SPOTLIGHT

Sponsored by: IonQ

Distributed quantum computing is the next phase in quantum computing development that will integrate quantum networking, quantum sensing, and quantum computing to enable and unlock new applications across industries.

Distributed Quantum Computing: Scaling Quantum from Standalone QPUs to Full-Stack System Architectures

January 2026

Written by: Heather West, PhD, Research Manager, Performance Intensive Computing, Worldwide Infrastructure Research

Introduction

The world is on the brink of a new era in computing, one where the power of quantum mechanics will redefine the boundaries of information processing. In this new era, quantum computing will evolve beyond isolated systems toward a distributed model — an interconnected infrastructure where quantum computers, sensors, and satellites work together to gather, transmit, and process quantum data. In this emerging paradigm, satellites play a pivotal role, enabling the secure collection and transfer of information encoded in quantum states, such as qubits or photons, across vast distances via quantum networking technologies. This shift will make it possible to link multiple quantum computers together as a network, dramatically scaling computational capacity and enabling the solution of problems that remain intractable for even the most advanced classical or standalone quantum systems. Just as connecting classical computers gave rise to the internet and cloud computing, distributed quantum computing represents the next transformative leap in IT.

AT A GLANCE

WHAT'S IMPORTANT

The true value of quantum computing, sensing, and networking emerges when these technologies are integrated into distributed architectures, enabling the scalability, resilience, and enhanced security needed to accelerate innovation across multiple industries.

Today, quantum computing is being commercialized, and organizations investing in these technologies are getting business value from use cases. While rapid technological advances characterize the field, there are still challenges in scaling, error correction, and integration with existing IT infrastructure. Nonetheless, the trajectory is clear: The next major milestone will be the transition from isolated quantum processors to distributed, networked systems capable of real-time parallel computing and data sharing.

Distributed quantum computing holds the promise of transforming industries, from pharmaceuticals and materials science to finance, logistics, and government. Public sector applications span secure communications, defense, infrastructure optimization, and climate modeling, areas where complex simulation and data analysis are essential. The need to overcome the physical and engineering constraints of individual quantum processors and harness the collective power of geographically dispersed quantum resources is driving the move toward distributed architectures. These developments also open the door to new kinds of collaboration among research institutions, government agencies, and end users.

Distributed quantum computing: A comprehensive quantum system

As quantum computing moves toward a distributed architecture, it is important to understand the enabling technologies that will make this evolution possible. Several core technologies will come together to shape future architectures and unlock new capabilities and applications, including:

- **Quantum networking:** This technology provides the critical infrastructure for linking quantum systems. By enabling the secure transmission of quantum information, such as qubits or entangled states, across fiber-optic cables or satellites, quantum networking allows geographically dispersed quantum computers and sensors to share data and resources. This type of connectivity is key for scaling quantum computing and supporting real-time parallel processing across distributed systems.
- **Quantum sensing:** By gathering high-precision data from the physical world, quantum sensing extends the reach of distributed quantum computing. Quantum sensors leverage the unique properties of quantum mechanics to detect and measure phenomena with exceptional accuracy, feeding valuable information into networked quantum systems. This is especially valuable for applications in navigation, materials science, and environmental monitoring, where the integration of sensing and computing drives new insights and solutions.
- **Quantum computing:** In a distributed context, quantum processors act as nodes within a network, executing algorithms and analyzing data collaboratively. Advances in error correction, modular hardware, and system performance are making it possible for quantum computers to operate as part of a larger, interconnected system, significantly boosting the scale and flexibility of quantum information processing.

Together, these technologies will form the backbone of distributed quantum computing, enabling organizations to harness the collective power of quantum resources, overcome the limitations of individual systems, and unlock new possibilities for scientific discovery, secure communication, and complex data analysis.

Why distributed quantum computing?

Currently, quantum networking, sensing, and computing largely operate as standalone technologies, delivering capabilities for early adopters ranging from Fortune 500 companies, small enterprises, and research communities. For example, quantum networking supports secure transmission of quantum information, with pilot projects demonstrating quantum key distribution (QKD) over fiber and satellite links. Quantum sensing is advancing precision measurement in areas such as navigation, medical imaging, and materials analysis. Quantum computing is applied to optimization, simulation, linear algebra, and factorization problems that push beyond the limits of classical systems.

The real potential of these technologies comes to life when they're integrated into distributed architectures. Networked quantum computers can share quantum states and computational workloads, overcoming the physical limitations of individual machines. Quantum sensors feeding real-time, high-fidelity data into these networks open the door to powerful applications in environmental monitoring, defense, and infrastructure management.

Key benefits include:

- **Scalability:** Pooling quantum resources increases computational power and enables solutions for previously unsolvable problems.
- **Resilience and redundancy:** Networked systems can reroute workloads and data in the event of hardware failures, improving reliability.
- **Enhanced security:** Quantum networks provide inherently secure communication channels, supporting advanced cryptographic protocols and post-quantum security models.
- **Accelerated innovation:** Real-time data sharing and collaborative processing accelerate scientific discovery and application development.
- **Cross-disciplinary impact:** Integration supports diverse use cases across industries and government sectors.
- **Emerging applications:** Distributed quantum computing will enable a new class of high-impact applications across government and industry, demonstrating the tangible benefits of these technologies:
  - **National security:** Secure communication, cryptography, and real-time threat analysis
  - **Defense and aerospace:** Advanced navigation, sensor fusion, and mission-critical simulations
  - **Climate and environmental modeling:** Large-scale simulations of weather, climate, and energy systems
  - **Infrastructure optimization:** Traffic management, logistics, and energy grid optimization using high-speed, quantum-enabled computations
  - **Scientific discovery:** Drug design, materials research, and fundamental physics simulations that require computation beyond classical limits

By combining these emerging applications with the foundational benefits of scalability, resilience, security, and accelerated innovation, distributed quantum computing is ready to deliver a transformative impact across both public and private sectors.

Accelerating the need for distributed quantum computing

Several trends are shaping the evolution toward distributed quantum computing:

- **Transition from standalone to integrated systems:** Quantum deployments are moving from isolated platforms to interconnected systems, emphasizing interoperability, modularity, and flexible integration.
- **Challenges in qubit scaling catalyzing distributed architectures:** Practical limits in scaling qubits within a single processor, such as maintaining coherence and managing errors, are driving innovation toward distributed quantum architectures. By interconnecting smaller, high-performance nodes, these models promise to unlock scalable

computational capacity, improved reliability, and greater flexibility, accelerating progress toward practical quantum advantage.

- **Workforce talent and resource constraints:** Growing demand for quantum talent and infrastructure is spurring resource sharing and remote access through distributed architectures, broadening access and strengthening the quantum ecosystem.
- **Quantum networking and security imperatives:** Distributed quantum systems are driving adoption of quantum-native cryptographic techniques such as QKD and entanglement-based security to safeguard sensitive classical data and critical infrastructure against emerging cyberthreats.
- **Regulatory and geopolitical considerations:** National security priorities, export controls, and data sovereignty requirements are shaping distributed strategies to ensure compliance and reduce reliance on single-region infrastructure.
- **Expansion of quantum networks:** Global initiatives are building fiber- and satellite-based quantum communication systems to enable secure, long distance connectivity for distributed quantum computing.
- **Advances in quantum error correction:** Enhanced error correction techniques are improving coherence and reliability across distributed systems, supporting scalable quantum operations.
- **Growth in quantum sensing applications:** Quantum sensors deployed in diverse environments are feeding real-time data into integrated networks, expanding the scope of quantum-enabled insights.
- **Hybrid quantum-classical workflows:** Distributed quantum resources are increasingly combined with classical computing to accelerate complex simulations and optimization tasks.
- **Standardization and ecosystem development:** Collaboration among vendors, governments, and research institutions is driving standards, protocols, and best practices for scalable, interoperable quantum systems.

As these trends converge, the integration of networking, sensing, and computing is poised to redefine what quantum technology can do, unlocking applications and efficiencies that were once out of reach.

Considering IonQ

IonQ is actively pursuing the realization of distributed quantum computing, aiming to create a global network of quantum resources that can securely transmit, share, and process quantum information across land, sea, air, and space. The company is building its strategy on the conviction that the future of quantum computing lies in the seamless integration of quantum networking, sensing, and scalable hardware, enabling collaborative problem-solving and unlocking new classes of applications.

To accelerate progress toward this vision, IonQ has focused on acquiring and integrating technologies that address the core challenges of distributed quantum architectures:

- **Quantum networking:** IonQ has acquired companies such as Lightsynq and Qubitekk to advance its quantum networking capabilities. These acquisitions bring expertise in photonic interconnects and quantum repeaters, key components for linking quantum computers and sensors across terrestrial and satellite-based channels. By developing a robust quantum communication infrastructure, IonQ is laying the groundwork for secure, scalable quantum networks.

- **Quantum sensing:** Through the acquisitions of Vector Atomic and Capella Space and the integration of advanced quantum sensing technologies, IonQ is enhancing the precision and reach of its distributed systems. Quantum sensors will play a critical role in gathering high-fidelity data and feeding it into networked quantum processors for real-time analysis, supporting applications in navigation, environmental monitoring, and materials science. IonQ has also recently announced its intent to acquire Skyloom and announced a strategic partnership with Heven Aerotech to further expand these capabilities, especially in the realm of national security.
- **Quantum security:** The addition of ID Quantique to IonQ's portfolio strengthens the company's capabilities in quantum-safe cryptography and QKD. These technologies are vital for ensuring the security of quantum data and classical data as they move across distributed networks, safeguarding sensitive data against emerging cybersecurity threats.
- **Modular and scalable architectures:** IonQ's integration of Oxford Ionics's ion-trap-on-a-chip technology is enabling the development of modular quantum systems. This approach supports scalable hardware design, allowing the interconnection of quantum processors as nodes within a distributed network and facilitating future expansion and adaptability. IonQ claims that its acquisition of Oxford Ionics dramatically accelerates the quantum hardware vendor's path to scaling and logical qubits, which IonQ considers to be the "linchpin of the distributed computing strategy."

By assembling the core components of distributed quantum computing (i.e., scalable hardware, secure networking, advanced sensing, and robust security), IonQ is helping lay the foundation for a new era of quantum information processing. The company's integrated approach reflects a commitment to building a flexible, resilient, and secure quantum ecosystem that leverages the strengths of multiple technologies and partners to unlock the full potential of distributed quantum computing.

Challenges

As the quantum ecosystem advances toward distributed architectures, it faces a set of challenges common across the emerging market. These conditions reflect both the realities of a maturing technology and the competitive dynamics of an industry in which multiple vendors are racing to demonstrate enterprise value, particularly with government entities, as well as with early adopters in the Fortune 1000. Organizations across the ecosystem must integrate quantum computing, networking, sensing, and security into interoperable systems while also scaling qubit performance, maintaining fidelity, and enabling secure, high-performance communication across distributed environments. New commercial deployments, evolving standards, high demand for talent, and regulatory and geopolitical considerations further heighten the pressure to deliver near-term value. Progress therefore depends not only on technical advancement but also on the ability to validate real-world use cases, differentiate through integration and partnerships, and build trust as the market enters into early production deployments.

IonQ's recent acquisition strategy positions the company to leverage these ecosystemwide dynamics by bringing together many of the critical building blocks required for distributed quantum computing under a single organizational and technical vision. By integrating capabilities across scalable trapped-ion hardware, IonQ has an opportunity to reduce fragmentation and accelerate system-level integration, an area where much of the broader ecosystem continues to face friction. These acquisitions also enable IonQ to pursue distributed and modular scaling approaches that help mitigate the physical limits of individual quantum processors while strengthening its ability to support secure communication, sensing-driven workflows, and emerging national security–oriented use cases. If successfully executed, this integrated approach could allow IonQ to move more quickly than many peers in translating distributed quantum concepts into deployable platforms as enterprise and government adoption begins to scale.

Conclusion

Distributed quantum computing represents a transformative shift in how organizations process, share, and secure information. As quantum networking, sensing, and computing technologies continue to mature and converge, the vision of scalable, resilient, and collaborative quantum systems is becoming real. IonQ's strategic road map, alongside industrywide efforts to integrate these foundational technologies, will assist in paving the way for new applications and efficiencies across public and private sectors.

Distributed quantum computing represents a transformative shift in how organizations process, share, and secure information.

Overcoming the industrywide challenges of integration, scalability, and ecosystem development will require ongoing innovation and collaboration. Still the promise of distributed quantum computing is clear: a future where quantum resources are harnessed collectively to solve problems beyond the reach of classical systems, driving scientific breakthroughs and technological progress for decades to come.

About the analyst

Heather West, PhD, *Research Manager, Performance Intensive Computing, Worldwide Infrastructure Research*

Heather West, PhD, is IDC's global quantum research lead within IDC's Worldwide Infrastructure Research Organization and part of the Performance Intensive Computing (PIC) practice. She leads IDC's quantum, analog, and neuromorphic computing research and plays a supporting role in IDC's research on artificial intelligence (AI) and high-performance computing (HPC) infrastructure stacks and deployments. Dr. West is deeply engaged with her clients on their solutions and services, as well as on their business and technology strategies. Her domain knowledge of the quantum computing industry, including proficiency in related workloads and use cases, has made Dr. West a trusted advisor to several emerging quantum and analog computing vendors and positioned IDC as the go-to vendor for market research on quantum computing.

MESSAGE FROM THE SPONSOR

IonQ: The world's leading quantum company

IonQ Inc. (NYSE: IONQ) is the world's leading quantum company across compute, networking, security, and sensing, delivering advanced solutions to tackle the world's most complex challenges. IonQ's latest systems, IonQ Forte and IonQ Forte Enterprise, represent the newest generation of high-performance trapped-ion quantum computers, enabling customers and partners such as Amazon Web Services, AstraZeneca, and NVIDIA to achieve up to 20x performance gains. In 2025, IonQ set a world record by achieving 99.99% two-qubit gate fidelity, marking a major milestone in quantum performance and reliability. IonQ is rapidly advancing its technology roadmap, with plans to deliver the world's most powerful quantum computers, scaling to 2 million qubits by 2030, to drive breakthroughs in drug discovery, materials science, financial modeling, logistics, cybersecurity, and defense. With global operations and availability across multiple cloud platforms, IonQ delivers trapped-ion quantum computing to enterprises worldwide.

Learn more at IonQ.com.

IDC Custom Solutions

The content in this paper was adapted from existing IDC research published on www.idc.com.

IDC Research, Inc.
One Beacon Street
Suite 33100
Boston, MA 02108, USA
T 508.872.8200
F 508.935.4015
blogs.idc.com
www.idc.com