Quantum Computers in Banking

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2022-12-15

Table of Contents

Classical Computers

Transistors

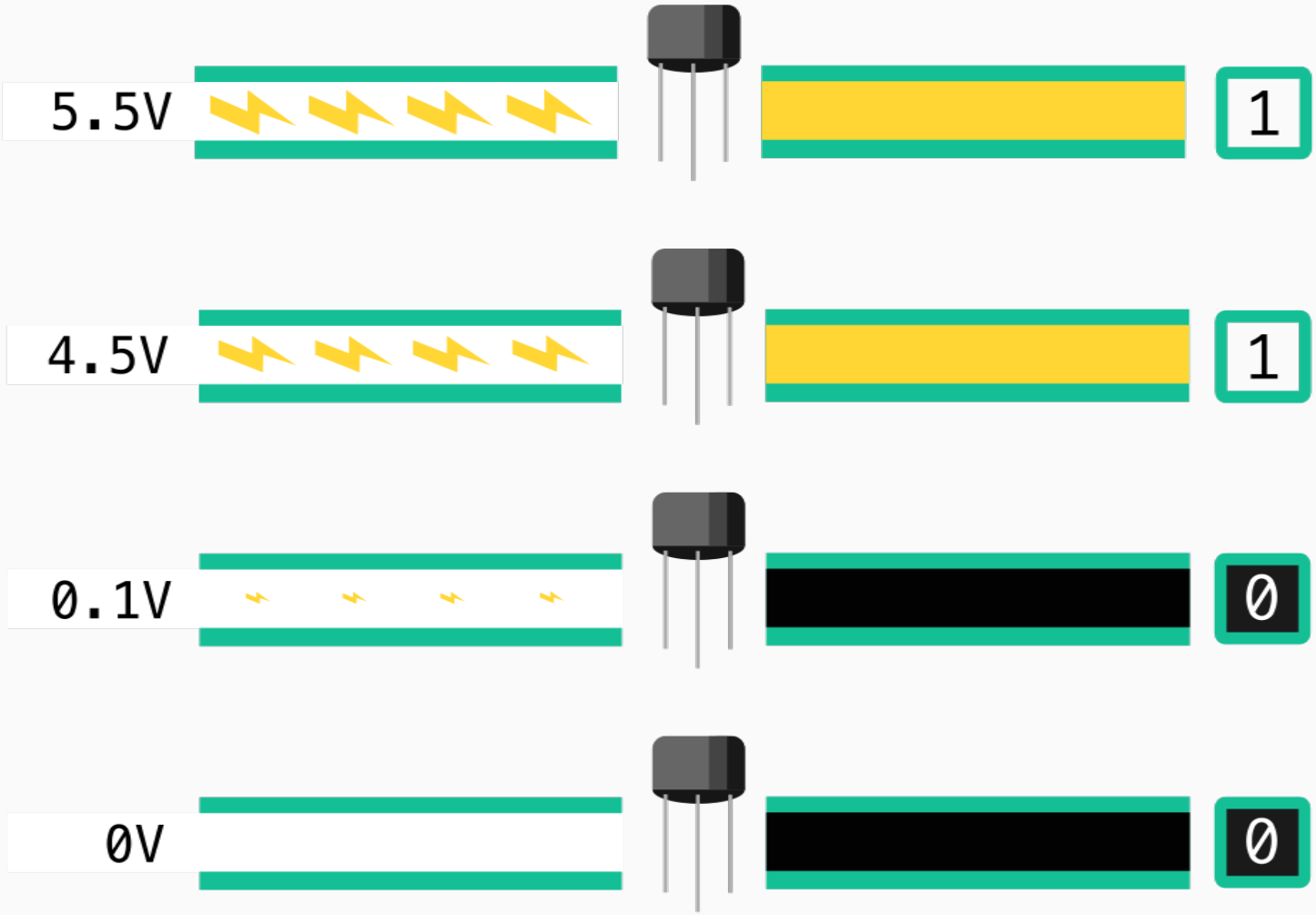


Figure 1: We use transistors to create logical states of 1 and 0.

Logical Gates

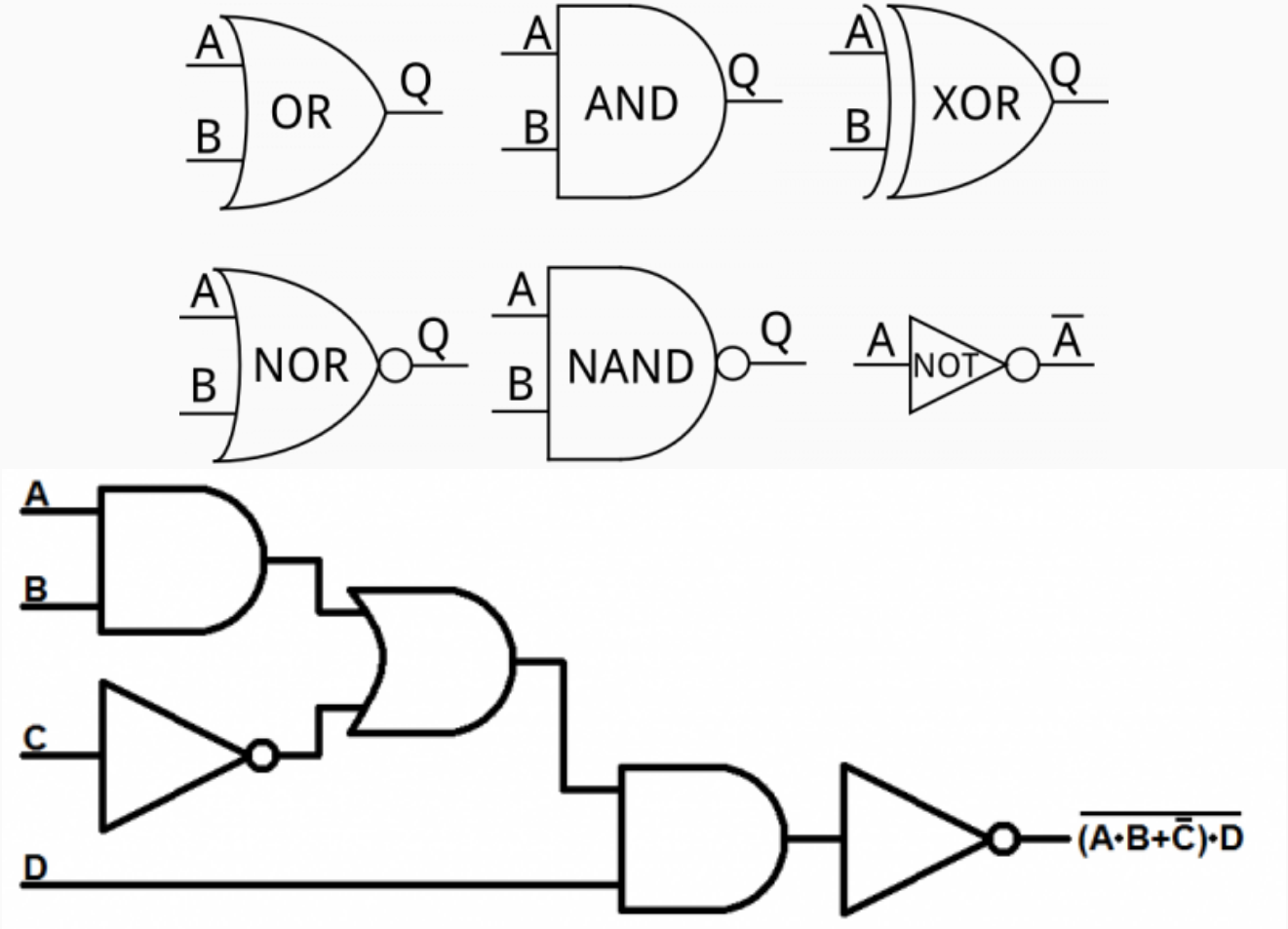


Figure 2: Those transitors are used to create logical gates that are in turn building blocks for logical circuits.

The Fastests Supercomputer: EXA FLOPS

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

SUPERCOMPUTER FRONTIER - HPE CRAY EX235A, AMD OPTIMIZED 3RD GENERATION EPYC 64C 2GHZ, AMD

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
Interconnect	Slingshot-11
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

QBit

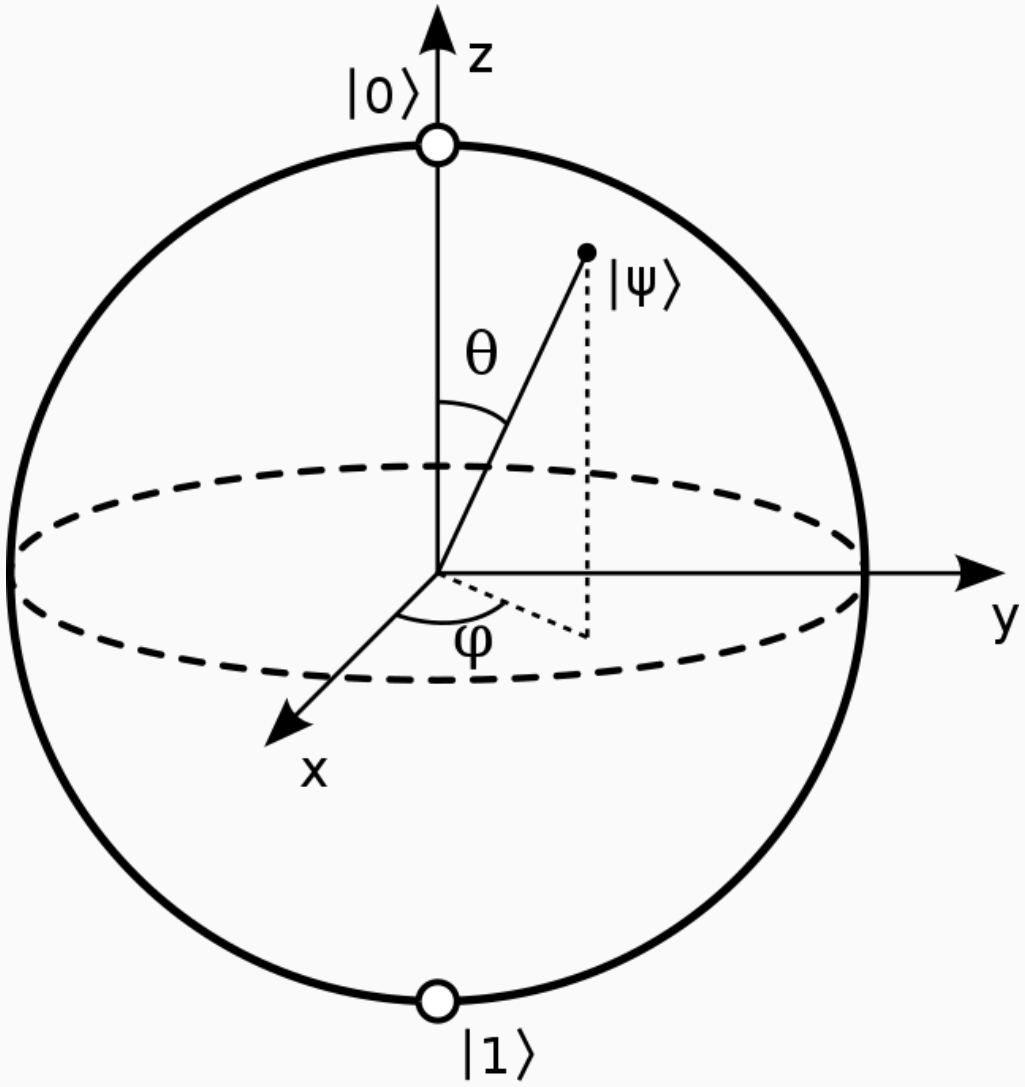


Figure 4: Source: nextplatform.com

Operations

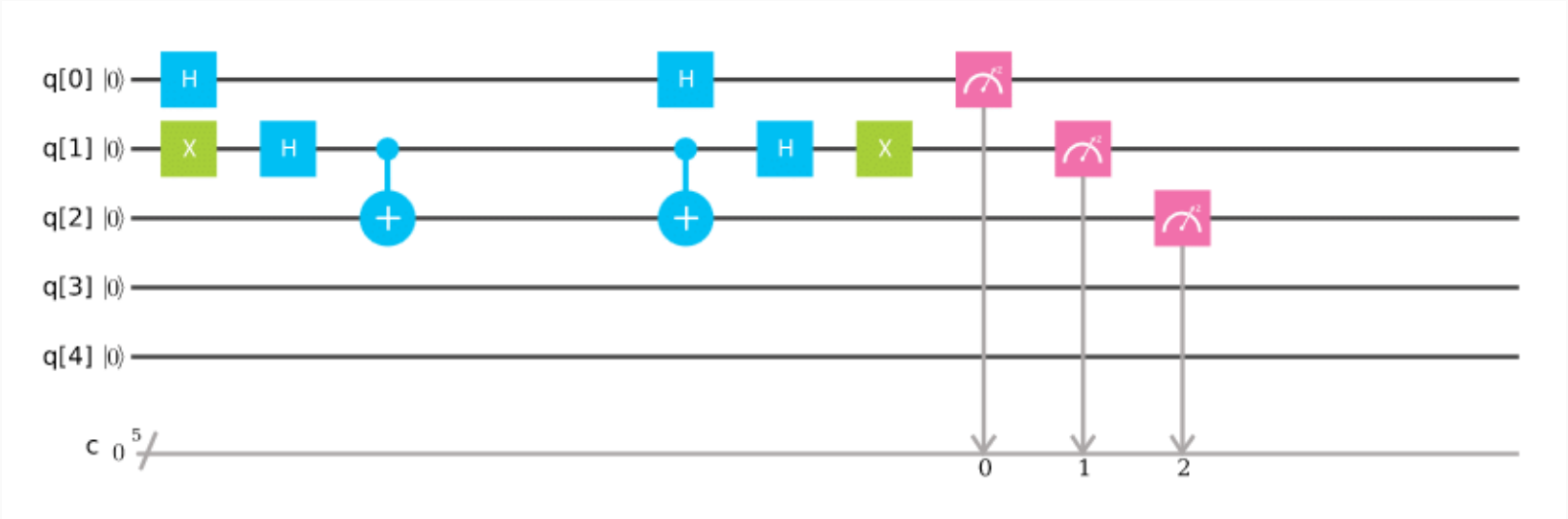
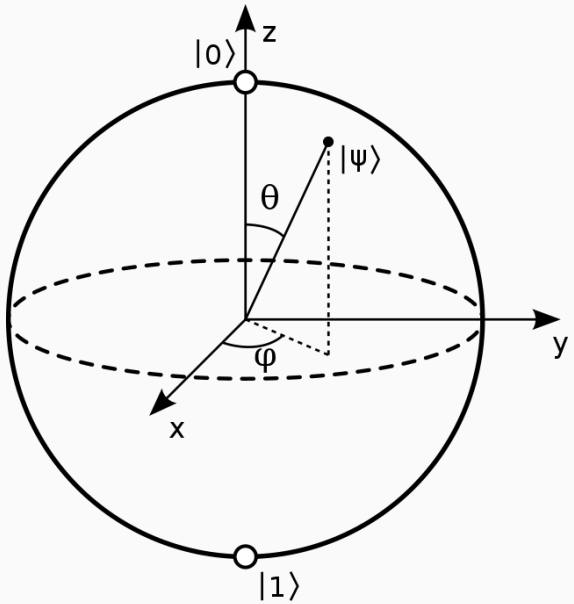


Figure 5: A quantum circuit: quantum gate operations on q-bits. Source: ibm.com

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

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

where

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

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.

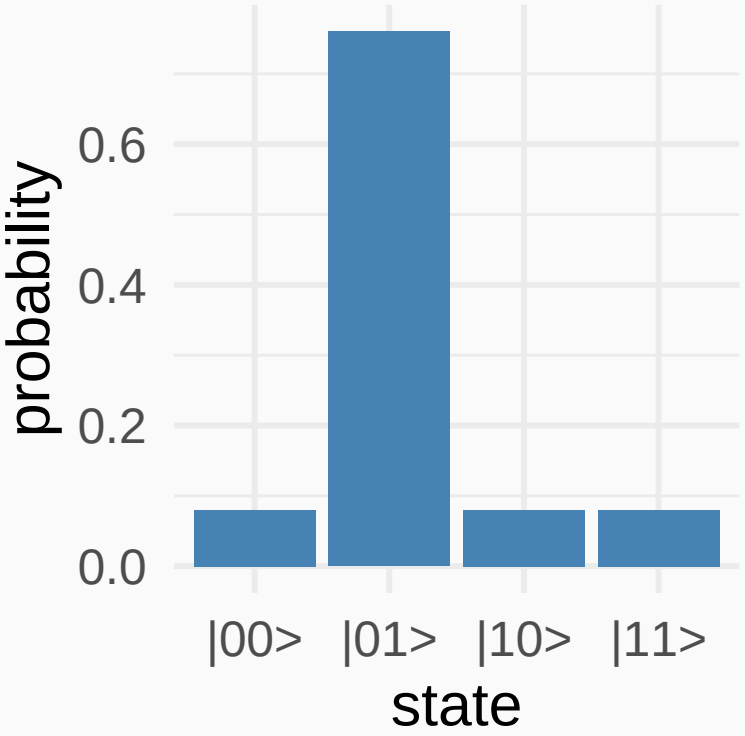
Example

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

$\frac{\sqrt{2}}{2} \, |01\rangle + \frac{\sqrt{2}}{2} \, |10\rangle$ 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

- qubit $\rightarrow$ 2 quantum states dimensions: $\alpha \left|0\right\rangle + \beta \left|1\right\rangle$

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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

D-Wave

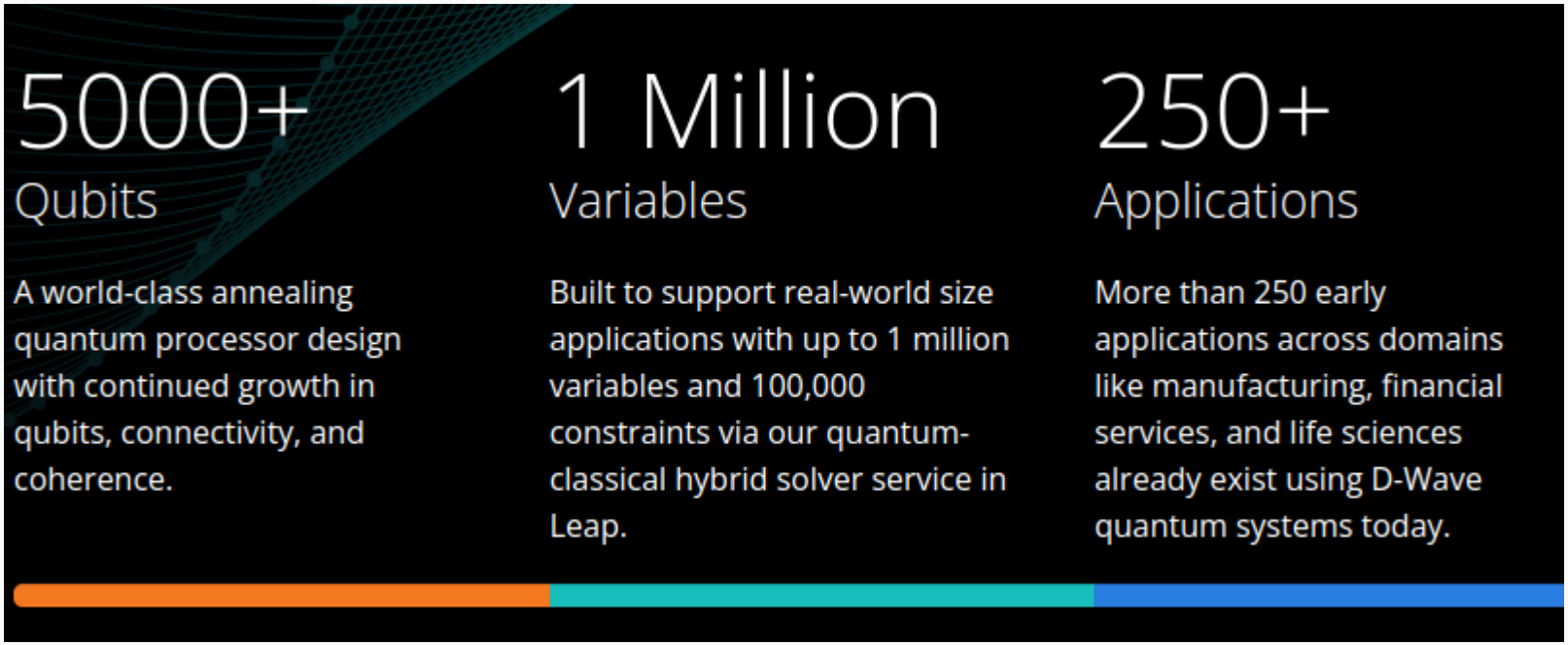

Figure 6: State of the art with D-Wave. Source: dwavesys.com

Banking application with D-Wave and Multiverse Computing

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

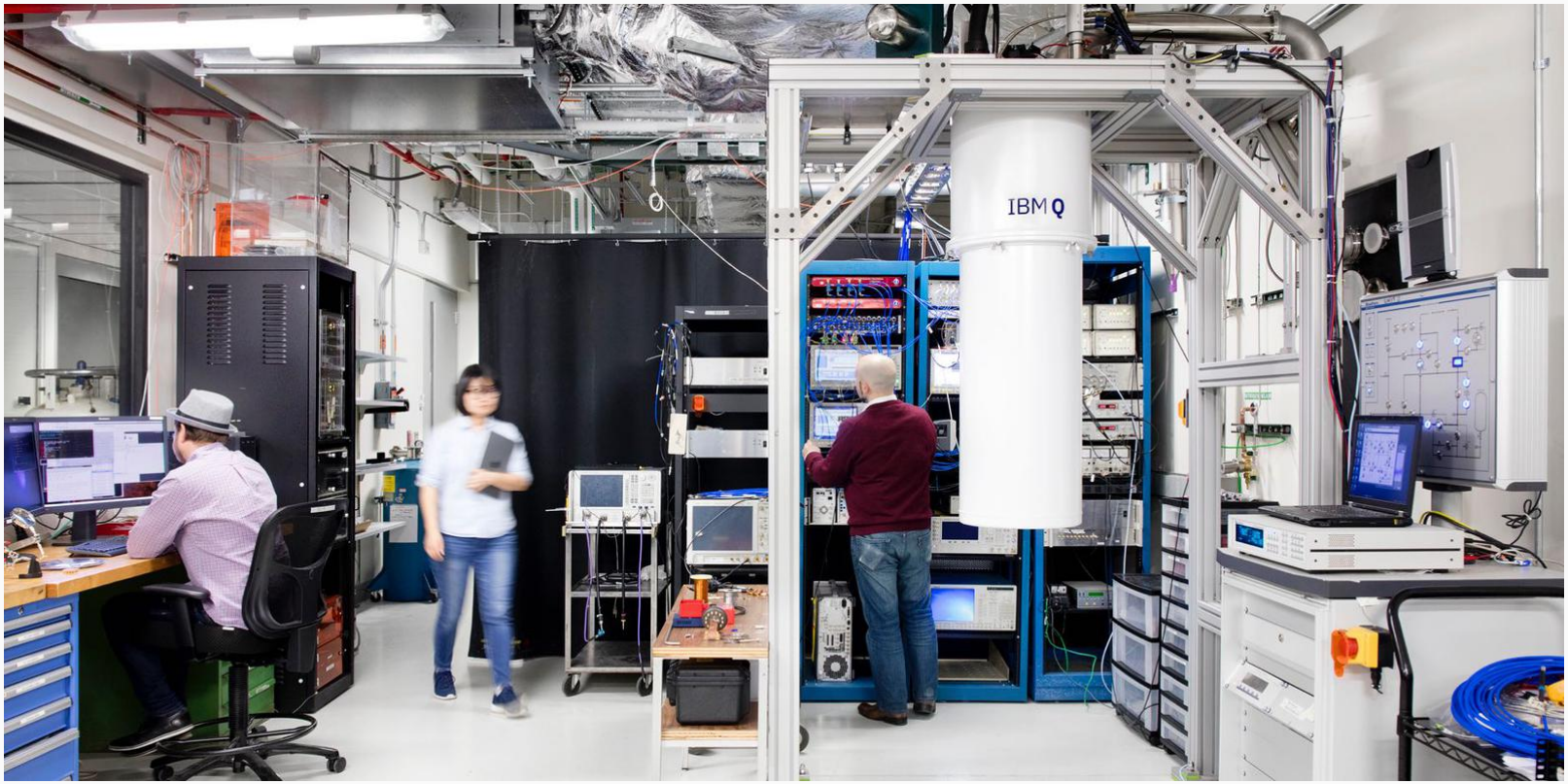

Figure 8: A quantum computer today. Source: ibm.com

Quantum Computing Achievements in Banking

Examples of banks's efforts

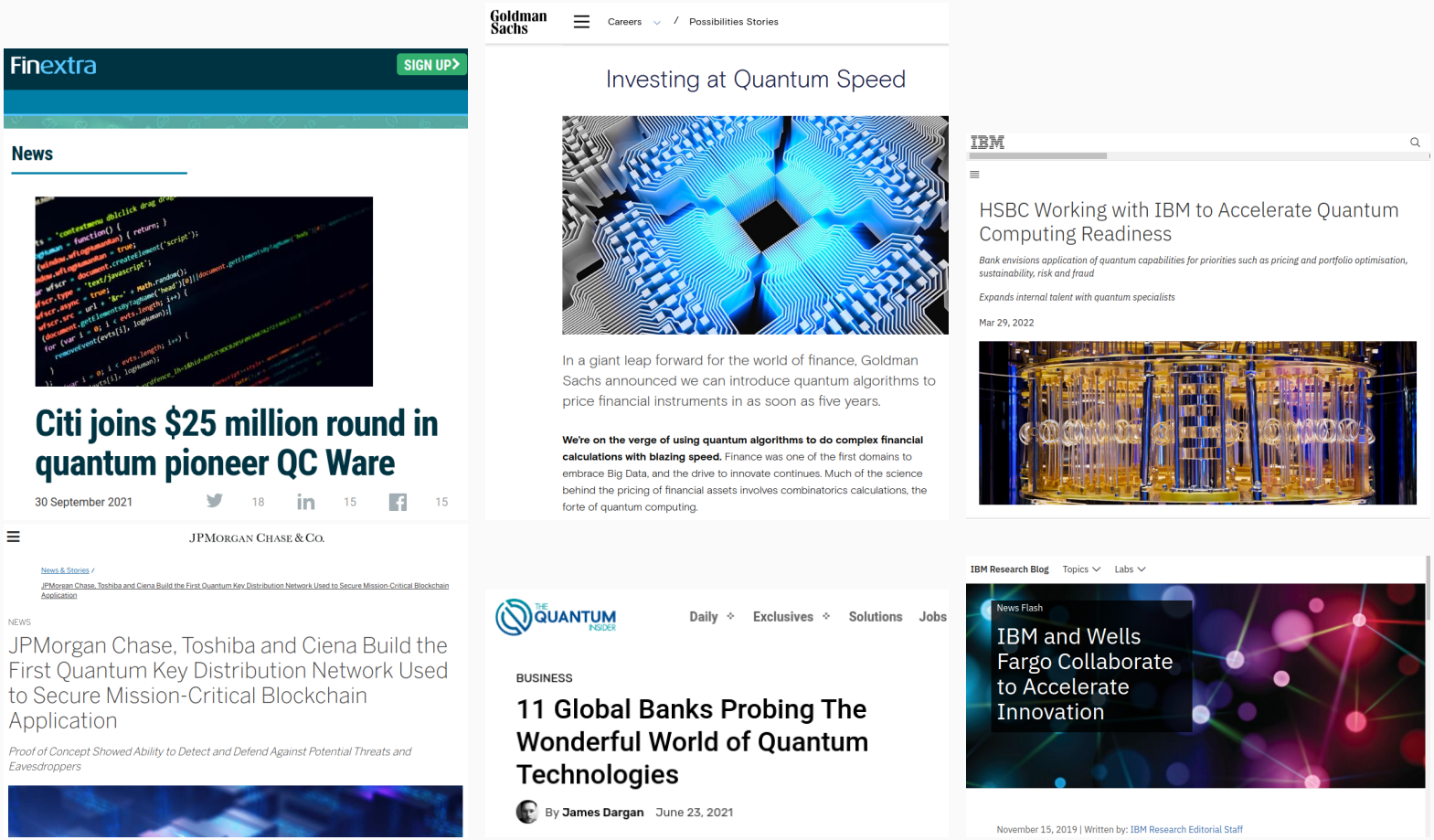

Figure 9: Sources: finextra.com, goldmansachs.com, ibm.com, and thequantuminsider.com

Some Real Results

- JPMC and IBM calculated prices for differnt options (European, path dependent, etc.) by Quantum Amplitude Estimation (similar to Monte-Carlo simulations)

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- 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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  1. portfolio optimization

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Resulting Advantages

quadratic to exponential speedup

- better risk management

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

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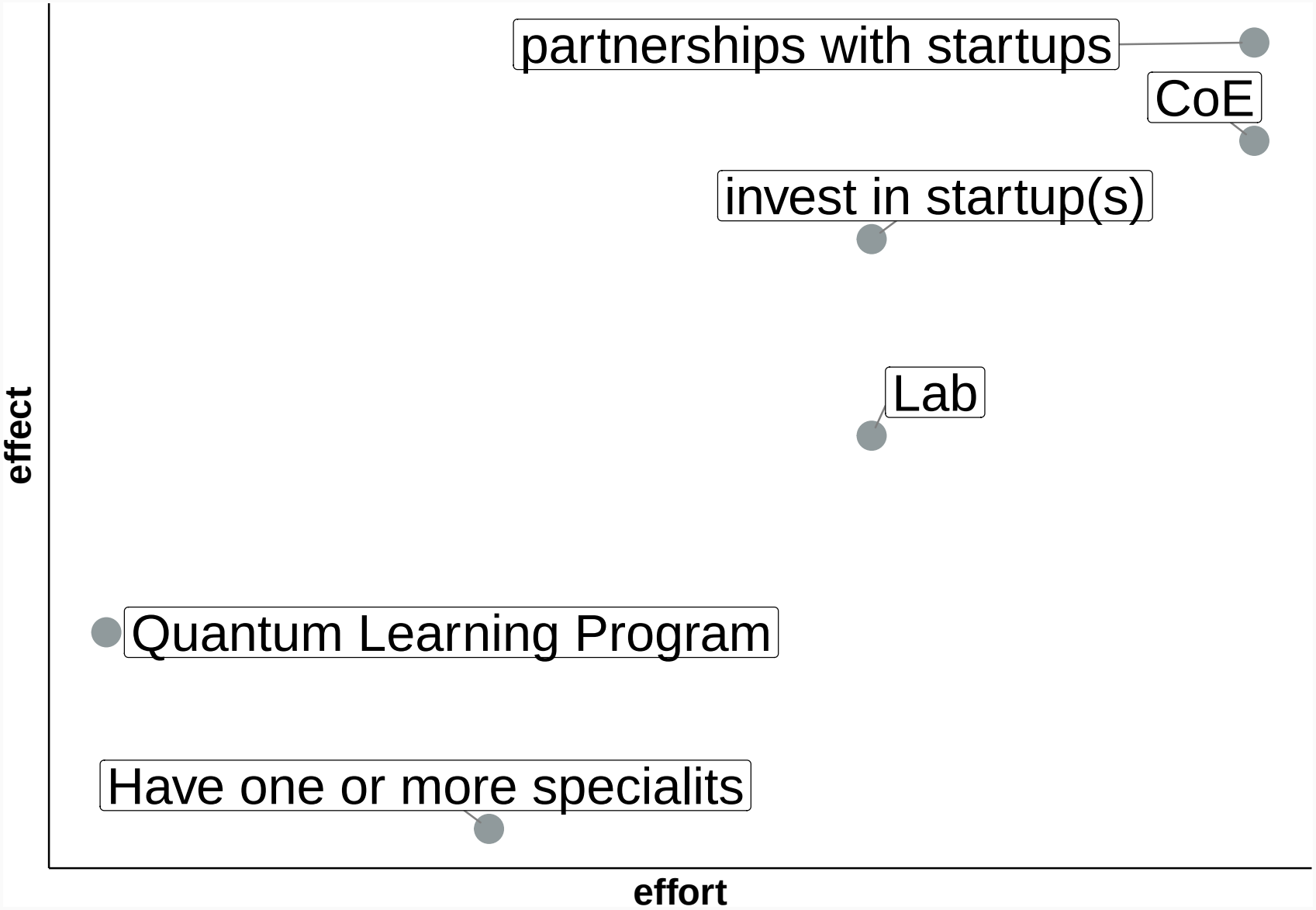
The Route to Quantum for the Banker

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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  - 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