ADGM Academy Research Centre

Article SERIES

QUANTUM COMPUTING AND FINANCE

In January 2024 Abu Dhabi Global Market Academy (ADGMA) Research Centre (in partnership with ADIA Lab, Imperial College London and Nanyang Technological University) hosted a three-day conference, Quantum Computing for Finance, gathering nearly 300 leading experts from the financial sector, quantum technology firms and academia from around the world.

Continuing our deep dive into the intersection of quantum computing and finance, ADGMA Research Centre sat down with Citi's Ronit Ghose (Head of Future of Finance Team) and Tahmid Quddus Islam (AVP, Innovation & Technology) to get their views on the opportunities and challenges presented by the intersection of quantum and finance.

ADGMA RESEARCH CENTRE: WE SEEM TO BE IN A PERPETUAL STATE OF EXPLORING AND UTILIZING THE LATEST TECHNOLOGICAL ADVANCES – AI / ML, BLOCKCHAIN, ETC. NOW WE ARE TALKING ABOUT QUANTUM. WHAT IS QUANTUM COMPUTING?

***Ronit / Tahmid**: In the realm of emerging technologies, a new technology is coming up the horizon – quantum computing. While traditional computers rely on bits to process information, quantum computers harness the power of quantum bits (or "qubits"), which could offer unparalleled computational capabilities. To understand the potential of quantum computing, let's delve into its fundamental principles and explore its applications.*

At its core, quantum computing leverages the principles of quantum mechanics to perform operations that are practically impossible for classical computers. Unlike classical bits, which can only exist in a state of 0 or 1, qubits can exist in a superposition of both states simultaneously. Superposition is the ability of a quantum system to be in multiple states at the same time. This unique property enables quantum computers to process vast amounts of data and perform complex calculations with remarkable speed.

Imagine classical computing as a series of roads where each road represents a bit, either 0 or 1. You can only travel on one road at a time, limiting your options for reaching your destination quickly. Now, envision quantum computing as a network of interconnected pathways where you can simultaneously explore multiple routes, drastically reducing travel time and offering limitless possibilities for reaching your destination.

Furthermore, qubits exhibit another fascinating property called entanglement. When qubits become entangled, the state of one qubit instantly correlates with the state of another, regardless of the distance between them. This phenomenon allows quantum computers to process information in a highly interconnected manner, leading to exponential gains in computational power.

So, how does quantum computing differ in practical terms from classical computing? Let's consider a task as simple as searching for a specific item in a large database. Classical computers would need to check each item individually, one at a time, until the desired item is found. In contrast, quantum computers could search through the entire database simultaneously, thanks to the parallel processing enabled by superposition. This capability enables quantum computers to solve complex problems in fields such as cryptography, optimization, drug discovery, and materials science much more efficiently than classical computers.

Despite its immense potential, quantum computing is still in its infancy, facing several technical challenges, including qubit stability, error-correction, and scalability. Qubits are delicate and can lose information which is known as decoherence. Researchers are actively working on developing error-correction techniques and building more robust qubits to overcome these obstacles.

We stand to benefit significantly from embracing quantum computing as it promises to revolutionize industries and drive innovation across various sectors. For example, financial institutions could utilise quantum computing to optimise portfolio management, accelerate risk analysis, and enhance fraud detection. In healthcare, quantum computing could facilitate the discovery of new drugs and revolutionize personalised medicine by analysing vast genomic datasets with unprecedented speed and accuracy.

As quantum computing continues to evolve, we must stay abreast of advancements in this field to capitalise on its transformative potential. However, uncertainty surrounding the pace of technological advancements, return on investment, and competitive positioning may deter some organisations from pursuing quantum computing initiatives.

ADGMA RESEARCH CENTRE: WHAT IMPACT WILL QUANTUM COMPUTING HAVE ON THE FINANCIAL SECTOR? WHAT BUSINESS AREAS WILL IT IMPACT?

***Ronit / Tahmid**: Quantum computing has the potential to revolutionise various aspects of financial services, from portfolio optimisation and fraud detection to algorithmic trading and quantitative analysis.*

<u>Portfolio Optimisation and Risk Management</u>: Quantum computing could enhance portfolio optimisation by enabling financial institutions to process vast amounts of data and identify optimal investment strategies with unprecedented speed and accuracy. This capability could also bolster risk management efforts by providing more nuanced insights into market dynamics and potential risks.

<u>Fraud Detection and Cybersecurity</u>: With Generative AI, the risks of deepfakes and financial fraud is increased. Quantum computing could allow for the analysis of complex patterns in real-time and enable enhanced fraud detection capabilities, thus enabling financial institutions to identify and mitigate fraudulent activities more effectively. Additionally, quantum encryption algorithms could enhance cybersecurity measures, safeguarding sensitive financial data from cyber threats.

Algorithmic Trading: Quantum computing's anticipated ability to process complex algorithms and analyse massive datasets in real-time could revolutionise algorithmic trading strategies, leading to more sophisticated and profitable trading models for financial institutions and their clients.

Quantitative Analysis, Pricing and Modelling: Quantum computing could accelerate quantitative analysis and modelling processes, allowing financial institutions to develop more accurate predictive models for pricing financial products, assessing market trends, and making informed investment decisions.

ADGMA RESEARCH CENTRE: WHAT ARE THE RISKS AND CHALLENGES OF QUANTUM COMPUTING?

***Ronit / Tahmid**: Quantum computing could potentially transform financial services, but it also presents several risks and challenges that must be mitigated. Financial institutions must proactively address security vulnerabilities, regulatory compliance, operational risks, talent shortages and ethical considerations to realise the full potential of quantum computing.*

Security Risks: Quantum computers may one day be able to break the encryption methods widely used today to ensure secure financial transactions and data. The encryption methods that both protect stored data and establish secure networks are at risk from quantum technology in the future. Protective steps are needed today, as adversaries may already be harvesting data. Public key encryption algorithms used today will need to be replaced in every platform that uses them. Given the scale of the challenge and the opportunity, it only makes sense for businesses and institutions to act now.

Algorithmic Bias and Fairness: The use of quantum algorithms in financial decision-making processes could introduce biases and fairness concerns. Financial institutions must ensure transparency and accountability in algorithmic models to mitigate the risk of discriminatory / unlawful outcomes to maintain trust with stakeholders and to comply with regulatory standards.

Incumbents Could be Disrupted: The adoption of quantum computing in finance could disrupt traditional market dynamics and trading strategies. For example, big banks could use the power of quantum computing to enhance their FX / securities trading capabilities and improve security for clients, potentially out competing smaller players.

Regulatory Risk: The introduction of quantum computing in financial services raises regulatory and compliance challenges. Regulators may need to develop new frameworks and standards to address the unique risks associated with quantum computing, including data privacy, algorithmic transparency, and systemic risks.

Interoperability Risks: Integrating quantum computing systems into existing infrastructure poses operational risks for financial institutions. Technical complexities, system interoperability issues, and potential disruptions during the transition phase could impact operational efficiency.

Talent Shortage: The field of quantum computing requires specialised expertise in quantum physics, computer science, and algorithm development. Financial institutions may face challenges in recruiting and retaining skilled professionals with expertise in quantum computing, potentially hindering the adoption and implementation of quantum technologies.

Hardware Scalability Challenges: Every qubit must interact with every other qubit to maximize computational power. However, it has not yet been possible to build quantum computers with a very large number of qubits, presenting a hardware scalability challenge.

Disruption of Existing Infrastructure, Huge Costs: Implementing quantum computing technology may require substantial investments in infrastructure, hardware, software and even talent development. Financial institutions may face challenges integrating quantum computing systems with their existing infrastructure, potentially leading to disruptions and transitional costs with unclear benefits.

Ethical and Regulatory Considerations: The use of quantum computing in financial services raises ethical and regulatory considerations, particularly regarding data privacy, algorithmic transparency, model explainability and potential biases in decision-making algorithms.

ADGMA RESEARCH CENTRE: QUANTUM COMPUTING IS NOT MAINSTREAM YET. WHY SHOULD THE FINANCIAL SECTOR CARE ABOUT THIS TODAY?

***Ronit / Tahmid**: There are new ways to search the web using artificial intelligence and machine learning, alternate payment systems using blockchain and tokenised digital money, and innovative ways to socialise using games and the Metaverse. In most cases, the advances have been facilitated by increasing computing speeds that enable faster calculations as well as better connectivity, but all are based on existing computing technology.*

After five decades of increasing computational power by Moore's Law (i.e., doubling the number of transistors per chip every two years), the growth rate of classical computing is reaching its physical limit. At the same time, the capabilities of quantum computers have been described to be advancing at a "doubly exponential" rate and are close to generating commercial value.

Hence, the phase of quantum computing becoming practically useful is getting closer as we are quickly coming to a point where quantum computers will be able to perform valuable tasks faster, more efficiently, or cheaper than classical computers.

Citi GPS estimates total addressable market for quantum computing in 2027 to be in the range of $700 million to $8.6 billion. Since quantum computers have exponential scaling power, by the time they offer a practical commercial advantage to businesses, the gap between early adopters and those using only classical computing will widen at an increasingly accelerated pace. Therefore, businesses should consider capitalising on quantum opportunities.

Based on the pace of technological advancements and its implications on finance in the last decade, it is only prudent that financial institutions prepare for the full arrival of quantum computing technology and embrace the benefits while mitigating the challenges. Financial institutions need to incorporate quantum computing into their long-term strategic planning to stay ahead of competitors as implementing quantum computing technology requires substantial lead time for system upgrades, infrastructure development, and integration with existing IT systems.

By starting the preparation process early, financial institutions can build the talent pool and can ensure a smooth transition when quantum computing becomes more mainstream. Financial institutions need to invest in training programs and talent acquisition strategies today to cultivate a workforce capable of leveraging quantum computing technologies effectively in the future. By embracing quantum computing today, agile financial institutions can differentiate themselves in the market and capture new opportunities for growth.

Quantum computing introduces new risks and compliance considerations for the financial sector, including security vulnerabilities, regulatory compliance, and data privacy concerns. By proactively addressing these risks and incorporating quantum computing into risk management frameworks, financial institutions can mitigate potential threats and ensure compliance with evolving regulations.

By investing in strategic planning, talent development, and security risk management related to quantum computing, financial institutions can proactively prepare for the transformative impact of the technology and remain competitive in the upcoming decades.

Quantum computing stands poised to fundamentally transform the financial sector. However, this innovation carries a double-edged sword. While it holds promise, quantum computers also pose a threat by potentially breaking the encryption algorithms integral to banking and financial security. There are also considerable operational hurdles to overcome to ensure interoperability with existing systems.

Conversely, quantum computing presents unique opportunities. Demonstrated successes underscore its capability to tackle computations beyond the reach of classical computers, which swiftly encounter memory limitations. Banks at the forefront of adopting quantum computing technology stand to gain a competitive advantage. The potential for revolutionising banking operations - from enhancing risk assessment and portfolio optimisation to bolstering fraud detection and algorithmic trading - abounds with quantum computing's transformative power.

In anticipation of this transformative future, banks must take proactive steps. Investments in research and development, cultivation of internal expertise, and exploration of potential applications in banking and finance are imperative. Such initiatives not only ensure readiness for the quantum era but also position banks as trailblazers and innovators within the industry.

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