

15-Minute Guide

Accelerate your path to quantum computing

Abstract

As one of the most disruptive technologies to come along in the last few decades, it is difficult to overstate the transformative power of quantum computing. Dell Technologies is leading the charge, enabling disruptive quantum use cases that simply aren't possible with traditional infrastructure alone.

Together with prominent industry partners, Dell Technologies offers hybrid classical/quantum systems that enable first-movers to adopt quantum technology today and stay ahead of the innovation curve as it advances.

In this guide, we share the Dell Technologies approach to creating pathways of choice for hybrid classical/quantum computation.

November 2022

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**29%**

of enterprises have adopted quantum computing¹

40%

of enterprises plan to adopt quantum computing in the next year¹

74%

of enterprise leaders agree that those who fail to adopt quantum computing will fall behind¹

Make a quantum leap in computational capabilities

Quantum computing changes everything

Quantum computing is one of the most disruptive technologies in decades—perhaps in human history. While there is a lot of hype around quantum computing, it is difficult to overstate how transformative quantum computing is. The unparalleled performance improvements enabled by quantum technologies provide astonishing gains in the time it takes to solve highly complex problems. Teams can unlock answers to extremely complex questions in just minutes — questions that might take today’s most powerful supercomputers hundreds or thousands of years to solve.

The potential impact on humanity is as exciting as it is incalculable. Pharmaceutical companies can use quantum computing to vastly increase the speed and efficiency of drug development to catalyze a wave of life-changing discoveries. Faster, more accurate weather modeling will protect lives and property to help mitigate the effects of global climate change on billions of people. Chemical materials development for new fertilizers promise to eliminate famine and support ever-growing populations. The leap-frog capabilities in algorithmic processing unlock truly revolutionary progress across an unimaginable range of use cases.

Dell Technologies is committed to taking the lead in quantum computing, helping our customers use quantum computational capabilities to develop innovations and disrupt markets. Dell Technologies partners with prominent quantum computing hardware vendors such as IonQ to offer hybrid quantum computing, with a constant pursuit of innovation that will help our customers keep pace as quantum computing evolves.

¹ Zapata, [The First Annual Report on Enterprise Quantum Computing Adoption](#), December 2021.



Activate data in unprecedented ways

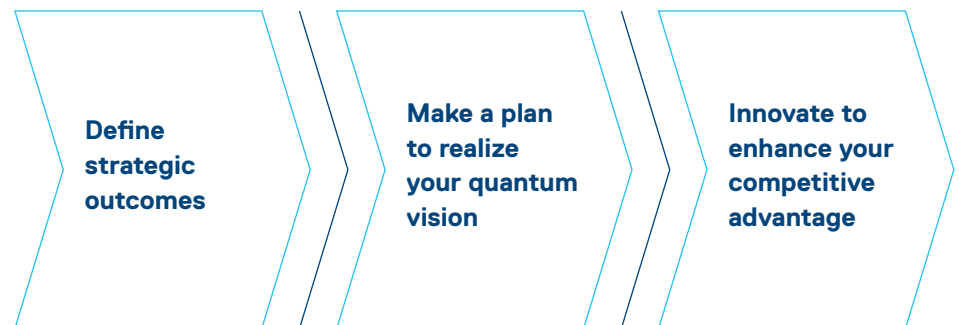
It's time to capitalize on quantum

Quantum technology is no longer on the horizon — it's already here. Recently, major governments have announced plans to invest billions of dollars in quantum-related research, and investments in quantum computing startups surpassed \$1.7 billion in 2021, more than double the amount raised in 2020.² Five quantum system developers have announced plans to have fault-tolerant quantum computing hardware by 2030, and industry insiders believe that within the next five years we will experience “the inflexion point for large-scale quantum computing adoption in real world applications.”³

Today, nearly a third of global enterprises have adopted quantum computing in some form, and 41% of them expect it to deliver an advantage over their competitors within the next two years.¹ These organizations are primarily using quantum computing to accelerate machine learning and analytics workloads.

Of course, every organization approaches implementing and deriving value from quantum computing differently. Dell Technologies can help you navigate the path to quantum, lowering barriers to entry, reducing the risk of adoption and bridging deployment so you use quantum computing with confidence.

Get started on the path to quantum



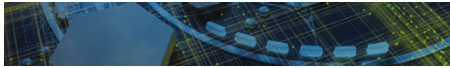
Define strategic outcomes. Analyze your existing technology landscape and business needs to form a hypothesis about how you could use quantum to solve some of your unique business challenges. This may involve education and training to bring staff up to speed on the state of quantum computing.

Make a plan to realize your quantum vision. Find a partner who can help you on your path to quantum computing, with strong industry partnerships, a proven ability to deliver a portfolio of advanced computing solutions and a commitment to continued innovation to keep you on the leading edge as quantum evolves.

Innovate to enhance your competitive advantage. Evolve your quantum vision as the technology advances and new use cases emerge. Dell Technologies can help you build on past successes to create new competitive advantages.

² McKinsey, [Quantum computing use cases are getting real—what you need to know](#), December 2021.

³ Forbes, [The State Of Quantum Computing: Future, Present, Past](#), April 2022.



Solving Unsolvable Problems in Minutes

Classical computer processors can only do one calculation at a time, so the more complex the problem, the longer it takes. That makes answering data-intensive questions subject to physical limitations. A problem that requires more power and time than a classical computer can reasonably accommodate is called an “intractable problem.” Quantum computing can solve these types of problems in just minutes.

Quantum computing primer

How quantum computing is powering a quantum leap in human progress

Recently Moore’s law — which predicted the doubling of processing power every two years — is running into very real physical limitations that are slowing the pace of innovation with traditional computing. Optimizing code and creating customized processors and accelerators has helped speed up computing performance. But as these measures bump into physical boundaries, the industry is eagerly seeking new ways to increase compute performance that don’t require, as Gordon Moore put it, “cramming more components onto integrated circuits.”⁴ Many are exploring fundamentally different computing architectures, like quantum computing.

Quantum computing is an approach to developing and programming computing systems that is built on the foundations of quantum physics. As a basis of comparison, a classical computer uses binary digits (bits) that can express a value of either one or zero, meaning two bits can be in only one of four possible states — 00, 01, 10 or 11 — at any given time. Because the computer can only process one input at a time, it solves a problem the way you might solve a maze, by trying every possible path until you find the way out.

Quantum computing goes far beyond classical binary states of 1s and 0s. Using quantum physics phenomena such as superposition, entanglement and duality, the basic unit of information in a quantum system — the qubit — can represent all four states of 0s and 1s *at the same time*, with a certain probability for each. Further, changing the quantum state of an entangled qubit will change the state of a paired qubit immediately, creating a computational multiplier for qubits that improves processing speed exponentially. Because of this ability, a quantum system can process information in a fraction of the time it would take classical binary systems.

A 100-qubit quantum processor could theoretically outperform today’s leading-edge supercomputers. A 300-qubit quantum computer could simultaneously do more calculations than there are atoms in the universe. Going back to the maze analogy, a quantum computer can effectively try all the paths at once — even if there were 10^{82} of them.

Hybrid is the near future.

Unlocking value from an ever-growing amount of data in today’s digital economy requires an exponential expansion of compute capacity using a collection of distributed, diverse computing architectures that come together to work as a system — including the ever-evolving space of quantum computing.

Quantum computation can accelerate many types of advanced computing workloads. However, there’s a common misperception that the quantum computer will replace all classical compute. In practice, quantum systems require classical infrastructure to harness their true power.

Hybrid classical/quantum computing combines quantum computation with classical compute infrastructure to power a useful class of applications for quantum computing. This can take the form of a simulator, which re-creates the quantum aspects of a quantum system, or an emulator, which re-creates both the quantum and classical aspects of a quantum system.

In this model, quantum computing can be thought of as a new class of accelerator technology. Sometimes referred to as quantum processing units (QPUs), these accelerators work alongside classical infrastructure to optimally deploy complex algorithms, process data and generate results using a hybrid classical/quantum design.

⁴ Electronic Design, [Can Advanced Materials Address Moore’s Law Slowdown and the Chip Shortage?](#), June 2022.

“Until about 2030, we believe that quantum computing use cases will have a hybrid operating model that is a cross between quantum and conventional high performance computing. For example, conventional high performance computers may benefit from quantum-inspired algorithms.”

— McKinsey²

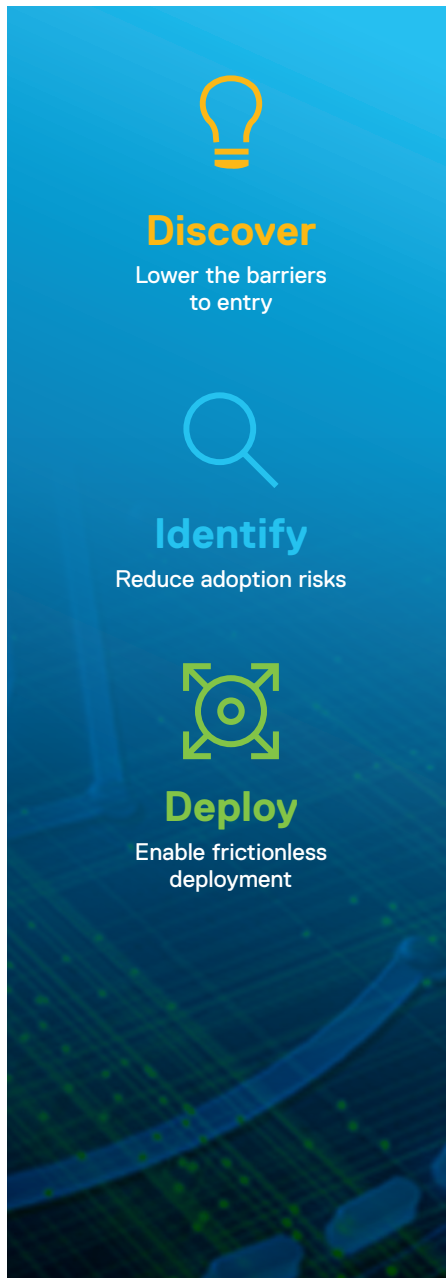
These hybrid systems can be used to augment subroutines of classical algorithms that can be run more efficiently on quantum computers. For example, eliminating an enormous range of possibilities before sending the problem back to a classical high performance computing (HPC) system for processing to save a huge amount of time and make a formerly intractable problem solvable.

How you can use the transformative power of quantum computing

Dell Technologies is dedicated to bringing the power of quantum to enterprises that are ready to harness its transformative power. Hybrid classical/quantum computing lends itself to many existing HPC and artificial intelligence (AI) workloads that could be sped up by quantum acceleration.

Digital services, IT and professional services	Agricultural, chemical and material science	Financial services technology	Healthcare and life sciences
• Consumer recommendations • Search engine optimization • Video streaming predictions • Digital information and distribution analytics • Data management optimization • Network optimization	• Chemical product design • Product lifecycle • Oil and gas refining and leak detection • Reservoir simulation • Quantum chemistry and materials discovery	• Investment risk analysis and investment optimization • Fraud detection, finance security, transaction settlement • Finance product recommendation and optimization • Portfolio management • Regulatory management	• Disease analysis • Disease risk reduction • Advanced diagnostics, imaging analysis • Genomics • Clinical trial enhancements • Medical/drug supply chain

Supply chain, distribution, logistics and transportation	Manufacturing	Security
• Disruption management • Transport freight forecasting • Supply chain and distribution management • Warehouse optimization • Workforce scheduling optimization • Transportation optimization • Fleet management	• Design optimization and simulation • Structural design and fluid dynamics • Autonomous vehicle navigation • Fabrication and manufacturing optimization • Robotics optimization • Quality control • Manufacturing supply chain	• Secure data communication • Secure data encryption • Access control optimization • Cryptography algorithms • Safe tape drive • Blind quantum computing



The journey to quantum computing starts today

Pathways to choices for seamless hybrid classical/quantum computation

Exploring, adopting and evolving quantum computing requires a commitment to ongoing digital transformation and the expert partnerships to help you get there.

Discover: Lower the barriers to entry with learning and experimentation

Quantum computing is an emerging field, and hiring quantum talent will continue to be a challenge for the foreseeable future. This can also be a costly undertaking for many organizations. Dell Technologies is helping to lower these barriers so you can begin your journey with experimentation faster and with more cost-efficient options. Dell Technologies can provide education to enable the discovery of key concepts. We also provide simulation for developing, porting and optimizing code for quantum computing on a classical infrastructure so your organization does not have to break the budget to get started with experimentation.

Identify: Reduce adoption risks by exploring uses cases and benefits

Identifying demonstrated use cases and their benefits for quantum computing will be a challenge as the industry continues to emerge and evolve. Dell Technologies can enable research and development (R&D) for applied theory and logic applications to use cases. We can also act as your trusted advisor for the tools, expertise and infrastructure needed to be successful.

Deploy: Enable frictionless deployment into production and real business benefits

Reducing the complexity of quantum computing will be a key step to operationalizing quantum computing and recognizing business benefits. However, reducing complexity must begin with selecting suitable execution environments for your workloads. Dell Technologies can assist you with converting your use cases into workable outputs using hybrid quantum-classical systems in a production environment. Once complete, the migration from test to production, and across different quantum vendors will be frictionless and you can achieve ROI driven by the business outcomes.

Dell Technologies solutions strategy

Dell Quantum Computing Solution

Dell Technologies is at the forefront of quantum, providing the technology that underpins hybrid quantum acceleration and makes tomorrow's innovations possible. You can rely on the Dell Technologies team of experts as quantum computing evolves.

Hybrid classical/quantum platform with IonQ

A cohesive way of exploring quantum computation is through an end-to-end hybrid classical/quantum solution utilizing virtual QPUs (vQPUs) for simulation. Dell Technologies and IonQ offer a [hybrid classical/quantum platform](#) that leverages Dell PowerEdge servers paired with IonQ's simulation engine and QPU to better enable the journey to hybrid classical/quantum solutions. With the platform, classical and quantum simulation workloads can execute on-premises, while quantum workloads, such as modeling larger, more complex molecules for pharmacological development, can be executed remotely on [IonQ Aria](#) QPUs.

“This hybrid emulation platform represents an important step forward for the Qiskit Ecosystem and the quantum industry as a whole. The platform allows users to work with Qiskit Runtime on their own classical resources, making it easier for both new users and established quantum developers to build and refine their algorithms. We look forward to working with Dell to expand the horizons of the quantum industry.”

— Jay Gambetta,
VP of Quantum at IBM⁵

Coupling Dell Technologies’ strength in classical infrastructure with IonQ’s coherence time, gate fidelity and scale enables this hybrid solution to solve more complex problems. It allows for better error correction to reduce the time spent using the QPU to solve problems. It also allows IonQ to run their QPU at room temperature. This enables placement in established data centers without exotic cooling. These specific IonQ benefits, in turn, enable customers to evaluate what approach works best for them on their quantum journey.

Hybrid platform with Qiskit Dell Runtime

Dell Technologies offers a [hybrid platform](#) that leverages Dell PowerEdge R750 servers with an open-source Kubernetes-containerized service for quantum computers, Qiskit Dell Runtime. The platform allows the user to replicate Qiskit Runtime locally, and explore how quantum applications will run. The Qiskit Dell Runtime environment can use quantum hardware to execute calculations, in just a single day, that would previously have taken several weeks.

As part of the Qiskit project, the technology is completely open source, allowing for third-party integrations and innovations to move the industry forward. The hybrid platform will help make the developer ecosystem more accessible and accelerate use case exploration and algorithm development.

Chart your own path to quantum with Dell Technologies

Dell Technologies has a team of experts who can assist with quantum computing strategy, planning and recommendations, including a customizable solution that can be optimized for different vertical market applications. For example, PowerEdge R750 servers paired with a quantum simulation engine and QPUs are available via the worldwide [Customer Solution Centers](#).

Product highlights

- [Dell Validated Designs](#) take the guesswork out of solution deployment to drive faster time to value, help you build solutions with confidence and enable business without boundaries.
- [Dell Data Science Workstations](#) are fully integrated AI hardware and software solutions designed together with NVIDIA®, Intel® and other leading technology providers. They deliver the data science platform you need with the performance and reliability you expect from Dell workstations.
- [PowerEdge servers](#) are engineered to deliver unmatched performance and versatile configurations to meet the demands of advanced computing workloads. Flash storage, the latest processors and memory with flexible local storage make PowerEdge servers a foundational choice for advanced computing.
- [PowerSwitch networking](#) helps you improve network performance, lower networking costs and remain flexible to adopt new innovations. Take control of your network’s future and learn how the Dell Technologies strategy for open networking can dramatically transform your business.
- [PowerScale storage](#) provides the large, scalable, reliable and efficient storage that advanced computing requires. With support for multiple workloads and enterprise-grade data and file management capabilities out of the box, Dell PowerScale scale-out NAS is the leading storage for HPC and AI. You can take advantage of the high capacity of PowerScale to reduce the acquisition and ownership cost for managing and monetizing data using advanced or predictive analytics and machine learning.

⁵ Dell Technologies blog, [Exploring Hybrid Classical-Quantum Compute](#), September 2021.



Dell APEX

[Dell APEX](#) gives you simple and consistent cloud experiences delivered as a service. With Dell APEX you can provision quickly, scale on demand and pay as you go across your entire multicloud, multi-edge and multi-data center environment. Consuming best-in-class Dell Technologies innovation as-a-Service helps you unlock the flexibility you need to adapt and thrive.

With Dell APEX you can get the optimized solutions you need for enhanced:

- **Simplicity** — Make room for innovation by reducing complexity.
- **Agility** — React quickly to capture new opportunities.
- **Control** — Minimize risk and maximize performance on your terms.

Experience and capabilities

Dell Technologies is committed to advancing quantum computing. We offer a range of opportunities for you to engage with our experts to start working with quantum computing.

Customer Solution Centers

Our global network of dedicated [Dell Technologies Customer Solution Centers](#) are trusted environments where world-class IT experts collaborate with you to share best practices; facilitate in-depth discussions of effective business strategies using briefings, workshops or proofs-of-concept; and help your business become more successful and competitive. Customer Solution Centers reduce the risks associated with new technology investments and can help speed implementation.

HPC & AI Innovation Lab

The Dell Technologies [HPC & AI Innovation Lab](#) in Austin, Texas, is our flagship innovation center. Housed in a 13,000 square-foot data center, it provides access to thousands of Dell servers, three powerful HPC clusters and sophisticated storage and network systems. It's staffed by a dedicated group of computer scientists, engineers and subject matter experts who actively partner and collaborate with customers and other members of the community. The team engineers HPC and AI solutions, tests new and emerging technologies and shares expertise, including performance results and best practices.

HPC & AI Centers of Excellence

Dell Technologies worldwide [HPC & AI Centers of Excellence](#) provide thought leadership, test new technologies and share best practices. They maintain local industry partnerships and have direct access to Dell and other technology creators to incorporate your feedback and needs into their roadmaps. Through collaboration, these Centers of Excellence provide a network of resources based on the wide-ranging know-how and experience in the community.

Additional resources and information

Visit our solutions page:
dell.com/quantum-computing

Services and financing

Along your quantum journey, Dell Technologies is with you every step of the way, linking people, processes and technology to accelerate innovation and enable optimal business outcomes.

[Dell APEX](#) offers a simple approach that gives you a wide range of consumption models, payment solutions and services so you can optimize for a variety of factors while realizing more predictable outcomes.

[Consulting Services](#) help you create a competitive advantage for your business. Our expert consultants work with companies at all stages to help you plan, implement and optimize solutions that enable you to unlock your data capital.

[Deployment Services](#) help you streamline complexity and bring new IT investments online as quickly as possible. Leverage our 30-plus years of experience for efficient and reliable solution deployment to accelerate adoption and ROI while freeing IT staff for more strategic work.

[Managed Services](#) can help reduce the cost, complexity and risk of managing IT so you can focus your resources on digital innovation and transformation while our experts help optimize your IT operations and investment.

[Payment Solutions](#) from Dell Financial Services help you maximize your IT budget and get the technology you need today. Our portfolio includes traditional leasing and financing options, as well as advanced flexible consumption products.

[Residency Services](#) provide the expertise needed to drive effective IT transformation and keep IT infrastructure running at its peak. Resident experts work tirelessly to address challenges and requirements, with the ability to adjust as priorities shift.

[Support Services](#) driven by AI and deep learning will change the way you think about support with smart, groundbreaking technology backed by experts to help you maximize productivity, uptime and convenience. Experience more than fast problem resolution — our AI engine proactively detects and prevents issues before they impact performance.

Take the next step

No matter where you are on the path to quantum, Dell Technologies can help you along the way. Get in touch to learn how we can help.

