available today. It will take some time and focus, and you don't have to understand everything. You do need to understand enough to appreciate the complex and complicated process of building software from the bottom up.

  While you're at it, be sure to gather an understanding of the requirements for the lowlevel hardware coding to configure and manage the quantum QPUs. Also explore the ongoing maintenance/lifecycle programming required for every update or expansion, should you choose to use quantum SDKs for quantum programming.

- Once you understand the fundamentals of quantum programming, do yourself a favor and evaluate QCI's Qatalyst Quantum Acceleration Platform. The Q API masks all quantum programming complexity from your SMEs and programmers. Using six simple API calls, you can submit your computational problems using the same familiar constructs your SMEs, programmers, workflows and applications we use today. Qatalyst does the rest. No need for programming hardware level code, no need for updating that code, no need for programming new quantum workflows or applications.

The tools are on the market today to understand what's needed to develop powerful applications with quantum systems as they come online. Investing in that discovery today will give you an early advantage in solving some of your most complex problems in the future.

Which leads us to our final recommendation.

3. Begin to evaluate your business for problems that are best possibilities for quantum.

There are specific areas where quantum can best help your business in the near and longer term. You can start identifying those areas now. What should you be looking for?

The first areas in your business to consider are where constrained optimization can bring significant value.

The classic traveling salesmen problem is a clear example of a constrained optimization problem which is perfect for quantum computers. We all know this problem: how do we get our salesmen to meet with every possible customer or buyer with the most effective use of time, miles, and cost?

Supply chains are similar to this conceptual problem, and as such are a prime target since they are extremely complex to optimize. With the dramatic shift to online purchasing and shipping, that complexity is growing every day. Don't just think about the supply side of the equation. Every step of creating, stocking, selling, delivering and servicing your customers is part of the supply chain/logistics operation today. Quantum computing has the potential to both accelerate the performance of computations around supply chain optimization, as well as identifying more and better answers to better optimize your business - which means happier customers and a better bottom line for you.

Another significant potential area in your business that could benefit from quantum are problem spaces that involve the need for community detection—identifying groups of interacting objects and the relations between them.

Community detection refers to the mathematical computations that are key to understanding the structure of complex networks of "things," like computers, people, bacteria and more, and ultimately extracting useful information from them.

Community detection might be used in your business, for instance, to identify groups of buyers, their interrelated buying patterns and preferences, their common reactions to offers and more.

Or, if you're in life sciences, to discover protein interaction networks, or new outcomes associated with clinical trials. Security companies can use community detection to detect aberrant behavior shared by multiple, seemingly disconnected parties. The possibilities are endless.

Whatever complex computational need you have, it's likely quantum will offer an opportunity to improve the insights you receive, driving better and more informed decisions for bottom line growth.

The Bottom Line

Quantum computing isn't ready for prime time right now. That doesn't mean it doesn't offer advantages to organizations right now.

Quantum techniques and approaches offer significant upside today. Even better, organizations have the time and opportunity to begin to explore quantum computing to fully understand and identify where and how it can and will help their bottom line.

It's an exciting technological advancement. When you take the right steps, right now, you'll create even more advantage for your business, today and in the future.

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