Applications of Quantum Computers in Banking

Strategic Innovation and Artificial Intelligence - Velvet Edition

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Classical Computers

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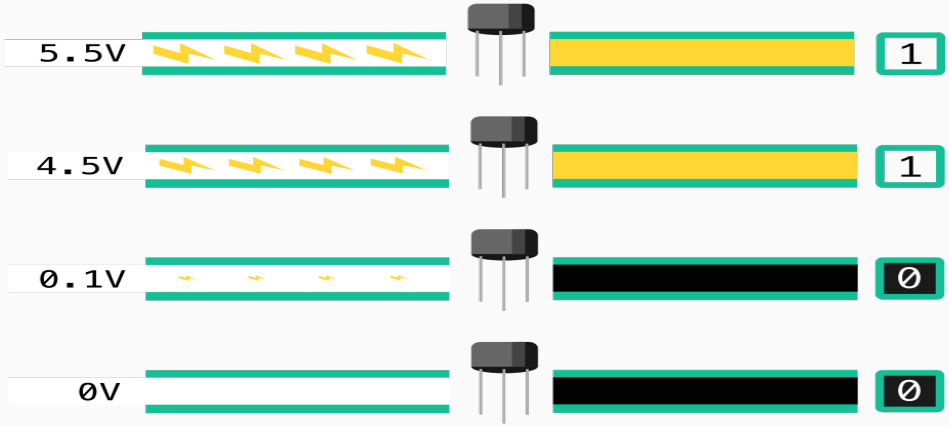


Figure 1: We use transistors to create logical states of 1 and 0.

Logical Gates

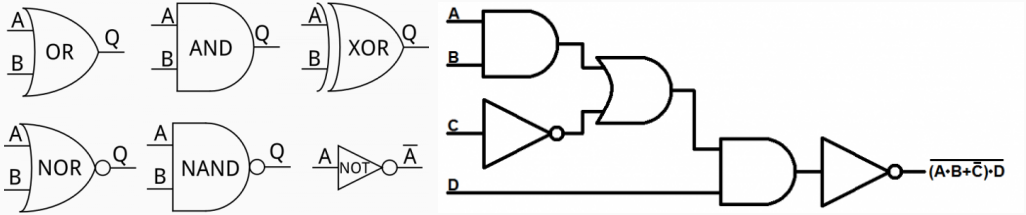


Figure 2: Those transitors are used to create logical gates that are in turn building blocks for logical circuits.

The Fastests Supercomputer: EXA FLOPS

Figure 3: More info: https://en.wikipedia.org/wiki/Frontier_(supercomputer), and https://top500.org/lists/top500/2022/06/

The faster super computer today

Table 1: SUPERCOMPUTER FRONTIER

Aspect	**Details**
Site	DOE/SC/Oak Ridge National Laboratory
System URL	`https://www.olcf.ornl.gov/frontier/`
Manufacturer	HPE
Cores	8,730,112
Processor	AMD Optimized 3rd Generation EPYC 64C 2GHz
Installation Year	2021
Performance	
Linpack Performance (Rmax)	1,102.00 PFlop/s
Theoretical Peak (Rpeak)	1,685.65 PFlop/s
Power Consumption	
Power	21,100.00 kW (Submitted)
OS	
Operating System	HPE Cray OS

What Are Quantum Computers?

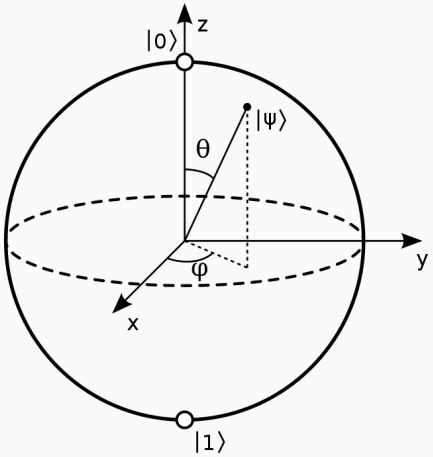


Figure 4: Source: `nextplatform.com`

Operations

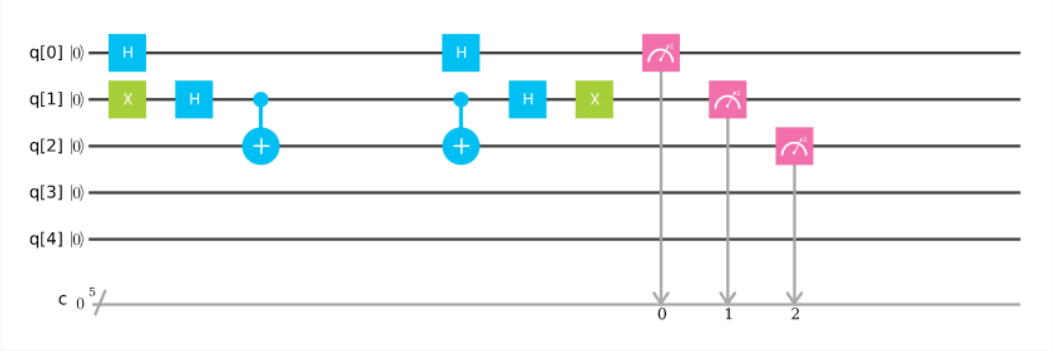
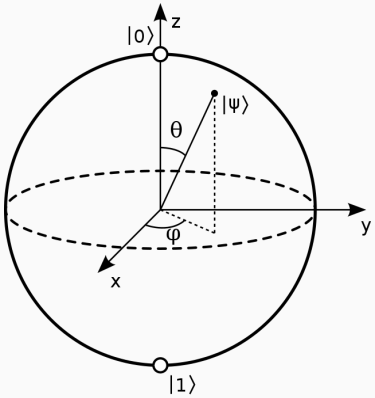


Figure 5: A quantum circuit: quantum gate operations on q-bits. Source: `ibm.com`

Aspects of Quantum Computing: Superposition



Superposition is a quantum state that is a combination of 2 mutually exclusive states

$$\alpha\ |0\rangle + \beta\ |1\rangle$$

Note that if $\alpha > 0$ and $\beta > 0$ then the qubit's state contains both $|0\rangle$ and $|1\rangle$

Aspects of Quantum Computing: Entanglement

A system of two qubits can be characterized by

$$\alpha_1 \left|00\right\rangle + \alpha_2 \left|01\right\rangle + \alpha_3 \left|10\right\rangle + \alpha_4 \left|11\right\rangle$$

where

- $\left|01\right\rangle$ means that the first qubit is $0\rangle$ and the second $\left|1\right\rangle$
- $\sum_{i=1}^{4} \left|\alpha_i\right|^2 = 1$

If two or more of α_i are non-zero, and we cannot separate the states, then they are entangled. Knowing one determines the state of the other.

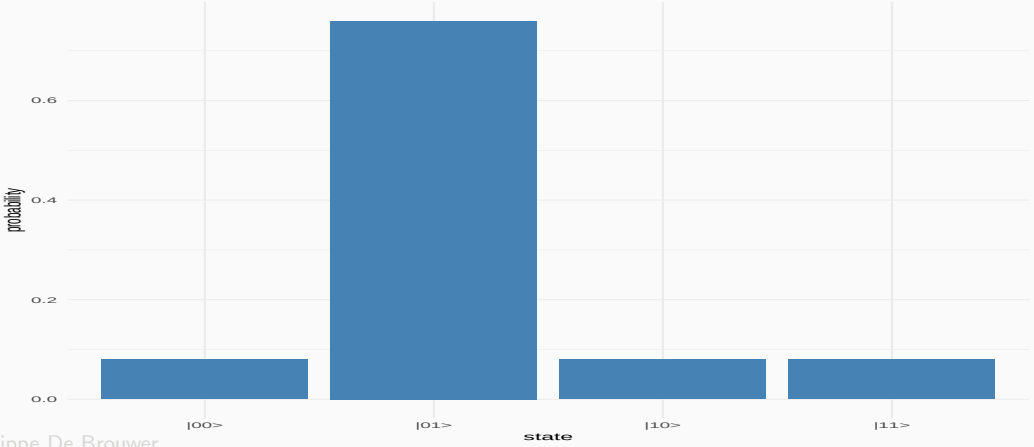
Example

$\frac{\sqrt{2}}{2} \left|11\right\rangle + \frac{\sqrt{2}}{2} \left|10\right\rangle$ is not entangled

$\frac{\sqrt{2}}{2} \left|01\right\rangle + \frac{\sqrt{2}}{2} \left|10\right\rangle$ is entangled

Aspects of Quantum Computing: Interference

Increase the probability of getting the correct answer (and reducing the probability of the wrong answer).



Aspects of Quantum Computing: Exponential Power

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- 175 qubits $\rightarrow$ 4.7890486×10^{52} states (ca. 10^{50} atoms on earth)
- 275 qubits $\rightarrow$ 6.0708403×10^{82} quantum states (ca. 10^{82} atoms in the visible universe)

Existing Quantum Computers

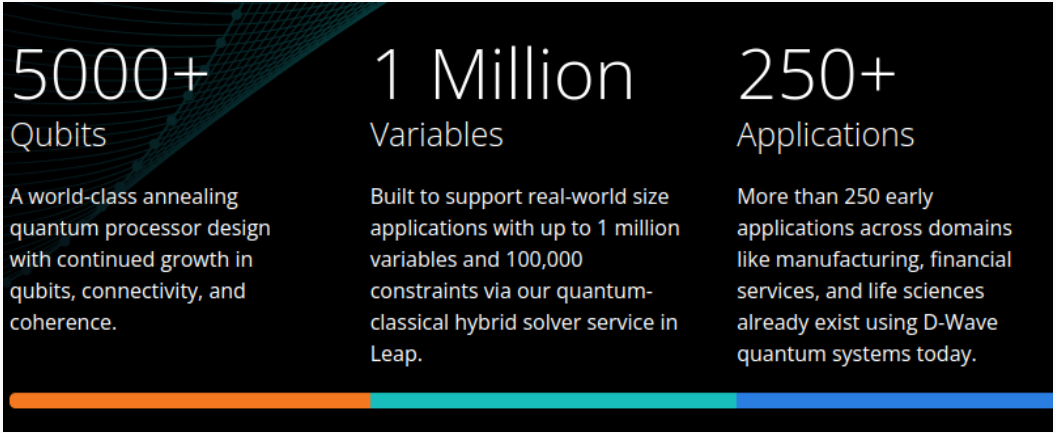


Figure 6: State of the art with D-Wave. Source: dwavesys.com

Figure 7: A paper about portfolio optimisation with the D-Wave computers. Source: arxiv.org

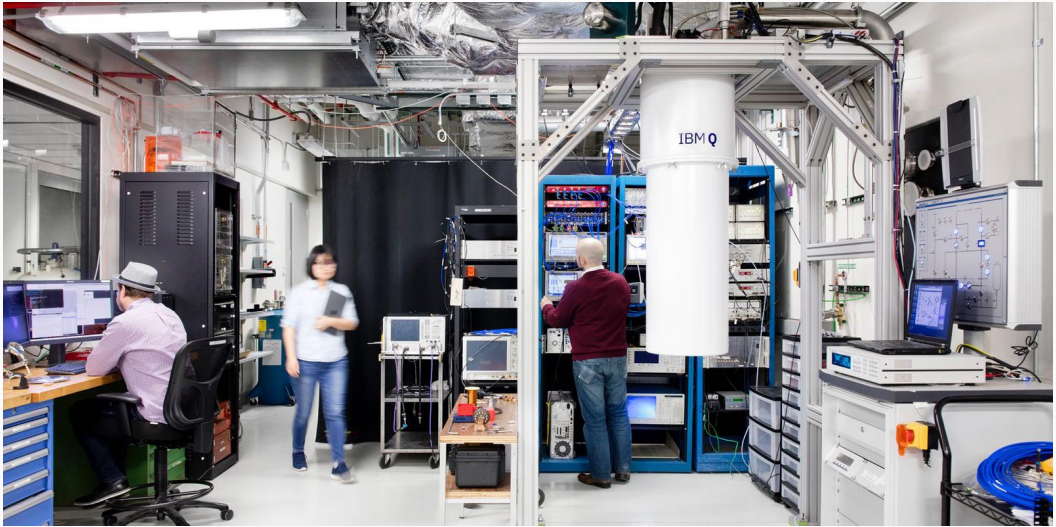


Figure 8: A quantum computer today. Source: `ibm.com`

Quantum Computing Achievements in Banking

Examples of banks's efforts

Finextra

SIGN UP>

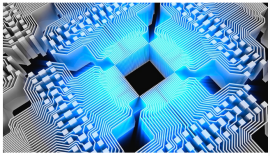
News

Citi joins $25 million round in quantum pioneer QC Ware

30 September 2021 18 15 15

Goldman Sachs Careers / Possibilities Stories

Investing at Quantum Speed



In a giant leap forward for the world of finance, Goldman Sachs announced we can introduce quantum algorithms to price financial instruments in as soon as five years.

We're on the verge of using quantum algorithms to do complex financial calculations with blazing speed. Finance was one of the first domains to embrace Big Data, and the drive to innovate continues. Much of the science behind the pricing of financial assets involves combinatorics calculations, the forte of quantum computing.

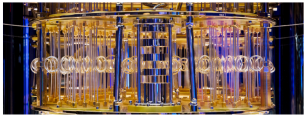
IBM

HSBC Working with IBM to Accelerate Quantum Computing Readiness

Bank envisions application of quantum capabilities for priorities such as pricing and portfolio optimisation, sustainability, risk and fraud

Expands internal talent with quantum specialists

Mar 29, 2022



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JPMorgan Chase, Toshiba and Ciena Build the First Quantum Key Distribution Network Used to Secure Mission-Critical Blockchain Application

NEWS

JPMorgan Chase, Toshiba and Ciena Build the First Quantum Key Distribution Network Used to Secure Mission-Critical Blockchain Application

Proof of Concept Showed Ability to Detect and Defend Against Potential Threats and Eavesdroppers

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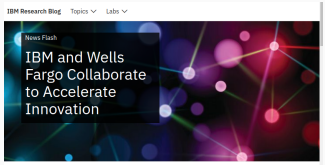
BUSINESS

11 Global Banks Probing The Wonderful World of Quantum Technologies

By **James Dargan** June 23, 2021

IBM Research Blog Topics Labs



November 15, 2019 | Written by: IBM Research Editorial Staff

Some Real Results

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- JPMorgan used Honeywell's quantum computer for mathematical operations that involve Fibonacci numbers
- Caixa Bank runs a hybrid framework of quantum and classical computing to improve credit risk scoring (PoC)

Quantum Computing Potential

Use cases in banking

- **Optimization**:

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- **Optimization**:
  1. portfolio optimization

Use cases in banking

- **Optimization**:
  1. portfolio optimization
  2. collateral optimization

Use cases in banking

- **Optimization**:
  1. portfolio optimization
  2. collateral optimization
  3. stress testing

Use cases in banking

- **Optimization**:
  1. portfolio optimization
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  4. transaction settlement

Use cases in banking

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Resulting Advantages

quadratic to exponential speedup

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Boston Consulting Group estimates a value of $42B to $67B for financial institutions

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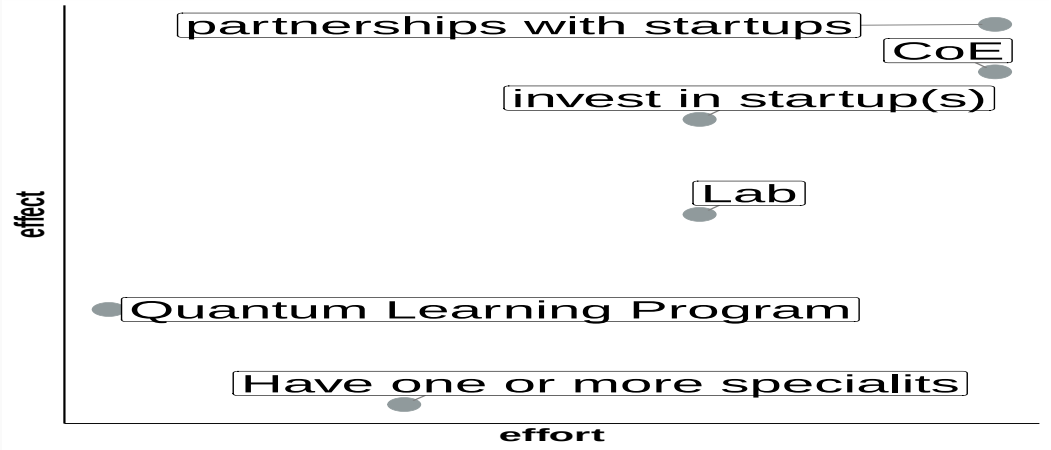
The Route to Quantum for the Banker

Solutions


partnerships with startups
CoE
invest in startup(s)
Lab
Quantum Learning Program
Have one or more specialits
effect
effort

Shortcuts to solutions

- Get access to learning, online quantum computers, etc. via the IBM Quantum Accelerator for enterprise
- Use Qiskit to learn programming on quantum computers – qiskit.org and their YouTube channel

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  - - improved accuracy of risk calculations
  - - improved deep learning
  - - improving computational speed
  - - providing a greener solution to computational intensive tasks

Further Reading

- McKinsey, 2020, "How quantum computing could change financial services" – download
- IBM, "The Quantum Decade" (e-book) – download
- E. Rieffel and W Polak, MIT Press, "Quantum Computing, a Gentle Introduction" – download
- Quantum Computing for the Quantum Curious, C. Hughes et al., Springer – download
- a list of books: download