IBM Technology Atlas

# Quantum roadmap

The future of computing is quantum-centric.

Updated May 2024

- completed
- pushed to next year
- on target

| | 2023 | 2024 | 2025 | 2027 | 2029 | 2030+ |
|---|---|---|---|---|---|---|
| **Quantum journey** | ***Introduce parallelization of quantum computations.*** | ***Expand the utility of quantum computing.*** | ***Demonstrate quantum-centric supercomputing.*** | ***Scale quantum computing.*** | ***Deliver a fully error-corrected system.*** | ***Deliver quantum-centric supercomputers with 1,000's of logical qubits.*** |
| **Strategy overview** | 2023 is all about pushing speed in quantum workflows by introducing parallelization in the Qiskit Primitives. | We will improve the quality and speed of quantum circuits to allow running 5,000 gates with parametric circuits. | In 2025, we will enhance the quality of quantum circuits to allow running 7,500 gates and bring together modular processors, middleware, and quantum communication to demonstrate the first quantum-centric supercomputer. | We will scale qubits, electronics, infrastructure, and software to reduce footprint, cost, and energy usage. The quality of quantum circuits will improve to allow running 10,000 gates. | We will bring users a quantum system with 200 qubits capable of running 100 milion gates. | Beyond 2033, quantum-centric supercomputers will include thousands of qubits capable of running 1 billion gates, unlocking the full power of quantum computing. |
| **Why this matters to our clients and the world** | Today, our systems are capacity limited and user jobs can take multiple days. Efficient parallelization between QPUs and parallelization of quantum and classical resources will enable efficient near-term algorithms. | Qiskit Primitives with error mitigation will provide the foundation platform where algorithm and application developers can focus on the workflows and get the best quality out of the quantum hardware. | Abstraction will move from quantum circuits to quantum functions leveraging the Qiskit patterns. This will make quantum computing more usable and will be the start of domain libraries. | Scaled quantum systems will allow users to run larger computations. Multiple computing resources will be seamlessly combined to optimally handle workflows and extend the computational reach of quantum systems. | Users will be able to run large-scale problems using high-rate quantum error correction. | Quantum computers running algorithms using thousands of logical qubits are expected to enable general applications in security, chemistry, machine learning, and optimization. |
| **The technology or innovations that will make this possible** | Middleware will automatically distribute tasks.<br>Serverless tools will allow users to focus on code and not the infrastructure.<br>Expanded classical resources in Qiskit Runtime will speed up compilation and maximize the utilization of the QPUs. | Built-in error mitigation will automatically determine the best method to reduce the effect of noise.<br>Transpiler services will optimally rewrite circuits for hardware, taking advantage of AI. Watson Code Assistant will help users write Qiskit code to program quantum systems. | A quantum node will be part of a network incorporating classical and quantum communication.<br>Resource management will handle quantum and classical workflows.<br>Qiskit will provide libraries of quantum functions and higher-level APIs for faster algorithm and application development. | Intelligent orchestration will analyze workflows to identify the optimal resource allocation (QPUs, communication, and classical resources) for the task.<br>Qiskit will orchestrate approaches to handle errors to provide noise-free outputs to the users. | A novel and efficient error correction code will extend the computational reach of quantum resources. The system will have low-level dedicated classical hardware and a compiler for quantum-centric supercomputing. | Efficient logical decoding will enable 2,000 qubits working in a distributed 100,000-qubit machine. The middleware will include distributed software tools to manage noise-free quantum computations working seamlessly with classical computations. Qiskit will include general purpose quantum computing libraries to simplify the work of developers. |
| **How these advancements will be delivered to IBM clients and partners** | Multiple 100+ qubit Eagle processors will be connected using classical communication. Ahead-of-time compilation will increase utilization of the QPUs. | Multiple higher-quality 100+ qubit Heron processors will be connected using classical communication. | Pre-built Qiskit functions and optimized libraries will be available. A 1,000+ qubit Flamingo system will be demonstrated, made from multiple processors, with each processor made from multiple chips. | The performance of our Flamingo systems will improve to allow users to run circuits with up to 10,000 gates and 1,000+ qubits. | The Starling system will be available to clients. It will be a modular, error-corrected quantum-centric supercomputer with 200 qubits capable of running a total of 100 million gates. | Our 100,000-qubit Blue Jay system will define 2,000 qubits capable of running a total of 1 billion gates. The middleware will integrate this system into ever more powerful quantum-centric supercomputers. |