

2023

Quantum Computing at PwC

**Essential, responsible,
scalable innovation**



Read Me [and delete before sharing]

The purpose of this document is to **present interested external audiences (including potential clients) a high-level view of why** Quantum Computing is increasingly important to their organizations, and **how PwC's Innovation Hub can help them along their QC journeys.**

If you have any questions after consulting **this deck**, please reach out to **Arit Kumar Bishwas**.

For additional Innovation Hub sales collateral and more information about our capabilities, service offerings, and frameworks please refer to our [Internal Innovation Hub Website](#).

Thank you,

PwC's Innovation Hub

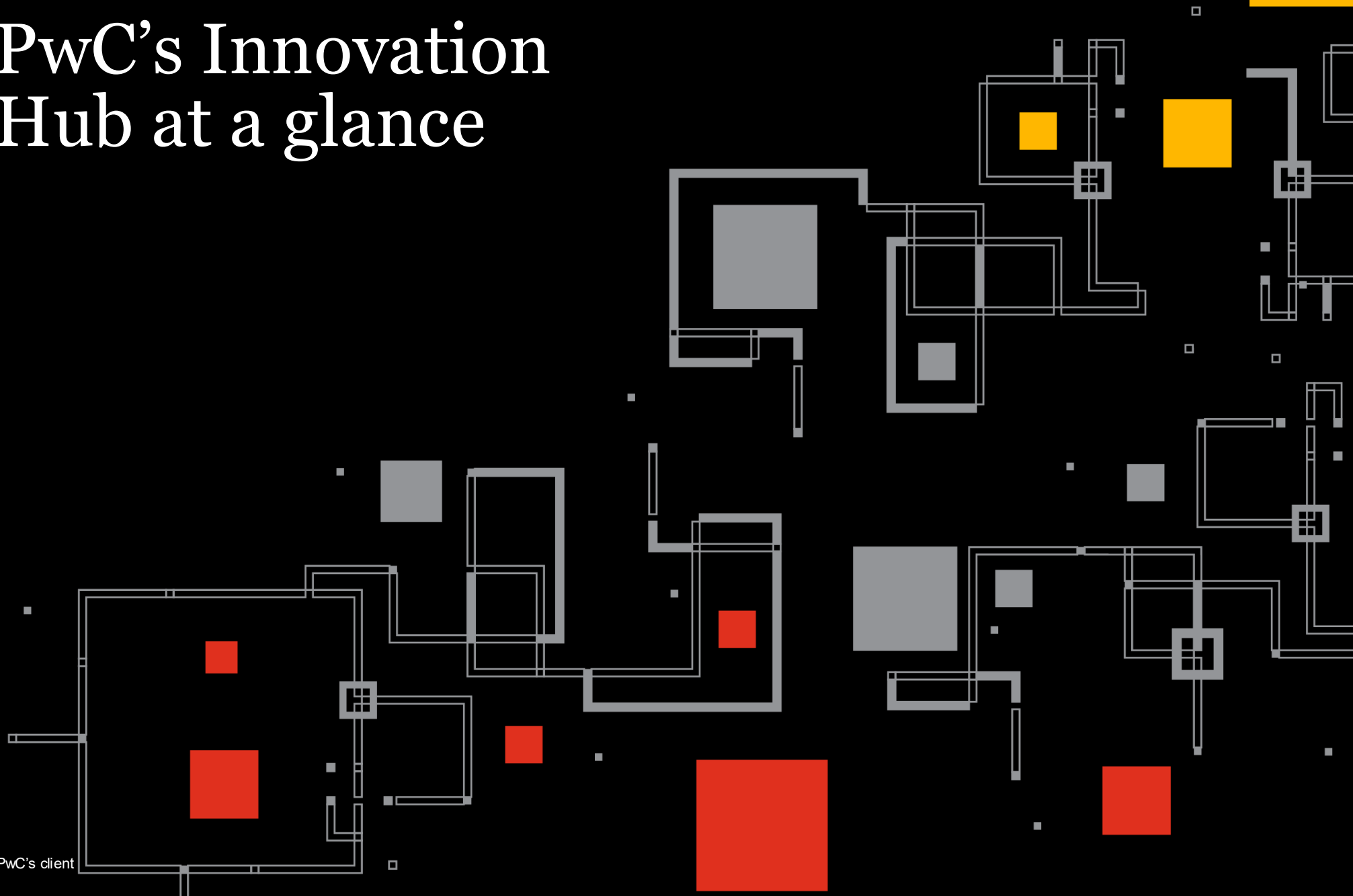
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01

PwC's Innovation Hub at a glance



We help clients drive innovation from ideation through development and scale.

Innovation doesn't have to be game changing to change the game for your business. No matter how big or small your idea is, if it's for your customers or employees, or if it's for one business unit or the entire enterprise - we can help you scale it to drive tangible business outcomes.

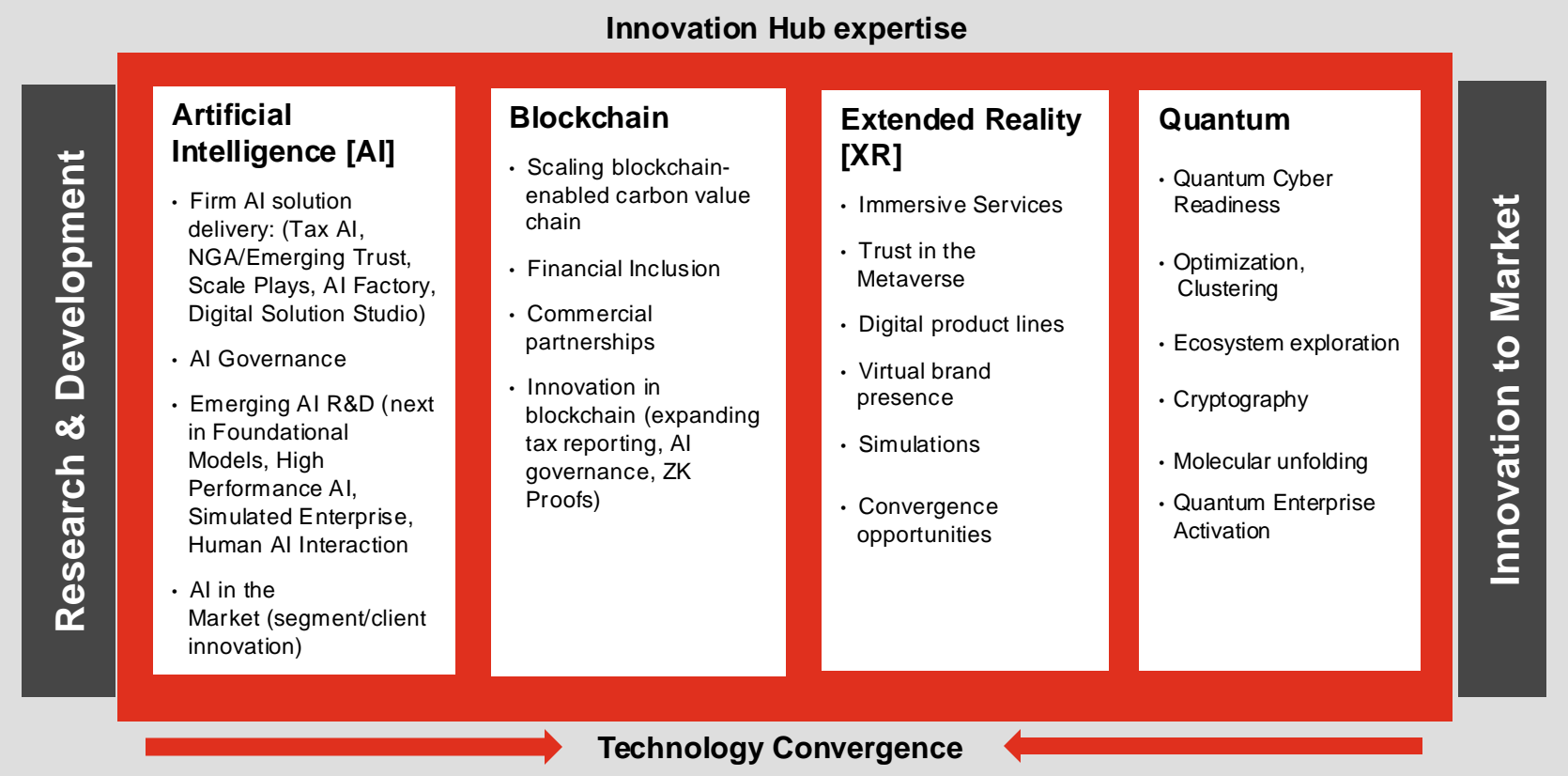
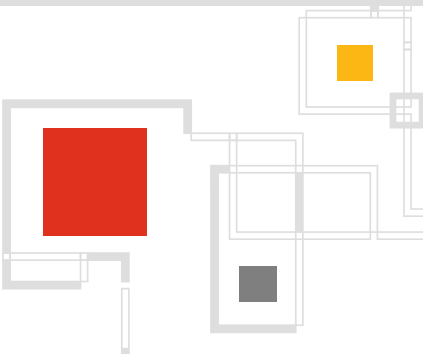
We work with clients to accelerate:

- Ideation and innovation at speed to identify challenges and opportunities worth investing in.
- Fail fast rapid prototyping and testing to validate user assumption and business alignment.
- Speed to launch and stand-up internal operations and change management function leveraging our own PwC product experience.



The Innovation Hub is PwC's innovation engine.

Our team of technologists and business strategists apply their research, insights and expertise to solve today's challenges and prepare for what's next.



Increase profits



Drive efficiency & reduce costs



Mitigate risk



Enhance client & customer experiences

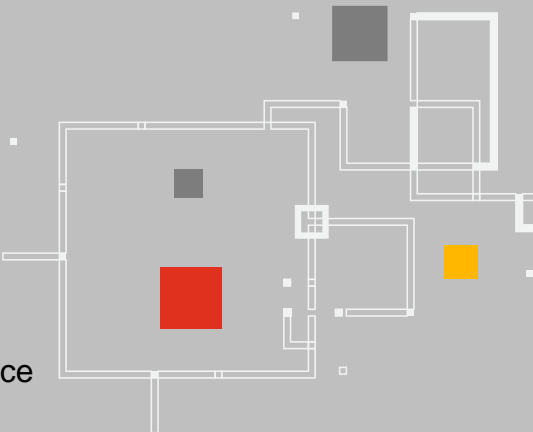


Create & scale new revenue streams



Future proof client business models

Our experience makes the difference...



Expertise	Speed	Relationships	Innovation Pilots	Data	Services
200+ business strategists and technologists, including data scientists, ML engineers, full-stack developers, crypto experts, VR developers, and more	Focused sprints and a mix of 4000+ code-based assets, apps, frameworks, and templates that accelerate value delivery	100+ new ventures, 40+ technology majors and start-ups, and 50+ universities.	180+ sprint cycles since inception; 30-40 PoCs completed annually	1000+ proprietary, synthetic, and 3rd party data sets to enrich analyses	<ul style="list-style-type: none">• Application as a Service (AaaS)• Platform as a Service (PaaS)• Software as a Service (SaaS)

And we're being recognized for our work.

Fast Company

PwC's **Responsible AI Toolkit** was ranked as the **2020 World Changing Idea**

PwC's **Bias Analyzer** was selected as the **2021 Next Thing in Tech**

Gartner

PwC was ranked as the **Leader for Data & Analytics Services**

CogX

PwC was recognized for **outstanding achievement in Enterprise Adoption of AI and AI Ethics**

IDC

PwC was ranked as the **Marketscape Leader in World-Wide AI services**, and **Responsible AI for Integrated Financial Crime Management Platforms**

Forrester

PwC has been ranked as an **AI Consulting Leader for the past 4 years**

World Economic Forum

PwC's **Blockchain Sustainability Framework** is regarded as the leading point of view on sustainable blockchain development

2023 Emerging Technology Survey

Our survey shows that a few companies — very few — are getting emerging technologies right. Executives in these organizations report significantly higher benefits from emerging tech in general, and from generative AI (GenAI) in particular, than their peers.

Our survey data not only identifies these companies, it pinpoints **four practices** that likely explain their success.

- 1 Use emerging tech for reinvention
- 2 Allocate the right resources
- 3 Integrate your emerging tech
- 4 Embed emerging tech into your business strategy

Top findings

- **89%** of companies responding are increasing their overall technology budget over the next 12 months, with a fifth (21%) increasing it by more than 10%.
- **55%** of all respondents say their company has invested in AI (i.e., it was within their top 3 priorities) in the last 12 months, more than any other technology listed.
- **58%** of all respondents plan to prioritize investment in AI in the next 12 months, followed by IoT (**46%**) and virtual reality (**35%**).
- **Half** of respondents **strongly agree** that their company's emerging tech strategy is integrated with the company's business strategy.
- More than a quarter (**28%**) of all respondents have **at least 20%** of their employees involved in emerging tech as part of their primary job function.
- **7%** of executives surveyed report significantly higher benefits from emerging technologies in general, and from generative AI (GenAI) in particular, than their peers.
- **74%** of EmTech Accelerators use emerging technology to expand into new markets.
- **51%** of EmTech Accelerators seek to build trust in emerging tech by training employees, compared to **38%** of all respondents.
- **83%** of EmTech accelerators have a high level of integration across the emerging technologies they have invested in or plan to invest in compared to 58% of all respondents.

[Read the full report](#)

About the survey

Between August 16, 2023, and September 13, 2023, PwC surveyed 1,026 executives in the United States (468 in business roles, 558 in technology roles) on topics related to emerging technologies. Respondents are from companies across industries that have at least \$500 million in revenue.

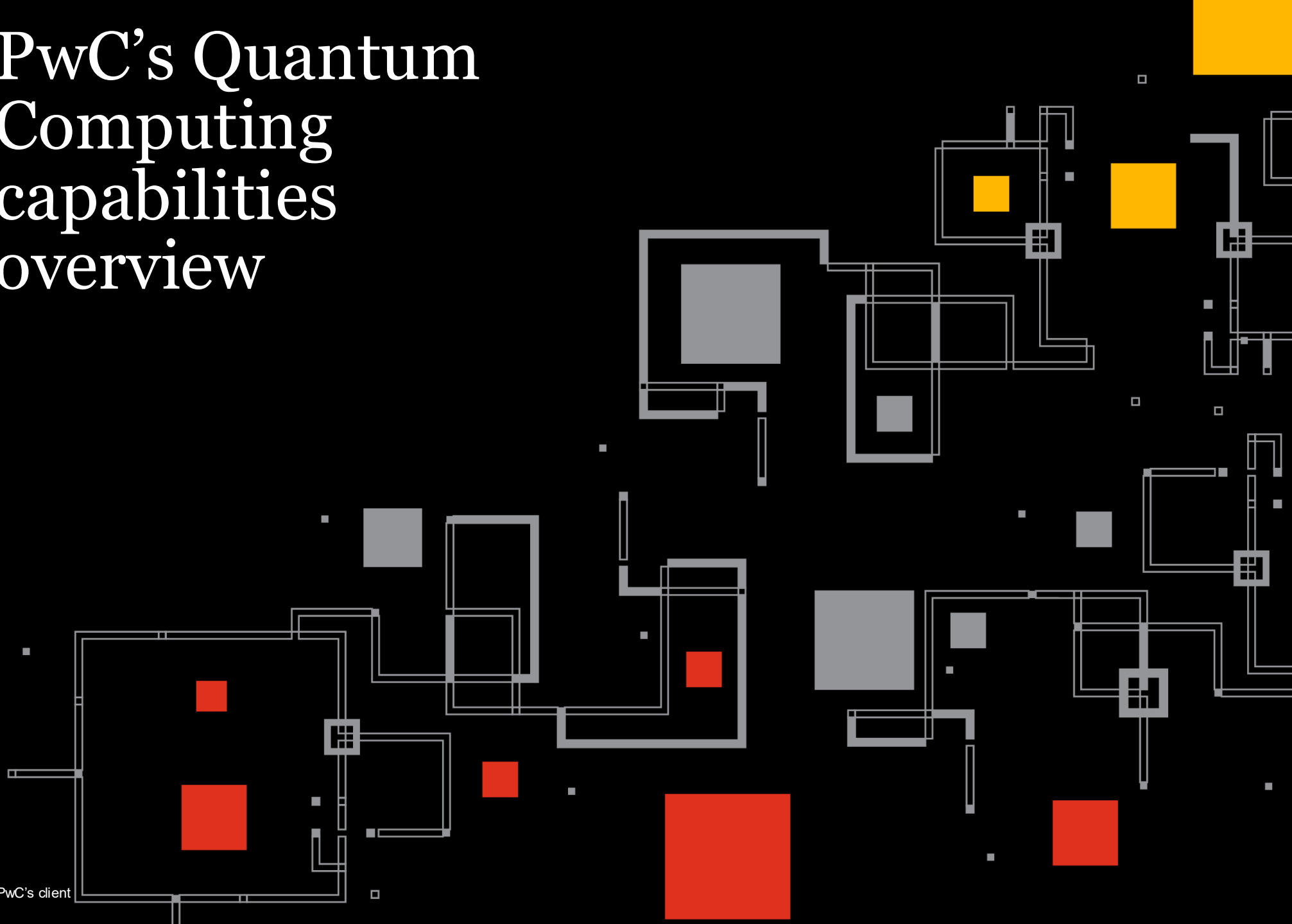
To identify the EmTech Accelerators, we designed two indexes to capture how much companies are already achieving measurable value from tech-related investments. One index covered all of the Essential Eight technologies. The other focused on GenAI specifically. EmTech Accelerators were those that reached the top 10% of both the broader and the GenAI-specific indexes. Data analysis then found common traits in how these companies approach emerging technologies.


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02

PwC's Quantum Computing capabilities overview





“If quantum mechanics hasn’t profoundly shocked you, you haven’t understood it yet.” — Niels Bohr

What if your unsolvable problems can be solved in seconds?

With **quantum computing (QC)** you'll gain the power to tackle complex optimization challenges with unrivaled efficiency, drive A.I. innovation at an unprecedented pace, and make groundbreaking discoveries with game-changing impact.

From optimizing logistics to safeguarding your data & systems, QC can transform your business in ways previously unimaginable.



Streamline your logistical operations

Rapidly plan and optimize routes, resources, and scheduling, saving time and costs while improving service levels and carbon footprint.



Instantaneous supply chain optimization

Factoring in countless variables like inventory levels, transportation routes, and demand fluctuations to provide near real-time direction.



Supercharge your AI investments

Combining QC with AI allows for faster machine learning and improved predictions in various fields.



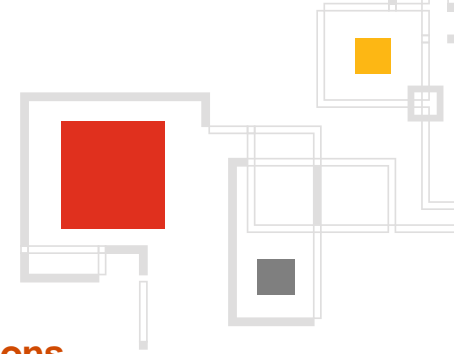
Safeguard your data and systems

Encryption protocols that provide enhanced security to protect and transmit data in ways that cannot be hacked by classical or quantum computers.



Lower Carbon footprint:

QC uses less energy than traditional computers by reducing both the time and power required for complex computations. QC will also lead to breakthrough advancements in low-carbon technologies.



HOW QC IS GROUNDBREAKING

Quantum computers can perform multiple calculations simultaneously, making them significantly faster & accurate.

Quantum computers are next generation supercomputers that perform parallel calculations using quantum mechanics, making them **significantly faster than classical computers** for certain types of problems.

Recent breakthroughs in QC has resulted in machines that **need only 200 seconds to solve a problem that would take the world's fastest supercomputer 10,000 years to figure out.**

Classical Computers



A classical computer will, at each junction, try a direction, turn back when it reaches the end, then start again until it finds the exit.

Quantum Computers



A quantum computer will "superpose": at each branch, one state will explore every single direction. So the quantum computer is trying all paths in parallel. It builds a state that superposes all states that are performing all the possible routes, including the one that gets through to the end.

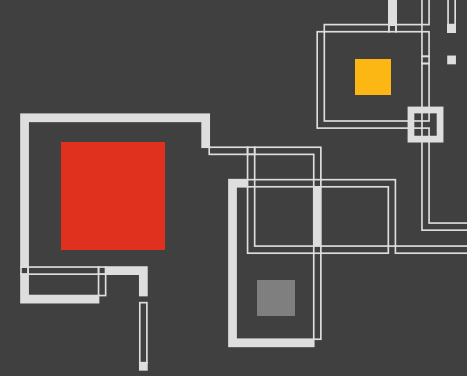
IMPACT OF QUANTUM COMPUTING (QC)

Quantum is already here
– and soon, it will be
everywhere.

We're solving our most difficult problems for clients using production-ready quantum computing (QC) today, while also preparing for a future where quantum is ubiquitous.

Are you ready to be **quantum-ready**?

How a **major fast food chain** optimized their delivery routing & hiring with quantum.



\$1M

Saved in annual transport costs when ran once per month*

(est. from 1 month run of \$87k avg. savings)

PwC used quantum annealing to optimize delivery routing of **13,000+ stores** in **4,643 cities** across the US.

The Quantum Advantage:

203k



Miles Saved
Annually*

9.2k



Hours Saved
Annually*

136



Less Contractors
Hired

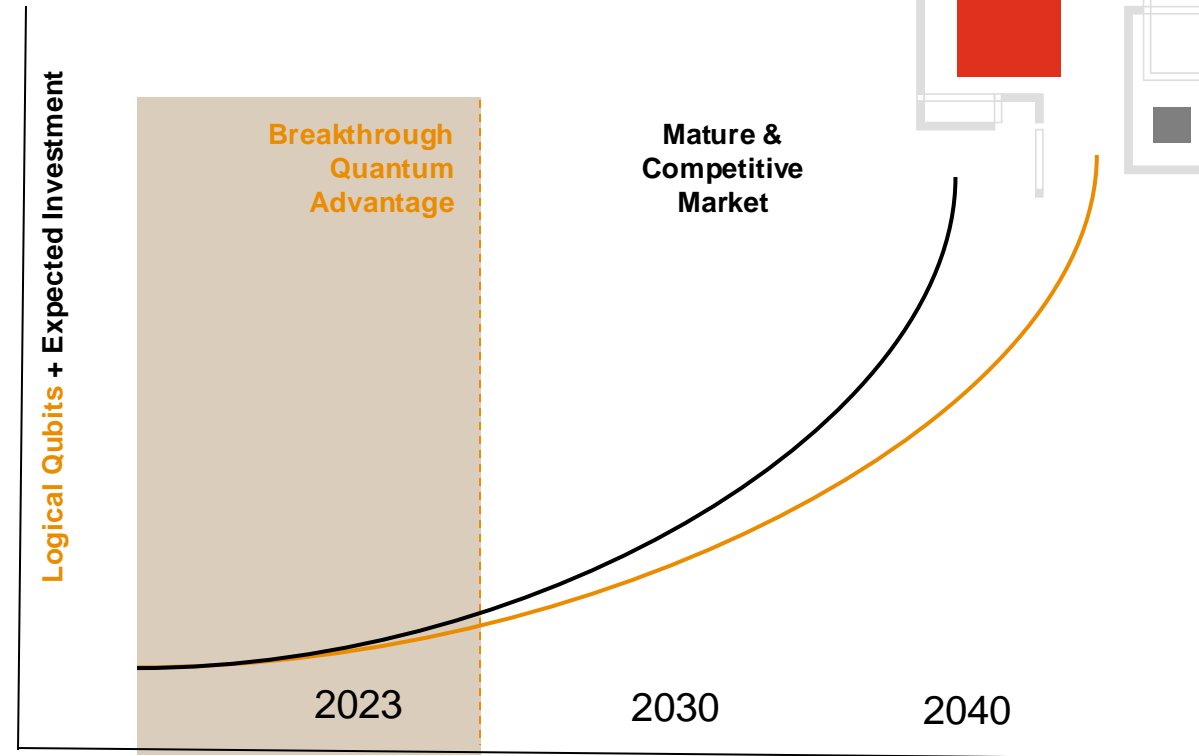
*Assuming that delivery is performed once-per-month with similar avg. savings.

THE TIME TO START IS NOW

Lead as a Quantum Fast-follower.

The technology growth curve is steepening. With Quantum, exponential developments will create exponential disruption. As QC advancements accelerate, **a disproportionate share of the value will go to those who invest early.**

QUANTUM QUBIT DEVELOPMENT & ENTERPRISE INVESTMENT

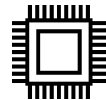


LATE ADOPTERS WILL FACE THE CHALLENGES NEEDED TO SCALE:



The scarcest resource will be talent to develop algorithms.

Providers are becoming increasingly reluctant to deploy them in client-facing work.



Computing resources will be limited in the period of early quantum advantage.

Providers must reserve capacity, and they are already vetting their opportunities to work with individual clients as they would a portfolio of investments.



Quantum computing solutions are custom and will take time to build.

The integration between quantum and classical resources is a particular challenge.

Key steps clients are going through on Quantum

1 Taking a trust-by-design approach and establishing **security policies and secure environment**.

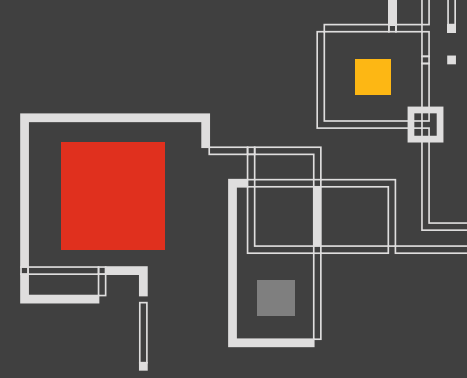
2 Defining **Quantum strategy** to prioritize transformational use cases and enterprise readiness.

3 **Building initial use cases** by establishing a core team to accelerate speed, repeatability and control.

4 **Scaling use cases**, building into workflows and applications and adapting use case patterns across the business

- Generally includes new tooling and integration services with enterprise data and applications

5 Continuing focus on Quantum governance, security and responsible QC



Security policies and secure environment



Quantum strategy



Initial use cases

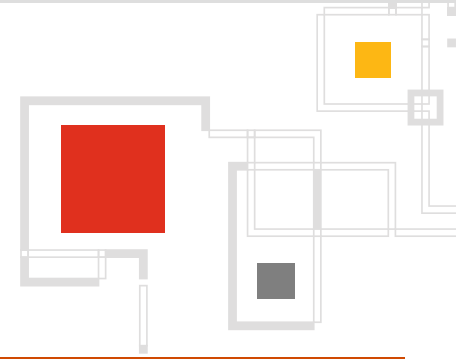


Use cases at scale



Continuing focus on Quantum Computing governance, security and responsible QC

We help deliver Innovation@Scale for you to become quantum-ready.



Strategy

Build

Scale & Govern

Operate

*Quantum
Use Case &
Org Design*

QC Strategy & Visioning

- Current-state assessment
- Business case development
- Business process transformation prioritization
- Identify, triage and prioritize initial use cases
- Identify convergences with AI, blockchain, other new tech.

QC Use Case Development

- Prepare pipeline data
- Tune output using embedded data
- Create applications/toolkits that leverage trained models to reimagine business processes
- Scale and deploy use cases
- Implement in workflows and applications

Governance & Org Models

- Use case intake process
- Codes of conduct with Quantum
- Guiding principles to promote opportunities while managing potential downsides
- Quantum tech stack & CoE creation

Quantum managed services

- Ongoing operations
- Data integrity and quality
- Maintenance and support

*Quantum
Sustainability*

QC Sustainability Strategy

- Current-State Assessment
- Carbon Footprint Calculation
- Business Case Development

QC Sustainable Build

- Develop use cases
- Assess carbon tracking and ESG reporting.

Responsible QC Framework

- Strategy
- Control (Monitor & Report)
- Responsible practices (Deployment)

Quantum Readiness Training & Workshops

- Technical skill development
- Executive training
- Quantum-secure technology education
- Vendor ecosystem

*Quantum
Cyber
Risk*

Cyber Risk Assessment

- Assess and analyze the current security posture
- Data scan & cryptography inventory
- Governance/Process Gap Analysis

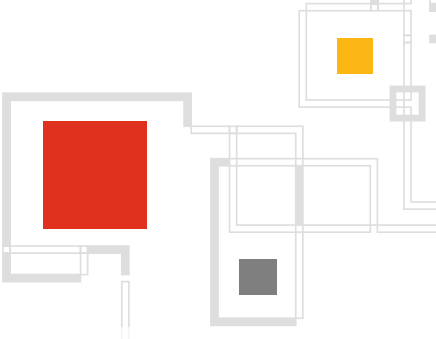
Secure Environment & Org

- Design and build cryptographic algorithms
- Security assessments, audits, penetration testing
- Compliance with relevant regulations and standards

Crypto-Agile Operating Model

- Adapt to emerging threats and new quantum-safe algorithms
- Navigate & adapt to future regulations

We start with identifying opportunities for your business.



Strategy

Build

Scale & Govern

Operate

QC Strategy & Visioning

Activities

Education & Leading Practices

- Level set on Quantum definition and scope
- Bring outside-in perspective on potential opportunities
- Generate first list of potential use cases to be further explored

Use Case Assessment & Prioritization

- Asses high-level value and feasibility
- Prioritize use cases and align on next steps

Deliverables
/ Outputs

- **Prioritized set of Quantum Use Cases**
- **Workshops, Education & Training**

QC Cyber Readiness

Quantum Risk Assessment

Identify security gaps & risk exposure to quantum computer attacks.

Readiness Design & Roadmap

Design a future-state plan to prepare for a quantum readiness transition.

Readiness Training & Workshops

Educate leaders & teams to equip them on how to act on quantum risks

- **Security Gap Analysis**
- **Remediation Plan Design & Roadmap**
- **Workshops, Education & Training**

QC Sustainability Strategy

Use Case Assessment & Prioritization

- Asses high-level value and feasibility
- Prioritize use cases and align on next steps

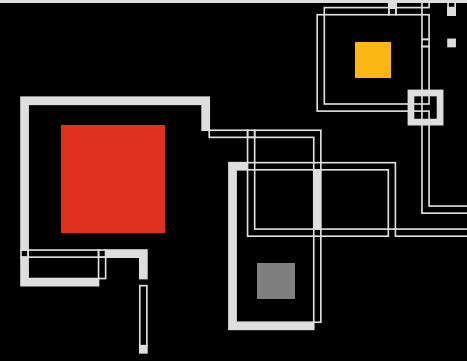
Use Case Assessment & Prioritization

- Asses high-level value and feasibility
- Prioritize use cases and align on next steps

- **Sustainability Assessment**
- **Carbon Footprint Calculation**
- **Prioritized Set of Quantum Sustainability Use Cases**

THE PWC DIFFERENCE

We can help you become quantum-ready.



Innovation meets Expertise

We hold multiple patents and boast a dedicated team of quantum specialists. Our industry & functional expertise allows us to tailor quantum solutions that precisely match your needs.

**5+ Quantum Patents,
5+ Research Publications**

Ecosystem & Alliances

Our formal Alliances and Enterprise Agreements with industry leaders gave us early access to their technologies and provide us a head start on developing solutions our clients' needs.



A.I. Talent & Tools

We have scaled capabilities in managing and developing AI solutions backed with classical-quantum hybrid framework.

Our AI leadership has been recognized by:





Our collaborative ecosystem of **academic and research institutions** help us deepen our understanding of market needs and develop new innovations to deliver greater value to you.

The Americas

- Carnegie Mellon Innovation Lab
- Carnegie Mellon Risk & Regulation Lab
- MIT AI Lab
- MIT Computer Science Lab
- MIT Sloan (Simulation)
- Johns Hopkins University
- Stanford University, Human-Centered AI
- University of California San Diego, Calit2
- University of Chicago

Asia and Pacific

- Institute for Infocomm Research
- Tokyo Institute of Technology
- Heriot Watt University, Dubai
- University of Sydney

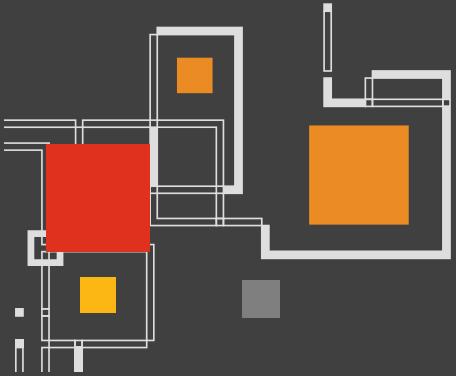
Africa

University of Cape Town

Europe

- Oxford University
- Cambridge University
- University of Leeds
- University of Edinburgh
- École Polytechnique
- Fédérale de Lausanne
- Fraunhofer Institute
- Free University of Amsterdam
- Tilburg University

**The above list is not exhaustive.*



Start exploring.

Learn more about Quantum
Computing and how it can bring new
value to your organization at
[PwC.com](https://www.pwc.com).

PwC Innovation Hub

Confidential information for the sole benefit and use of PwC's client

Get in touch.



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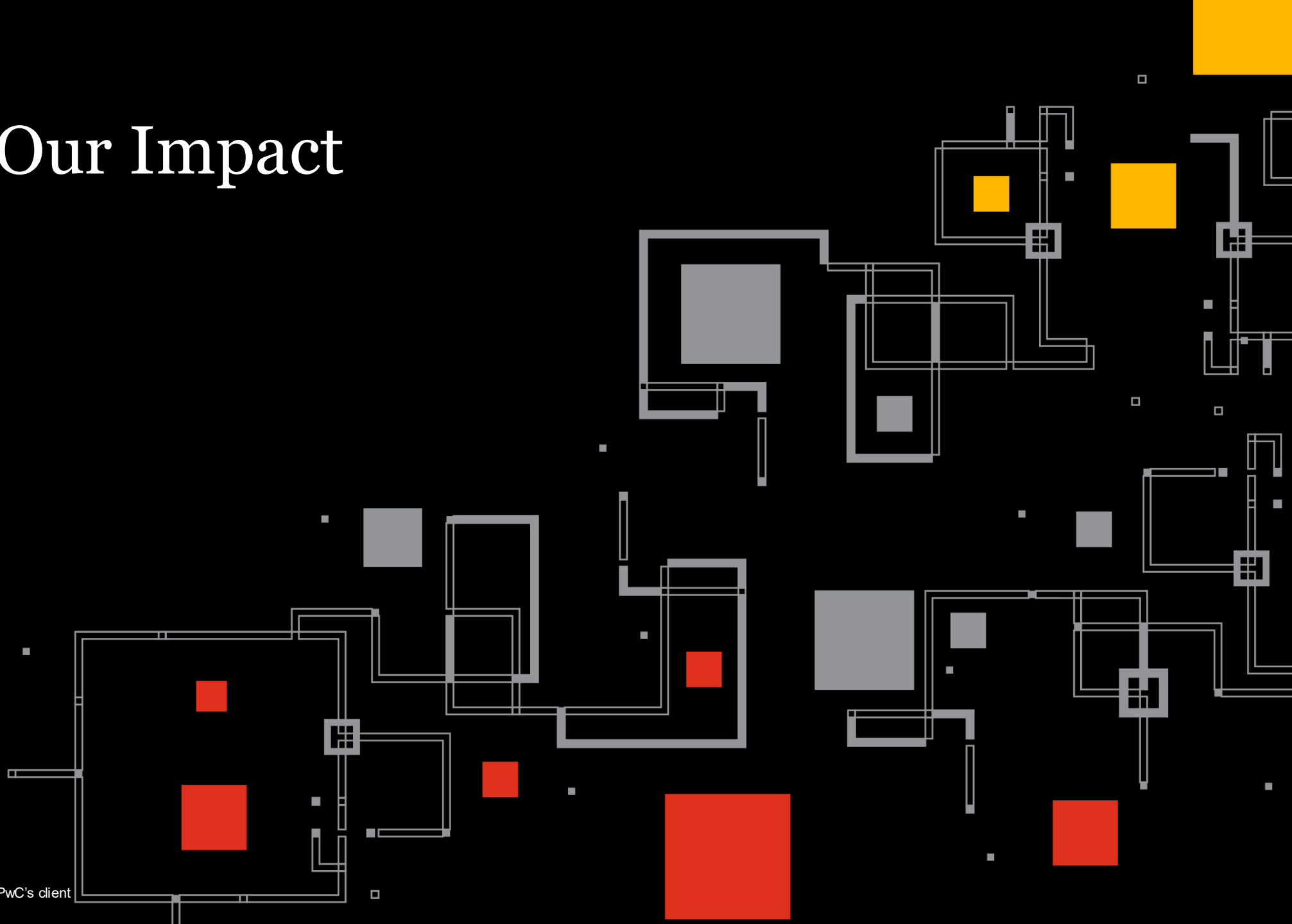
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03

Our Impact





Agent Route Optimization

01. What's the situation?

Many businesses require to assign agents to various stores (or locations) in order to accomplish certain tasks. This assignment involves certain complex constraints on time, distance and number of personnel, which needs to be optimized. Currently such tasks are considered NP-hard problem and involves solutions based on greedy search algorithms or genetic algorithm.

02. What is our solution?

Developed a quantum annealing based solution which can optimize the assignment process using Constrained Quadratic Models. Based on the solution, the number of personnel required, their respective routes etc can be calculated.

03. What are the benefits?

Better quality of solution consisting of optimized routes along with significant reduction of the time taken for the calculation of the solution.

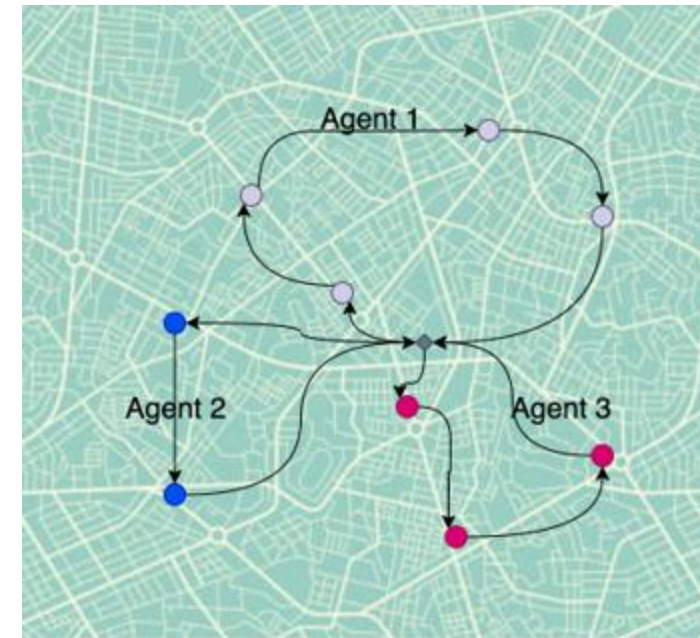
More than 11% of time and 33% of solution runtime can be saved using this method.

Problem Statement

Optimizing routes for multiple store inspections to minimize costs by strategically deploying a precise number of agents/contractors.



Input: Latitude and longitude of outlets



Output: Route of agents

Classical

Quantum



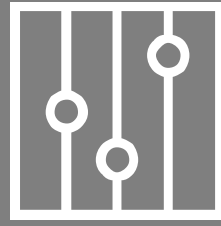
Data Collection and Preprocessing

- Collection of location data comprising of Latitude and Longitude
- Filtering out locations with certain properties and restrictions
- Calculation of the time and distance matrices



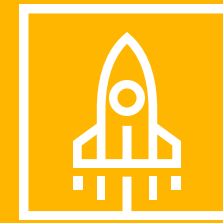
$$X_{dist} = \begin{bmatrix} d_{00} & d_{01} & \dots & d_{0n} \\ d_{10} & d_{11} & \dots & d_{1n} \\ \dots & \dots & \dots & \dots \\ d_{n0} & d_{n1} & \dots & d_{nn} \end{bmatrix}$$

$$X_{time} = \begin{bmatrix} t_{00} & t_{01} & \dots & t_{0n} \\ t_{10} & t_{11} & \dots & t_{1n} \\ \dots & \dots & \dots & \dots \\ t_{n0} & t_{n1} & \dots & t_{nn} \end{bmatrix}$$



Clustering

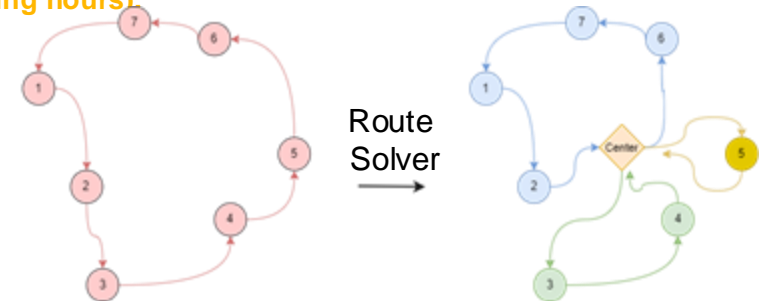
- Creation of clusters (if required)
- Its dependent on the hardware limitations



Route calculation

- **TSP Solver**: Finding the most efficient route that covers all the stores essentially converting it into Travelling Salesman Problem (TSP).
- **Route Solver**: Breaking the route in segments for each agent based on the following constraints:
 - The number of parts (i.e. number of agents) should be minimum.
 - The time to traverse each part should be ≤ 8 hours (i.e. the working hours)

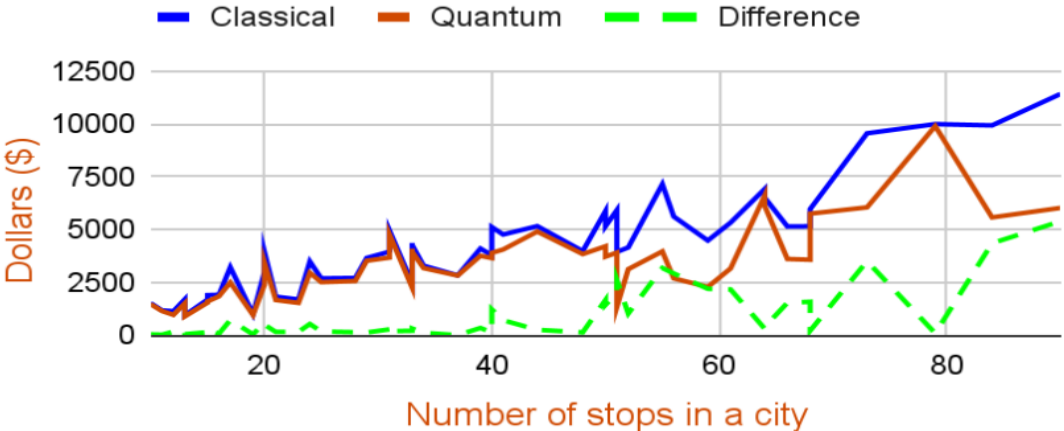
TSP Solver



Results

Agent Route Optimization

Quality of Results



Agent Route Optimization

Runtime (~25% - 60% speedup)

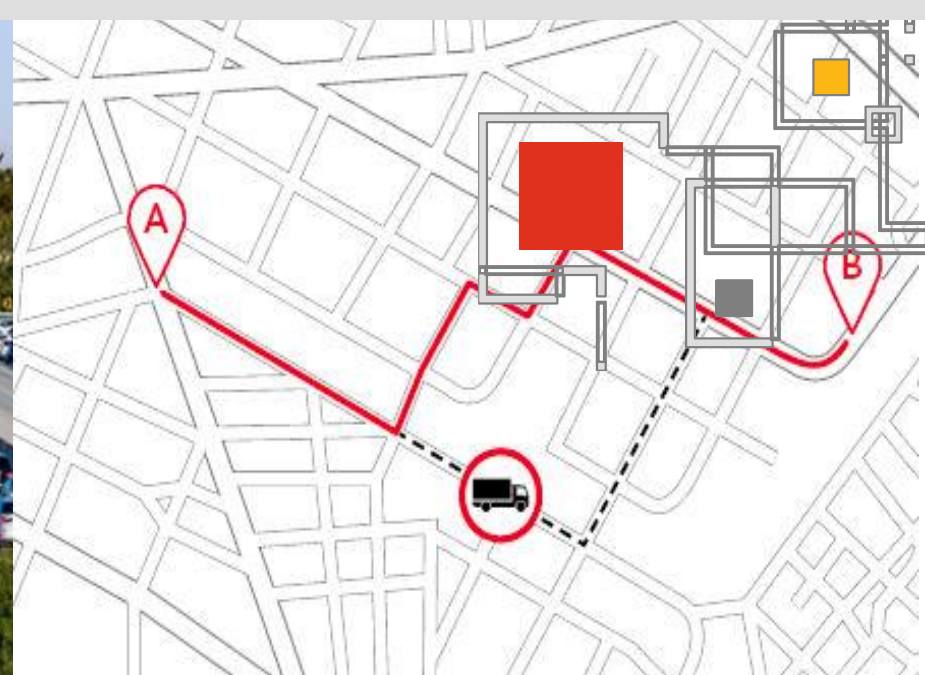


For 98 cities

Assumptions (these are illustrative for the example)

Per Mile: \$ 1.15
Per Hour: \$ 30.00
Per Overnight: \$ 160.00

	% improvement as compared to classical solution
Total Agents required	12.2 %
Total Distance travelled by agents	9.48 %
Total work hours of the agents	8.67 %



Relevant tech: Quantum Computing

Traffic Flow Optimization

01. What's the situation?

Many cities need to minimize the time taken by a given set of cars to travel from a particular source to a particular destination by reducing congestion over road segments

02. What is our solution?

Developed a quantum annealing based solution which can optimize the traffic flow using Quadratic Unconstrained Binary Optimization (QUBO).

QUBO was formulated using occupancy cost of a particular segment as function of the binary variables associated with routes that share it. For each segment penalize it according to weight of vehicles allocated to it.

03. What are the benefits?

The input can be entered with any number of classes of vehicles and the QUBO can be solved using various solvers depending on the requirements.

Hybrid solvers can speed up the solving process upto 70% while giving almost the same level of optimization.

Quantum solvers are able to provide a slightly better optimized solution as compared to classical solvers in complex cases.



Relevant tech: Quantum Computing

Quantum cryptography

01. What’s the situation?

Modern cryptographers emphasize that security should not depend on the secrecy of the encryption method (or algorithm), only the secrecy of the keys. The secret keys must not be revealed when plaintext and ciphertext are compared, and no person should have knowledge of the key. The design of secure systems using encryption techniques focuses mainly on the protection of (secret) keys.

02. What is our solution?

Unlike “conventional” encryption based on mathematical algorithms, QKD will not be compromised by the continual increase in computing power or mathematical progress.

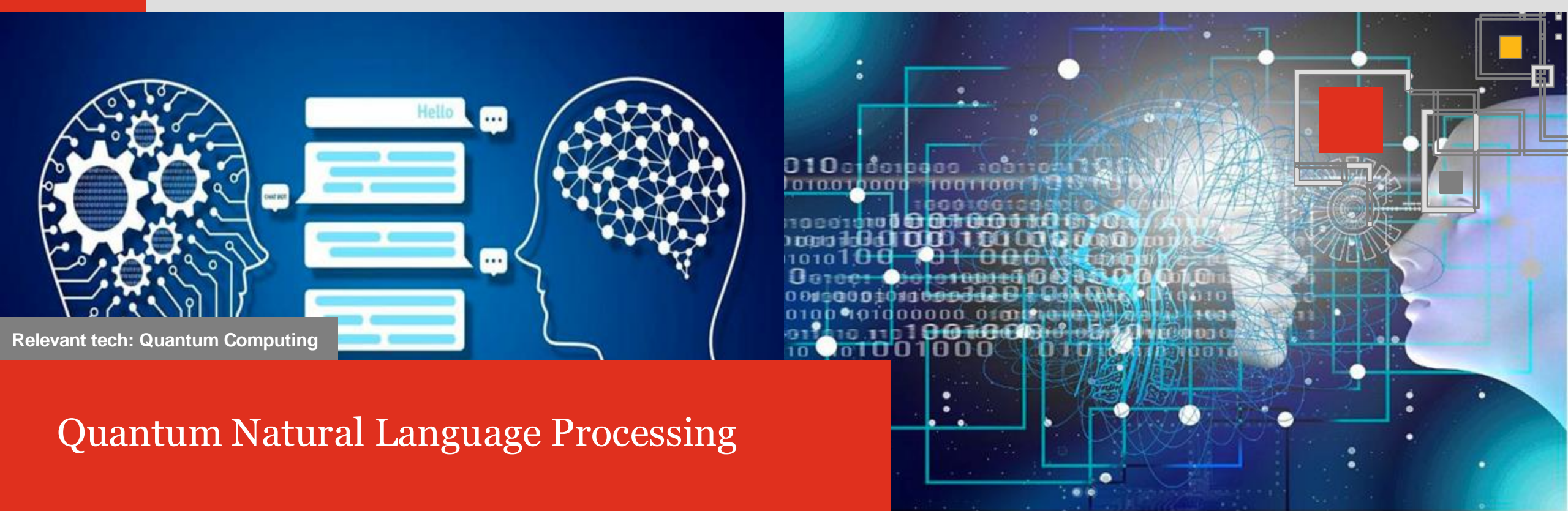
It thus ensures true future-proofed security of key distribution. QKD derives its security from the proven principles of quantum physics - namely, that the generation of the quantum key is truly random, and that any interruption or eavesdropping of the data will perturb the system and can thus be detected.

It basically depends on two major principle-Heisenberg Uncertainty principle and principle of photon polarization.

03. What are the benefits?

Modern algorithms are based on mathematically difficult problems - for example, prime number factorization, discrete logarithms, etc. There is no mathematical proof that these problems are in fact are hard, just empirical evidence. Modern cryptographic algorithms are too complex to be executed by humans because of unpredictable nature of quantum physics..

Today's algorithms are executed by specialized hardware devices, and in most cases are implemented in computer software. Keys can be protected either by encrypting them under other keys or by protecting them physically, while the algorithm used to encrypt the data is made public and subjected to intense scrutiny.



Relevant tech: Quantum Computing

Quantum Natural Language Processing

01. What's the situation?

Semantic and pragmatic analysis in classical NLP is very much resource-intensive. Automating the understanding and analytical ability of NLP models while dealing with enormous data set cause significant time and computational resource overhead leading to uncertain outcome and inaccurate precision.

02. What is our solution?

Quantum enabled NLP can convert sentences into quantum circuits using sentence structure (syntax) and meaning (semantics) using quantum entanglement to drastically speed up the training process.

Our approach is to use DisCoCat framework and ZX calculus to parse sentences and optimize generated quantum circuits to run more complex data in today's available superconducting qubit based quantum hardware.

03. What are the benefits?

Quantum-enabled NLP has the potential to outperform classical NLP in terms of better training accuracy and lesser training time when number of inputs are significantly high. In addition to that, due to faster computation, this will consume less power than the available high-end transformer NLP models.



Relevant tech: Quantum Computing



Quantum Random Number Generator

01. What's the situation?

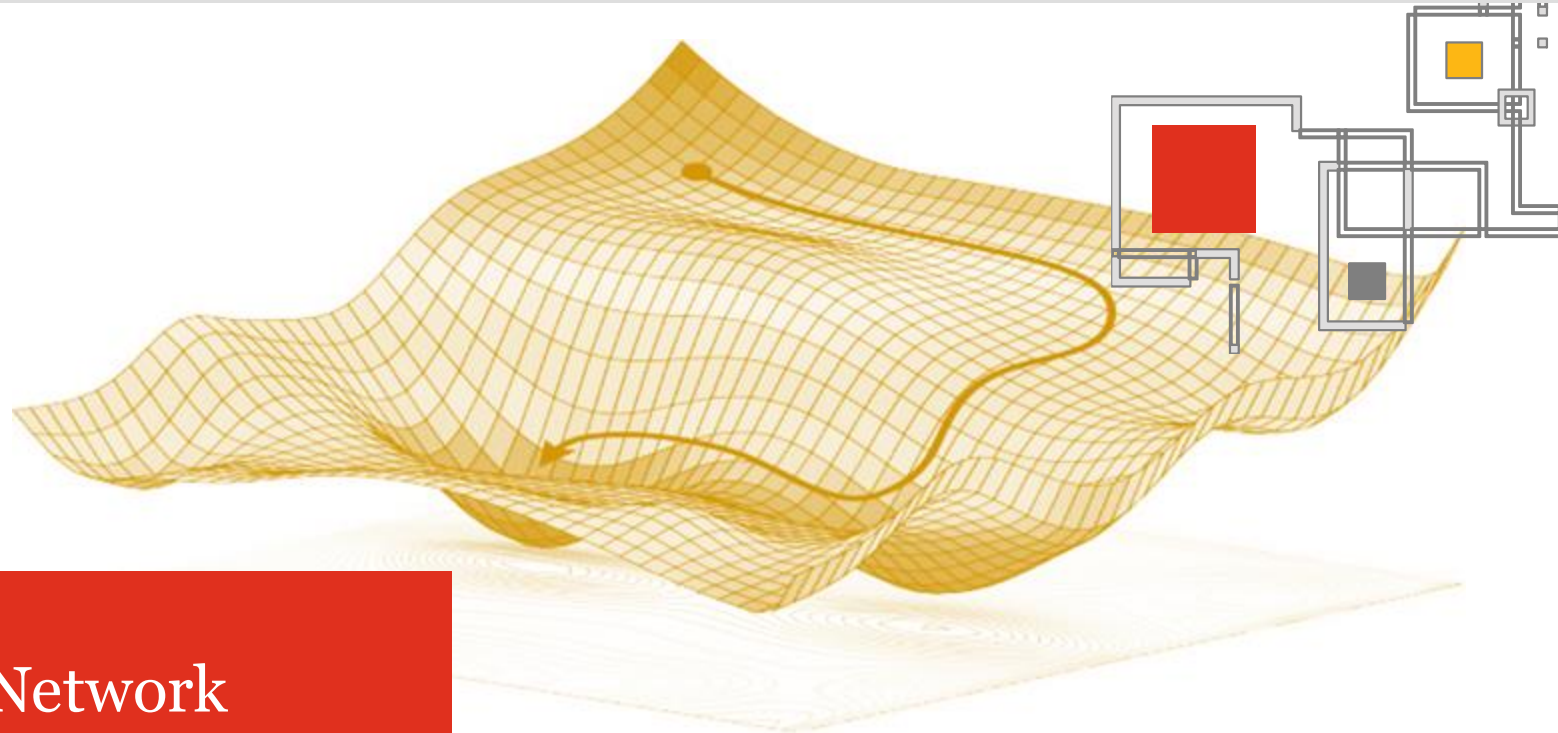
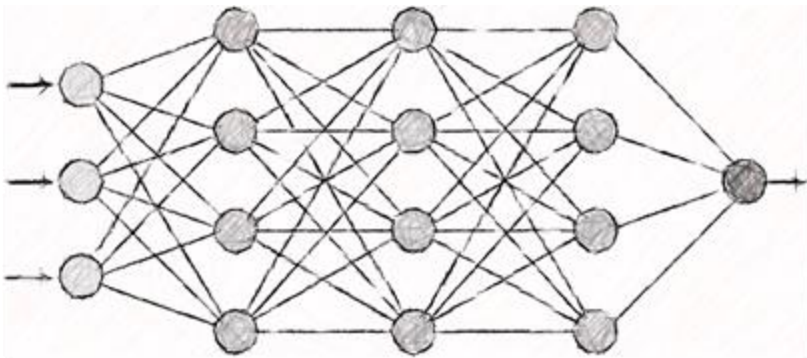
Existing pseudo random number generators (PRNG) rely on mathematical functions to generate random numbers which has diverse range of applications like in cybersecurity, statistical analysis, simulation, BFSI, defense and many more. Challenges with these generators are of less entropy/ randomness produced which causes easy predictability of random bits. Another set of available RNG is Hardware based, which has a very slow bit generation rate and also susceptible to physics of the underlying hardware.

02. What is our solution?

Quantum RNGs are based on principles of quantum physics which is non-deterministic in nature and are able to generate true random bits. Existing quantum RNGs are able to provide significant entropy required for security-intensive applications. Our QRNG enabled solutions can prove to be quantum-safe in post-quantum era. Our objective is to extract the maximum number of entropy from the underlying quantum device and to propose a quantum key as a service model.

03. What are the benefits?

Quantum RNGs can produce bits with enhanced security level, statistically non correlated, unbiased random numbers which can be used further for creating dynamic QR, captcha, secure cryptographic key, initial seed for sampling, OTP etc. QRNG market value in 2022 was 300 million U.S. dollars, which has a projected growth rate of 35% by 2025.



Relevant tech: Quantum Computing

Quantum Optimizer for Neural Network

01. What's the situation?

Artificial Neural Networks and their variants depends on classical optimization algorithms like gradient descent, RMSprop to update their weights. Major disadvantage of such optimizers is the computational complexity. Training time of a model increases with an increase in the number of parameters.

02. What is our solution?

Hybrid Quantum Neural Network is the proposed solution which replaces the computationally expensive optimization process with its quantum counterpart.

Working on a quantum annealing based approach that considers Mean Absolute Error as the cost function to be optimized.

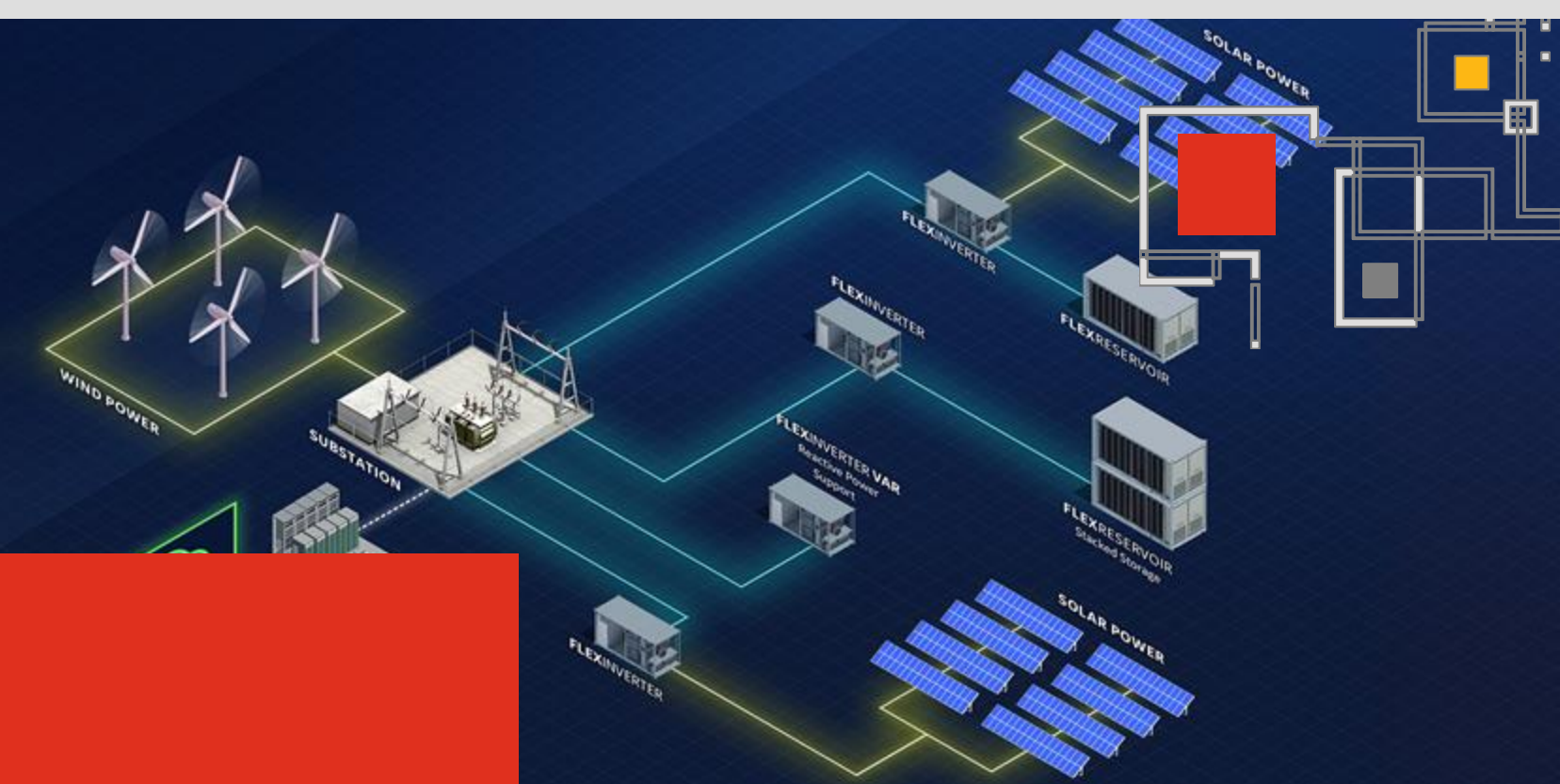
03. What are the benefits?

Replacing classical optimizers with appropriate quantum function helps to develop faster machine learning dependent quantum products.



Relevant tech: Quantum Computing

Hybrid Energy Optimization



01. What's the situation?

With the rapid demand of energy, traditional power stations no longer match the needs of energy consumption, and they are not environmentally friendly. Hybrid energy systems, as an alternative to traditional energy systems, are sustainable and less harmful to the environment since they utilize low-carbon renewable power derived from infinite natural resources.

02. What is our solution?

We propose to study hybrid energy system optimization with Quantum Annealing algorithm on D-Wave quantum chip. Compared with classical algorithms on solving optimization problems, quantum annealing takes advantage of quantum tunneling to tunnel through large energy barriers and provides more chance to find a global minimum.

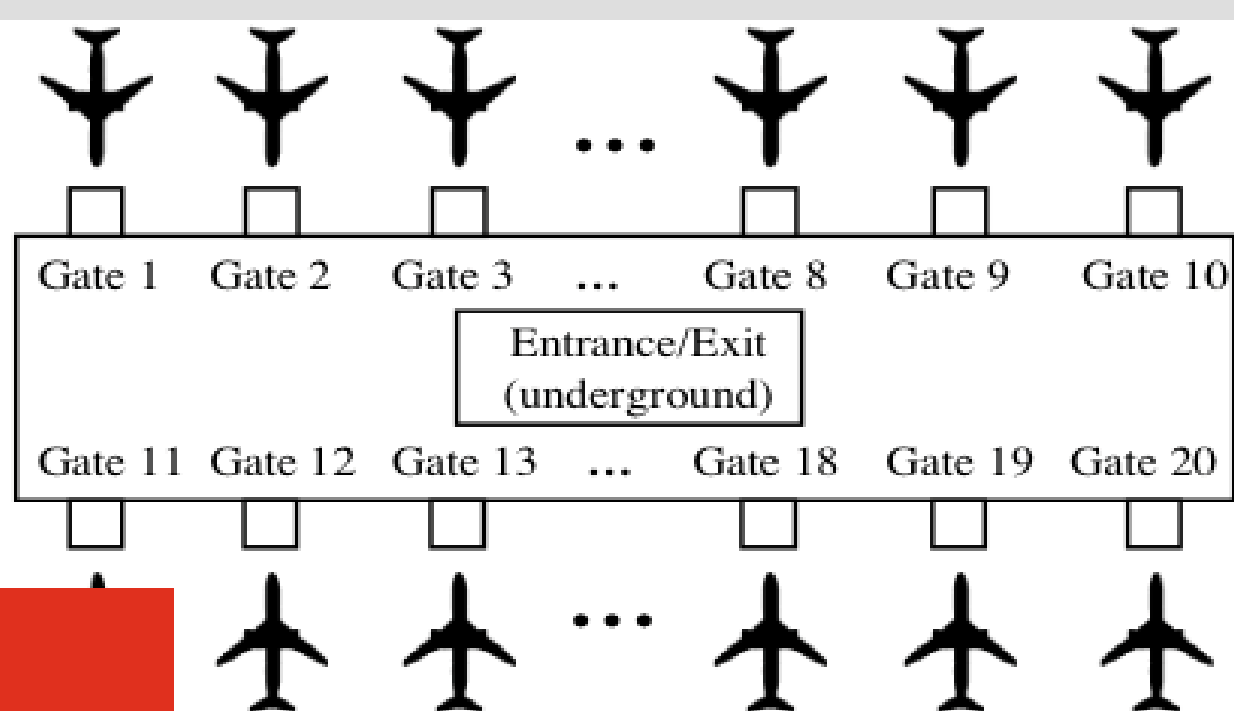
03. What are the benefits?

Hybrid renewable energy systems can help to reduce greenhouse gas emissions. The low-carbon emission of renewable energy system is more welcomed than traditional fossil fuel energy system. Governments across the world are vigorously advocating the development of renewable energy for power supply. We believe if we can improve the hybrid energy system optimization, there is a large commercial potential in designing a hybrid energy system optimization method based on quantum algorithm.



Relevant tech: Quantum Computing

Airline Gate Optimization



01. What's the situation?

Optimization of large combinations of cargo and passenger traffic among planes, gates and the air traffic flows originating or terminating at an airport is a major challenge in the aviation industry. High quality solutions to this complex optimization problem is important in reducing costs and increasing efficiency.

02. What is our solution?

A quantum annealing based solution which can optimize the gate allocation process using Constrained Quadratic Models.

The gates are allotted to each flight by reducing the total distance the passengers from all flights have to travel in case of arrival, departure and transit.

03. What are the benefits?

Optimization done using hybrid CQM solvers gives good quality of solutions and also runs faster than conventional classical algorithms for complex cases.



Relevant tech: Quantum Computing

Portfolio Optimization

01. What's the situation?

For any organisation it is an important step to allocate the required resources/employees in verticals/shifts.

02. What is our solution?

Developed a quantum annealing based solution which can optimize the allocation process using Constrained Quadratic Models, Discrete Quadratic Models.

Allocated the given number of employees to the given shifts/verticals based on the preference order of employees and given resource requirement of the shifts/verticals.

03. What are the benefits?

The optimization from hybrid CQM solvers gives a better quality of solutions in less time as compared to the classical tabu sampler.



Relevant tech: Quantum Computing

ALM Portfolio Optimization

Optimizing asset portfolio

01. What's the situation?

Actuaries have been performing ALM since the first insurance companies projected liabilities and interest on assets. The objective is to maximise yield on assets whilst ensuring cash flows match the liabilities to specified requirements.

02. What is our solution?

This is an optimization problem that involves choosing the subset of assets with the lowest market value possible, subject to the restrictions that the liabilities and cash flows must match specified constraints.

We are working on a product that will solve the given ALM optimization problem using a variety of hybrid and classical solvers.

03. What are the benefits?

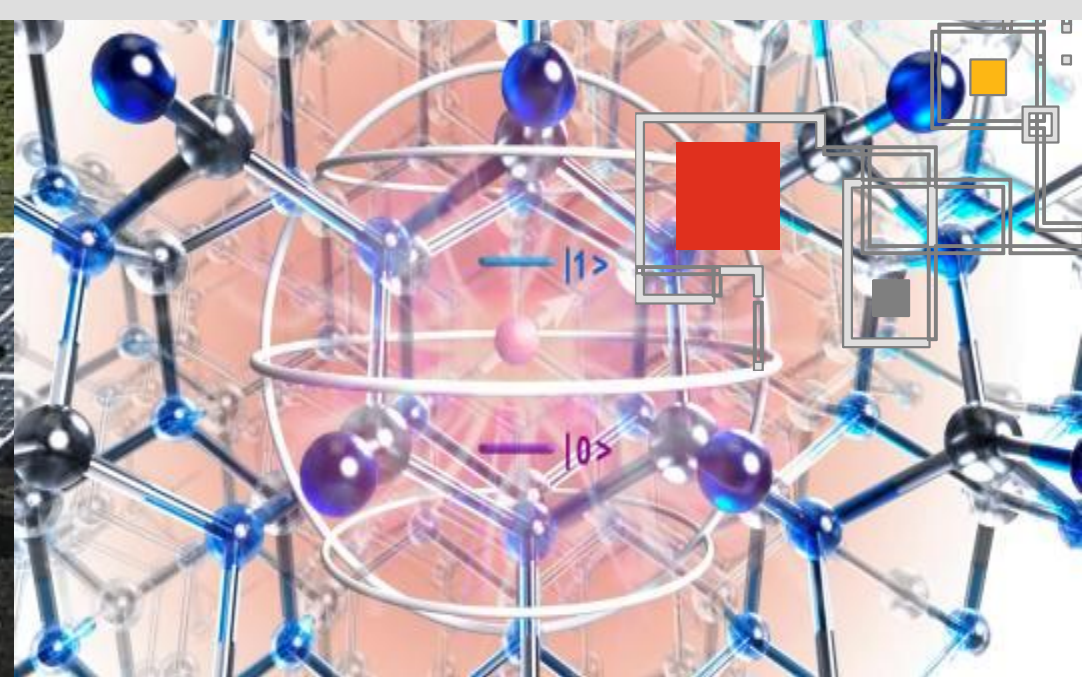
Computation using quantum computers can be completed orders of magnitude more quickly than using conventional computers.

³⁵
A simple algorithm would be to consider all asset combinations and find a solution to the problem that also meets the constraints. While this algorithm would eventually work, even with the most powerful supercomputer, a simple brute force approach would take billions of years*. A set of 100 assets, for example, has 2^{100} possible combinations, which is on the order of 10^{30} .



Relevant tech: Quantum Computing

Investigation on solar cell efficiency



(Image by University of Chicago)

01. What’s the situation?

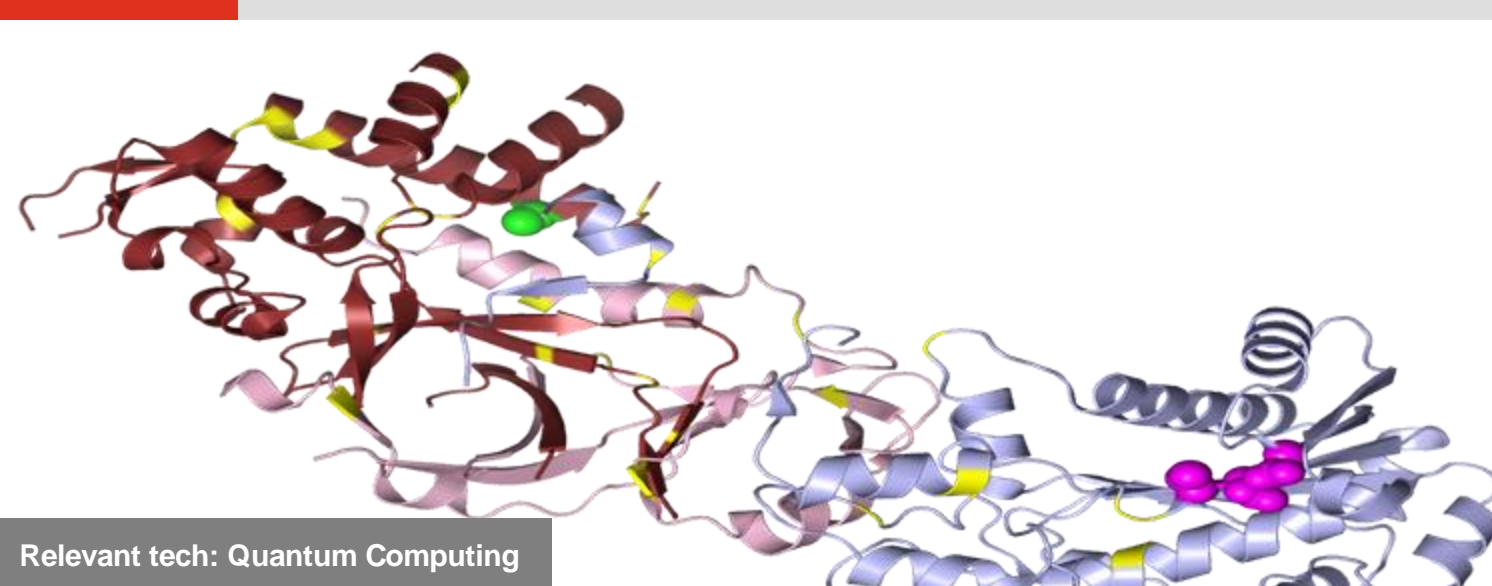
Solar energy is an increasingly important solution for addressing pressing environmental challenges and meeting growing energy needs. However, the progress of this technology is currently limited by a shortage of suitable materials that can effectively convert sunlight into electricity. This highlights the importance of continued research and innovation to develop more efficient and cost-effective solar cells.

02. What is our proposed solution?

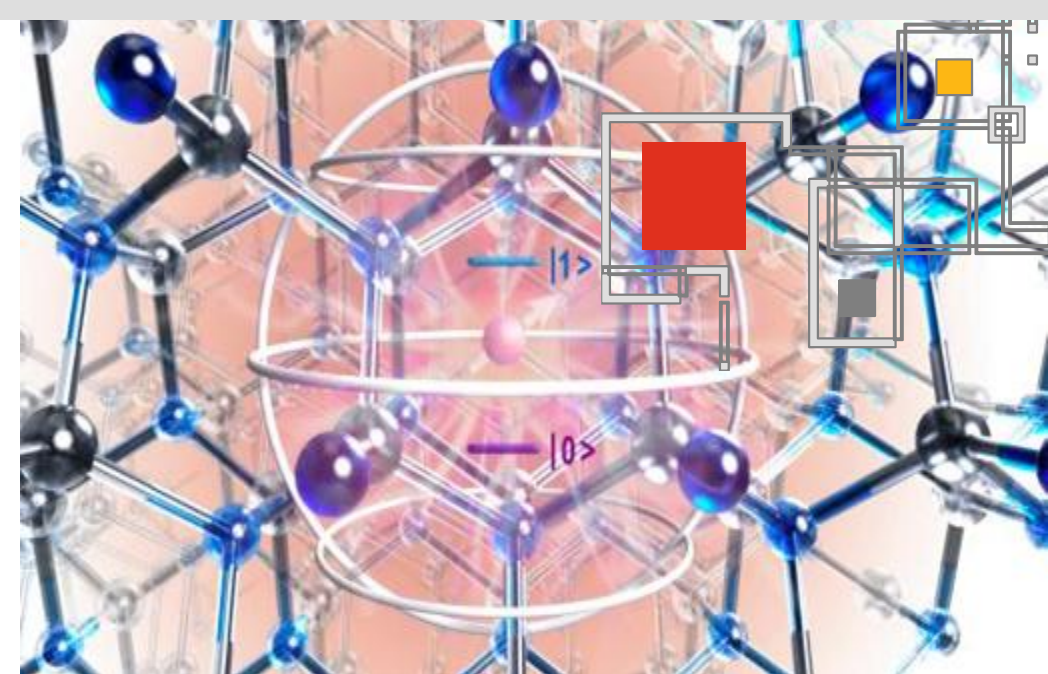
Optimizing thin-film solar cell layer thicknesses is crucial, with quantum optimization algorithms might be a faster, more accurate optimization method than parameter sweep.
Hybrid quantum simulation with density functional theory (DFT) screening, including spectroscopic limited maximum efficiency (SLME), charge carrier mass, convex-hull stability and ML identifies solar absorber materials for experimental investigation.

03. What are the expected benefits?

Developing a more precise optimization technique for solar cell thickness design can result in higher efficiency and lower cost.
By accurately identifying the most promising solar cell materials for experimental investigation, research efforts can be focused, which can ultimately lead to the development of more efficient and cost-effective solar cells.



Quantum Molecular unfolding



(Image by University of Chicago)

01. What's the situation?

Molecular docking plays a crucial role in the drug discovery process by determining the optimal position and shape of two molecules when they are bound to each other. To achieve this, 3D representations of molecules are adjusted based on their degree of freedoms. This analysis provides valuable insight into the interaction between molecules and can guide the development of effective drug candidates.

02. What is our solution?

Molecular unfolding is a phase of molecular docking that expands a molecule to simplify its manipulation within the target cavity. The objective is to find the optimal configuration that maximizes the internal distances between atoms or molecular area. This involves finding the ligand shape that maximizes the internal distance of the molecule and sum of distances between each pair of atoms.

03. What are the benefits?

The use of molecular unfolding in drug discovery through quantum computing can provide significant benefits in terms of speed and accuracy. By optimizing molecular configurations more efficiently, the drug development process can be accelerated, potentially reducing costs and time to market for new drugs.



Relevant tech: Quantum Computing

Exploration of Parallel and Distributed Quantum Annealing

01. What's the situation?

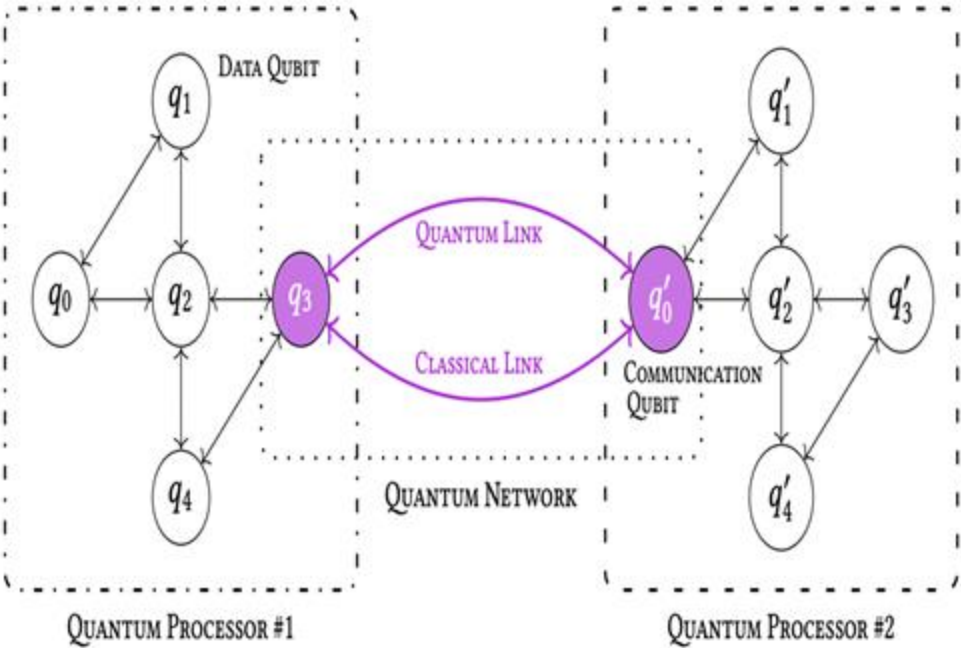
Quantum Annealing is a powerful technique in solving certain optimization problems. However since the number of qubits as well as the connectivity between is somewhat limited currently because of hardware limitations, the scale of problems that could be handled becomes limited.

02. What is our solution?

Parallel quantum annealing could make use of qubits that are available and not being used thereby increasing utilization and Distributed quantum computing could potentially use multiple quantum processors together to solve a problem thereby possibly giving efficient computation for larger scale problems.

03. What are the benefits?

Making use of Parallel and Distributed techniques in quantum annealing could make the computation more efficient and faster.



Source (right image): Distributed Quantum Computing: a Survey

www.pwc.com

Let's start exploring.

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