Expert Insights

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Exploring quantum computing use cases for airlines

A new technology is cleared for takeoff

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Today, the focus is to enable clients to be prepared to take advantage of the future disruptive computational power of quantum computing.

Talking points

Solving problems

Using quantum computing in tandem with classical computing will play a crucial role in solving airlines' complex business problems and present new opportunities.

Quantum experimentation

In anticipation of commercial quantum computing, leading companies are running experiments and creating in-house quantum capabilities.

Advantage: first movers

Industry-specific applications that show quantum advantage are expected to be proprietary for the companies that develop them first.

Quantum advantage for business advantage

"Quantum advantage" is the point when we can definitively demonstrate, in certain use cases, a significant performance advantage over today's "classical" (conventional) computers. By "significant," we mean that a quantum computation is either:

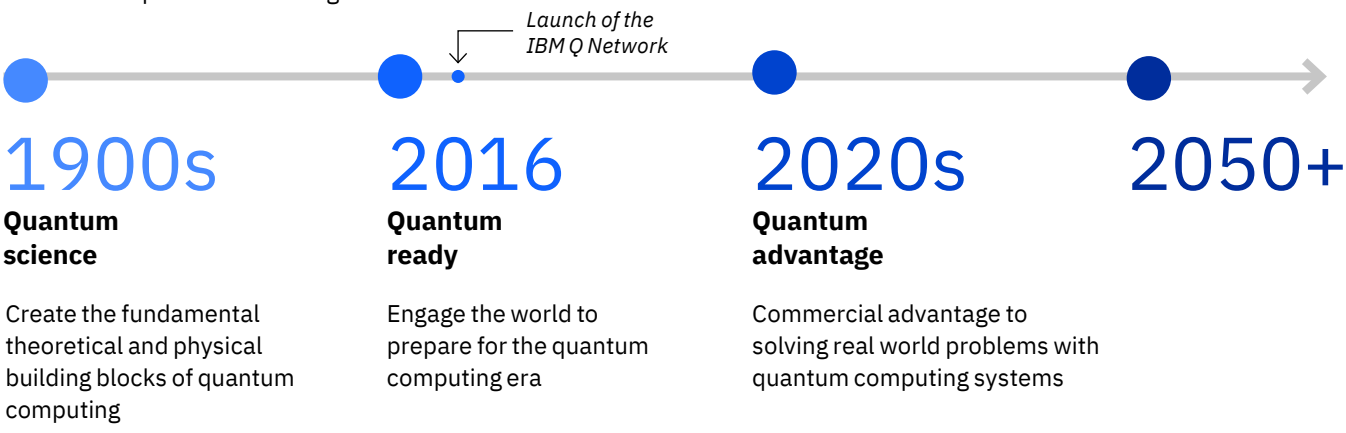
- Hundreds or thousands of times faster than a classical computation
- Needs a smaller fraction of the memory required by a classical computer, or
- Makes something possible that simply isn't possible now with a classical computer.

With the acceleration of efforts to increase the computational power of quantum devices, quantum advantage is on the horizon. Today, during what IBM calls the "quantum ready" phase, the focus is to enable clients to be prepared to take advantage of the future disruptive computational power of quantum computing. Key insights can already be developed by executing versions of future use cases that are small enough to run on current systems.

As the technology continues to improve, industry application developers will grow the scope of these use cases and leverage quantum computing for business advantage (see Figure 1).

Figure 1

The road to quantum advantage

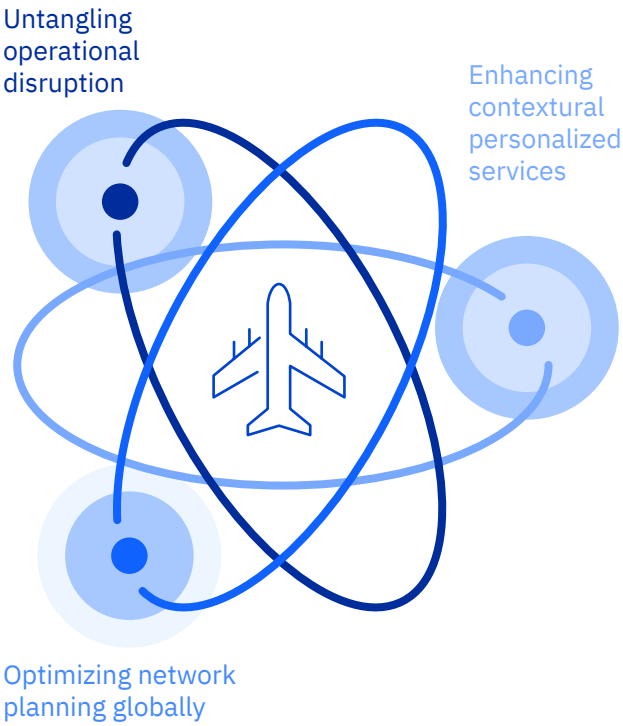


In the future, we expect quantum computing will play a crucial role in solving airlines' complex business problems.

In the next twenty years, air travel is expected to double, increasing operational complexity. In the future, we expect quantum computing will play a crucial role in solving airlines' complex business problems. It will produce new opportunities, mainly through higher computational speed, greater accuracy of data-driven actions, and the creation of new algorithms and systems capabilities to address challenges that classical systems cannot solve. This report identifies three use cases where quantum advantage may be a game-changer for airlines to optimize operations and improve customer experience (see Figure 2).

Figure 2

Quantum computing use cases for airlines



Use case 1: Untangling operational disruption

Storms, operational issues, technical problems, and other issues such as the coronavirus pandemic can wreak havoc with airline schedules and staffing. Recovering from these disruptions is one of the most difficult problems that airlines manage. Current solutions are fragmented and primarily focused on operational information with less consideration given to inventory, profit maximization, or even the impact on customer service and satisfaction.

Airlines currently work through these disruptions—known as irregular operations management (IROPS)—using sub-optimal algorithms on classical computers. Due to the limitations of current computers, each specific element, such as crew, slots, and equipment, is managed in a sequential and siloed manner. System-wide recovery can take a week or more, threatening passenger satisfaction. Second-order effects on other flights and airports can cost an airline up to USD 500 million annually.

The technical limitations of current IROPS solutions are primarily linked to:

1. Lack of data visibility to incorporate all relevant inputs into the resolution of the disruptions, and
2. Fragmentation of solution development. Different parts of the IROPS problem—fleet, crew, passengers, look-ahead impact—are solved separately in multiple steps with different tools, which leads to sub-optimal and inefficient solutions.

It's this second limitation—fragmentation of solution development—where quantum computing may help. Due to the massive scope of IROPs and the resulting complexity of its underlying global mathematical optimization problem, solving a single operational disruption on today's computers could take years—or even centuries. But, with quantum algorithms, airlines may be able to:

– Improve the accuracy and speed of scenario simulations that quantify the impact of potential solutions on future flights and passengers. And do it in time to respond quickly to a disruption. Quantum computing algorithms have already been shown to be effective in choosing the best scenarios in Monte Carlo simulations used in banking and finance.

– Provide a simulation tool to operation control center analysts so they can proactively test scenarios before a major event that may disrupt operations, such as air-traffic control or crew work stoppages or aircraft delivery delays. Due to the complexity of these issues, today they can only be solved for each functional area separately, thwarting the development of integrated solutions.
– Deliver advisory tools to customer service agents and automated customer care systems using quantum machine learning to advise on best approaches to IROPS resolution. For example, a quantum computing algorithm could advise agents on how to best compensate each specific customer whose travels have been disrupted based on their personal preferences for cash, accommodations, upgrades, or other amenities. Imagine how your customer satisfaction might improve if you could do this today.

In these ways, quantum capabilities could dramatically shorten recovery time and reduce the cost of irregular operations while mitigating their negative impact on passengers.

Use case 2: Enhancing contextual personalized services

For airlines, it's key to differentiate services, improve customer experience, and drive incremental revenue though individualized offerings. Providing personalized customer engagement and services requires four specific steps:

1. Collecting and extracting data, including customer data and transactional data.
2. Performing data engineering to build customer data features.
3. Training customer segmentation models based on customer and journey context features.
4. Scoring and identifying the best offers depending on customers' individual travel contexts.

Insight: Bits and qubits

In classical computing, the bit is the basic unit of information with only two possible states: 0 or 1. The qubit is the basic unit of quantum information. Unlike the bit, a qubit can be in a superposition of 0 and 1, where the qubit is in a quantum combination of both states simultaneously, allowing it to represent more information than a classical bit. Qubits can be entangled with each other so that they become quantum twins – any operation on one will simultaneously change the state of the other before knowing the final state of either. These properties are responsible for the exponentially-sized solution space of quantum computers.

When quantum advantage is achieved, it could help unlock the promise of contextual and dynamic personalization.

Today's personalized offering systems often fall short of living up to their promise, mainly because of limitations in the customer segmentation step. Current segmentation methods often rely on basic customer features such as demographic and sales data, but do not include contextual data, reducing the pertinence of the recommended offer. Current systems also lack multi-dimensional segmentation to effectively capture contextual differences in preferences, intent, and behavior of travelers. One of the reasons for the absence of contextual features is insufficient computing capacity and scale to handle the high number of data elements required to build complex segmentation models.

The "segment-of-one" is a personalization strategy for which scalability is probably the biggest challenge. As sophistication in digital marketing grows, organizations are likely to see increases in the number of users for whom they need to create personalized experiences. It is one thing to personalize a landing page for one customer segment, but it's a completely different challenge when you have hundreds of personas, multiple geographies, a dozen sites, and thousands of places where personalization is needed. At that point, personalization strategies need to scale in order to be feasible.

Quantum computing may solve these problems, enhancing the personalization process by:

- Supporting richer customer segmentation, incorporating more complex customer features for multi-dimensional passenger segmentation, and allowing for higher specificity in contextual profiling to improve personalized offerings
- Improving the accuracy of machine learning models that deliver insights and interpretability of results to help marketers or customer service agents better understand the causality links between customer data and delighted passengers
- Enabling the identification of a dramatically greater number of finely-tuned customer segments that is unmanageable for classical computers.

When quantum advantage is achieved, it could help unlock the promise of contextual and dynamic personalization. In turn, that can help increase ancillary revenue, provide better customer experience, and support service differentiation.

Use case 3: Optimizing network planning globally

Network optimization, starting from flight planning and fleet allocation to crew scheduling, is at the heart of airline operations, significantly impacting the operations costs of any airline. But, despite substantial efforts dedicated to streamlining this process, there are still important limitations—mainly linked to a step-by-step approach that leads to local optimization of the sub-processes deployed with isolated decision support tools. These tools generate sub-optimal, local, and uncoordinated solutions.

For example, aircraft route planning often does not incorporate crew scheduling; similarly, crew scheduling does not include block times; and block time planning does not factor in fuel planning, often with detrimental consequences. Additionally, network planning typically does not coordinate its solution optimization with revenue management (RM) and pricing, resulting in two major processes happening daily with the same objective—profit optimization—but with separate models and parameters.

This out-of-sync approach leads to inferior solutions in terms of total cost, profit, and adapting to change. It also causes confusion during key operational updates, such as the introduction of new types of aircraft or the opening of new routes. While RM or pricing is optimizing offers based on schedule, capacity, and aircraft configuration, network planning may be inadvertently changing these parameters based on profit optimization. The main reason for airlines taking this distributed solution path is the complexity required to solve a global network optimization problem in a single step. It is practically impossible to solve with current classical computers.

In the future, quantum computers should enable an airline network to co-optimize fleet, schedule, block/gates, crew, and fuel, while dynamically coordinating with RM, pricing, cost targets, sales, and customer relationship management (CRM) because quantum optimization algorithms could allow more efficient exploration of the potential solutions of such type of large size problem with complex constraints and business objectives. In order to make the best use of future quantum capabilities, airlines will need to change the way they manage network operations, with more centralized operating models and tighter data integration. The expected results could be a proprietary competitive advantage for the airlines that embrace quantum technology.

Flying into quantum

While commercial quantum computing remains several years in the future, companies are running experiments and creating proprietary algorithms today. For example, since 2016, a global community of users has run more than 100 billion executions on IBM quantum computers, available via the cloud. Based on these experiments, more than 200 scientific papers have already been published.

Action guide

Exploring quantum computing use cases for airlines

To be ready for the approaching quantum advantage era, airlines should prepare now by pursuing the following three steps:

1. Identify quantum champions and partners to help you learn more about the different types of quantum computing and their benefits.
2. Begin exploring quantum computing use cases and associated value propositions specific to your business strategy and industry value chain.
3. Partner with experts in quantum computing to experiment with real quantum systems and begin creating new quantum algorithms that aim to create competitive advantage.

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