How Will Quantum Computing Affect M&S?

Who Am I?

Hex Miller-Bakewell (they/them)

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Currently on sabbatical while managing a chronic pain disability.

Direct Offering For M&S

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- But **people will try and sell it to you anyway**
- But there are some expected changes (which we'll cover)

Why use Quantum?

For a quantum computer to be impactful it must do something **cheaper** than classical computers can.

Classical (“Not Quantum”) Computers

Inside A Classical Computer

What are they good at?

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They're very good at arithmetic: $(\text{add}, |010|, |001|) \rightarrow |011|$

Classical Limitations

But what are they bad at?

Let's find some expensive problems

Classical Bank Transfer

Example: Cybersecurity

- A customer buys something online

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- It must be **cheap** for the bank and the user to communicate securely
- It must be **expensive** for anyone else to break that security

Operational Cost

	Classically
Decrypting	Cheap
Hacking	Expensive

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The "computational complexity" of these tasks is a well defined and intensely scrutinised field.

TSP

Example: Routing Deliveries ("Travelling Salesman Problem")

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- Solving this problem precisely is **expensive**
- But *approximate* solutions are **cheap** (to within "a couple of percent")

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Approximate routing	Cheap
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"We think the combined effect of personalization and recommendations save us more than $1B per year."

– Netflix, 2015

Recommendation Systems

Example: Recommending Items On Netflix

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- Customers lose interest at 60 to 90 seconds
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- Out of around 4000 films and series
- Recommendation systems use a whole host of algorithms; matrix factorisation, principal component analysis, machine learning

Operational Cost

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Approximate routing	Cheap
Exact routing	Expensive
Recommendations	Expensive

Classical Recap

Classical computers work with $|0|$s and $|1|$s.

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Because of this there are certain problems that are expensive to solve, although there are sometimes cheaper approximate solutions.

Quantum Computers

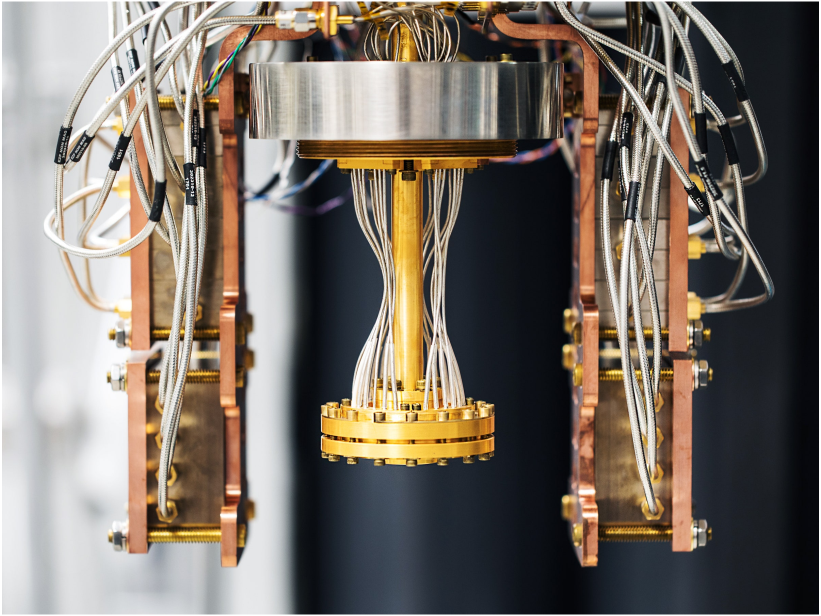

Figure 1: Rigetti's superconducting system (2017)

Quantum Computers (the good)

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$\alpha_{00}|00| + \alpha_{01}|01| + \alpha_{10}|10| + \alpha_{11}|11|$

So the amount of information in n qubits seems to grow like 2^n.

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Quantum information can't be copied.

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Actual existing implementations of quantum information storage **lose fidelity over time**

Quantum Computers (the important)

Quantum computers **are not** faster classical computers

They are **fundamentally different** in the information they process

But this means they are well-suited for **different tasks** to classical computers

Quantum decryption

Current encryption regimes can be broken **easily** on a large enough quantum computer

(e.g. Shor, 1994)

Operational Cost

	Classically	Quantum Algorithms
Decrypting	Cheap	-
Hacking	Expensive	Exponentially faster
Approximate routing	Cheap	
Exact routing	Expensive	
Recommendations	Expensive	

(2022 saw the introduction of *hopefully* quantum-resistant encryption protocols)

Quantum Logistics

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But is it noticeably cheaper?

Operational Cost

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Decrypting	Cheap	-
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Approximate routing	Cheap	-
Exact routing	Expensive	A bit faster
Recommendations	Expensive	

Quantum Recommendation Algorithms

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All of the recommendation algorithms make heavy use of linear algebra.

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When?

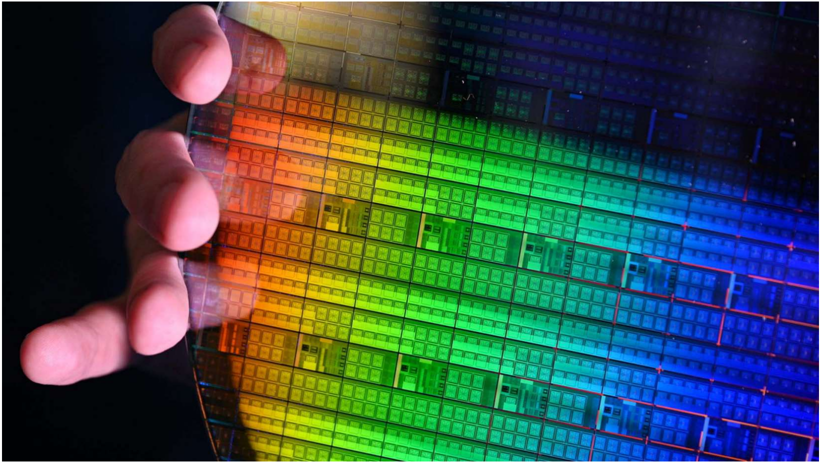

Figure 2: Intel's recently announced quantum computing chip (2022)

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Intel has just announced (6th October, 2022) a method of creating quantum computing chips based on their existing method for creating silicon chips.

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But I wouldn't hold your breath. The rate of progress is phenomenal, but there are likely to be growing pains, just like the adoption of (classical) computers.

Future-proofing

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We **have proved** that there are quantum algorithms faster than all available classical algorithms.

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Essentially everyone is convinced that we won't find better classical algorithms.

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But in the same way that most people didn't predict how important classical computers would become for our lives, it will take getting our hands on, and experimenting with, quantum computers to see how useful they are.

Recap

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Quantum computers and classical computers **are different at their core**

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Other problems are no faster on quantum computers

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And there could be more!

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- Logistics: Affected a little
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And there could be more!

But sticking the word "quantum" on something doesn't mean it's well suited for your business strategy.

Thank You

Any Questions?

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