Enterprise Software to accelerate the quantum revolution

NCCAVS 2020 Technical Symposium

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General Manager Asia
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OUTLINE

- WHAT IS QUANTUM COMPUTING?
- WHAT CAN QUANTUM COMPUTING DO?
- WHAT CAN ZAPATA DO FOR YOU?

THE EVOLUTION OF COMPUTERS

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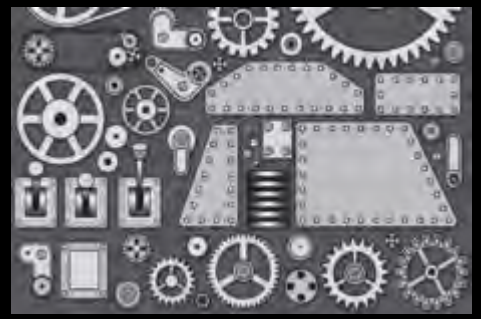
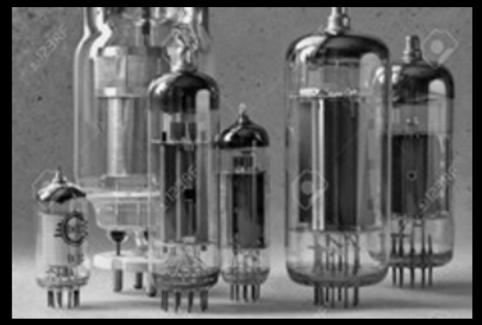
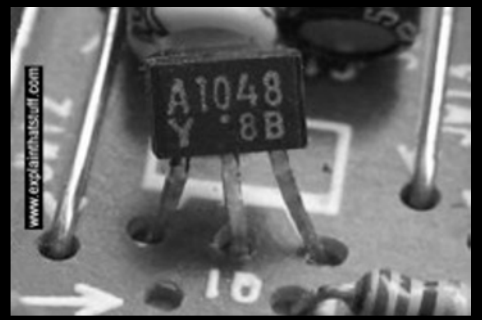
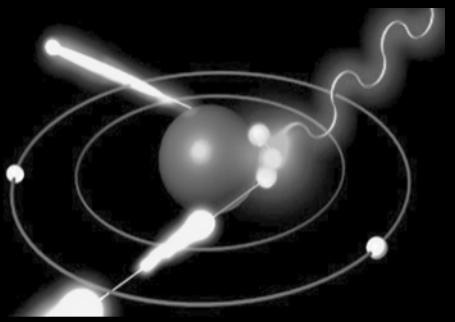
1300 BC-1950s	1940-1960s	1950s-present	2010s-present
Mechanical devices	**Vacuum tubes**	**Transistors**	**Quantum States**
			

THE EVOLUTION OF QUANTUM COMPUTERS

1920s-1990s

Primarily theoretical research, with limited physical experimentation

Theoretical breakthroughs in quantum physics by

- *Paul Dirac (1929),*
- *Richard Feynman (1981)*
- *Peter Shor (1994)*

2000s

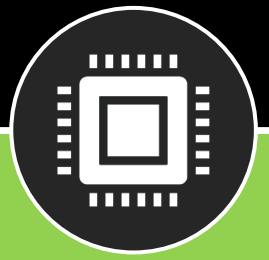
Establishment of fundamental mechanisms with physical machines

- *1 qubit (1999)*
- *1st 5-qubit computer (2000)*
- *Factoring 15 (2001)*
- *quantum byte (2005)*

2010s

Development of quantum processors and rudimentary quantum computers

- *A photonic quantum computer simulates hydrogen (2010)*
- *D-Wave develops the first commercially available quantum computer (2011)*



2016-2018

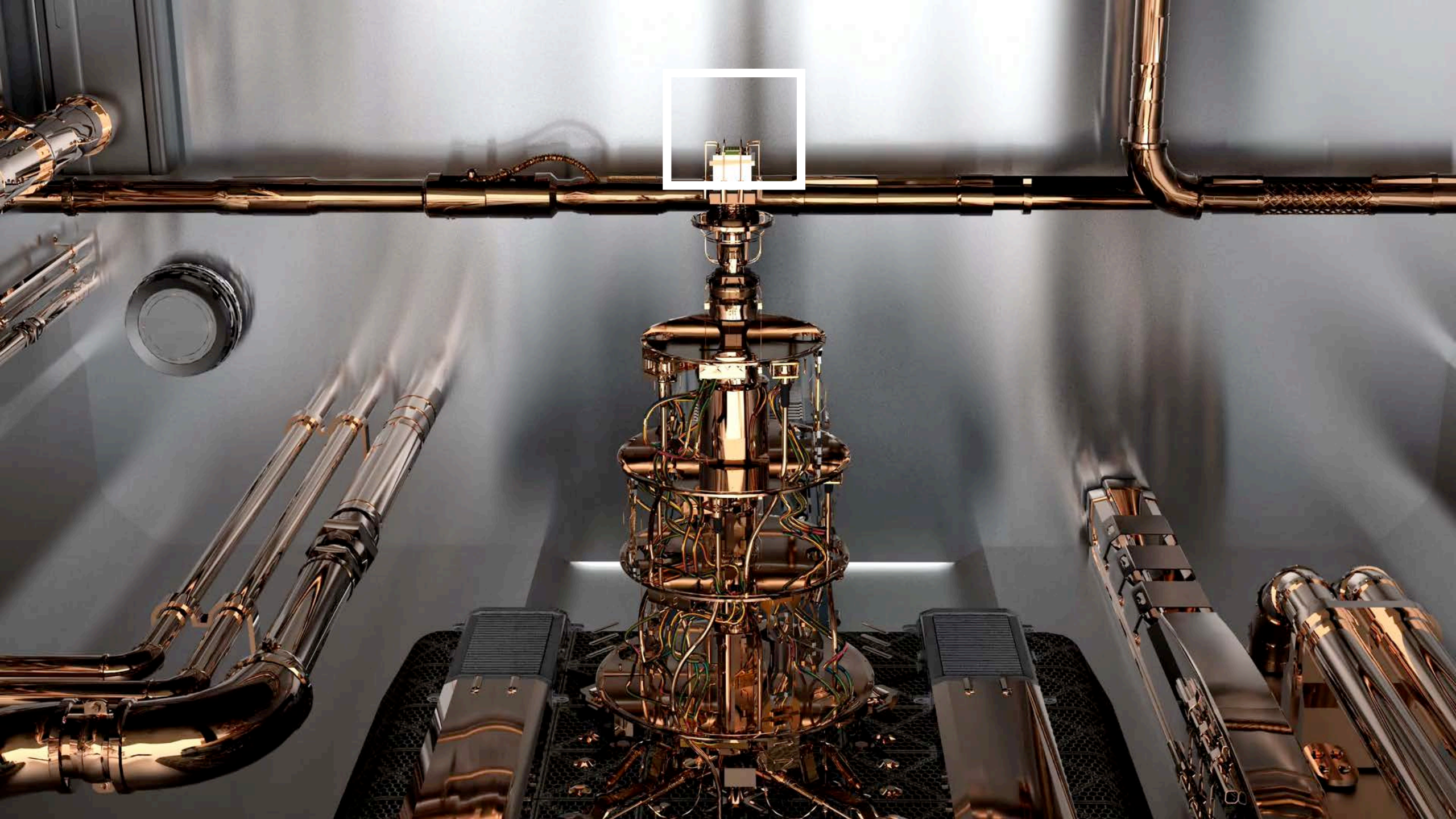
System-level engineering for practical quantum computers

Quantum hardware providers; D-Wave, IBM, Intel, Google, Rigetti and more; announces growing qubit count on their quantum machines

2019 and beyond

Production use of quantum computing systems to solve real-world problems

*Google proves **quantum advantage** (2019) and commercial applications are demonstrated to solve real-world problems*



COMPUTATION

FAULT-TOLERANT QUANTUM SPEEDUP

CLASSICAL COMPUTER

CLASSICAL COMPUTER FACTORING A 2048-BIT NUMBER:

- Best classical algorithm:

$\sim 10^{34}$ steps

- On a classical THz Computer (with a trillion operations per second):

~317 trillion years

QUANTUM COMPUTER

QUANTUM COMPUTER FACTORING A 2048-BIT NUMBER:

- Shor's quantum algorithm:

$\sim 10^{9}$ steps

- On a quantum MHz computer* (with a million operations per second):

~8 hours

* Fault-tolerant device with 4099 logical qubits

WE BELIEVE WE CAN SOLVE THE GREATEST PROBLEMS OF OUR TIME WITH QUANTUM.

FUNDAMENTAL DIFFERENCES

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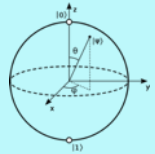
Component	Classical Computer	Quantum Computer
Information unit:	Bit	Quantum bit
Info storage:	Transistors	Superconductors/Ions
Info processing:	Logical gates	Quantum gates
Information unit equivalent:	2-sided coin 	Superposition 
Units working together:	No coordination 	Entanglement 

FUNDAMENTAL DIFFERENCES

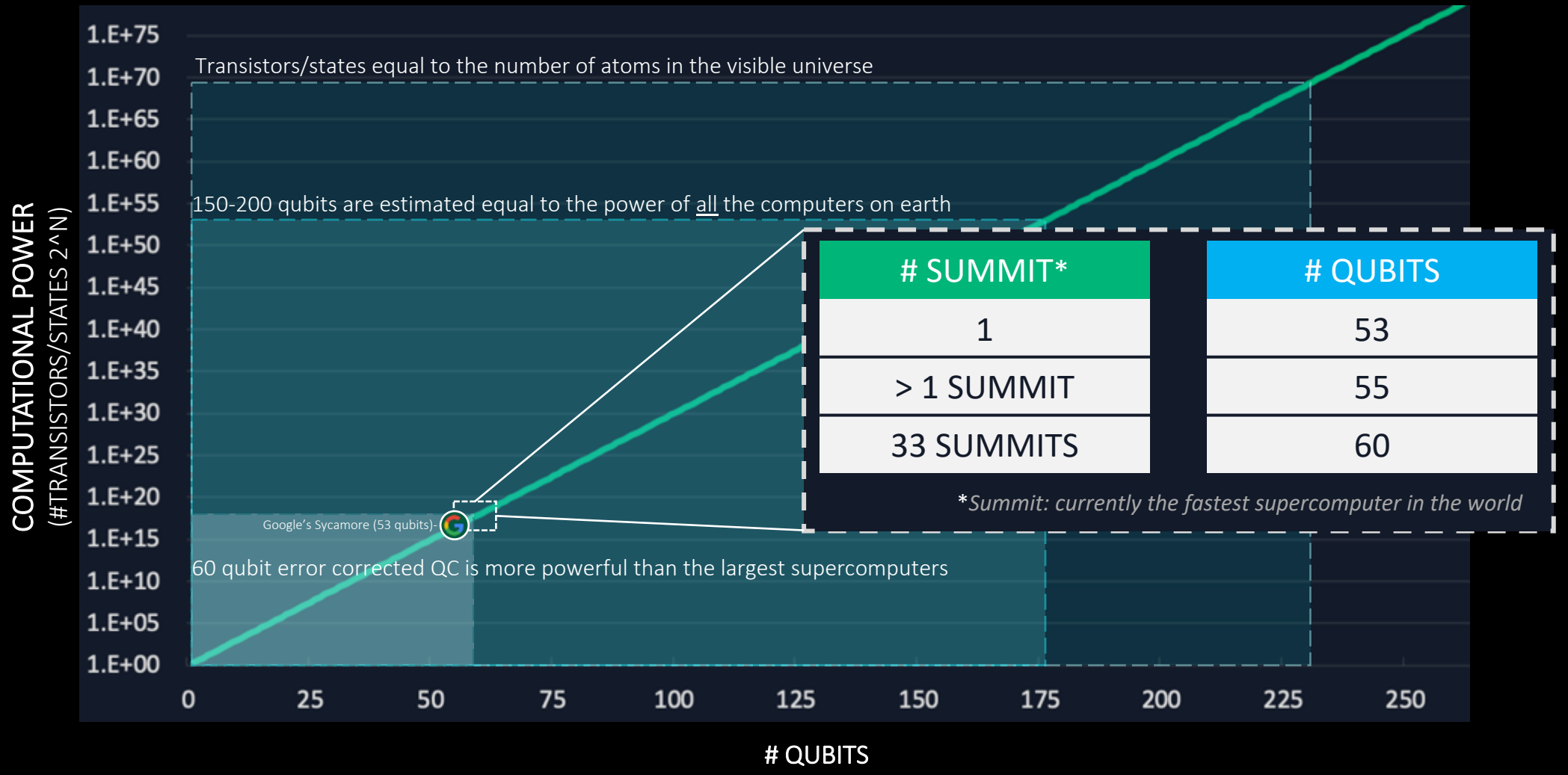
CLASSICAL COMPUTER A bit can be 0 or 1	QUANTUM COMPUTER A qubit can be 0 and 1
 	 2^1
00 01 10 11 	 2^2
000 001 010 011 100 101 110 111 	 2^3

Quantum computing power **doubles with each additional qubit!**

- 30 qubit error corrected QC is more powerful than the largest supercomputers
- Approx. 150-200 qubits is equal to the power of all the computers on earth
- 2^{300} is larger than the number of atoms in the visible universe*

* note: common est. 2^{265}

THE EVOLUTION OF QUANTUM COMPUTERS



HARDWARE PLATFORMS

		STARTUPS	CORPORATE
GATE-BASED	SUPERCONDUCTING CIRCUITS	rigetti, qci, bleximo, SeeQC	Google, IBM, Alibaba Group, intel
	TRAPPED IONS	IONQ, AQT	Honeywell
	SILICON QUBITS	SILICON QUANTUM COMPUTING	intel
	TOPOLOGICAL QC		Microsoft
	NEUTRAL ATOMS & PHOTONICS	ATOM COMPUTING, ORCA Computing, PsiQ	
ANNEALING	DIGITAL (CMOS CIRCUITS)		HITACHI, FUJITSU
	QUANTUM (SUP CIRCUITS)	D-Wave The Quantum Computing Company, QILIMANJARO	
NON-UNIVERSAL	NEUTRAL ATOMS & PHOTONICS	QuEra, ColdQuanta, XANADU	
SIMULATORS	HPC		aws, Atos, Microsoft
	DEDICATED		TOSHIBA

SIGNIFICANT ARCHITECTURAL CHALLENGES OF DOING QUANTUM COMPUTING.

Framework compatibility

Deployment on computing resources

Data management

Reproducibility

WE'RE AT AN INFLECTION POINT

2019 and beyond

Production use of quantum computing systems to solve ***real-world problems***

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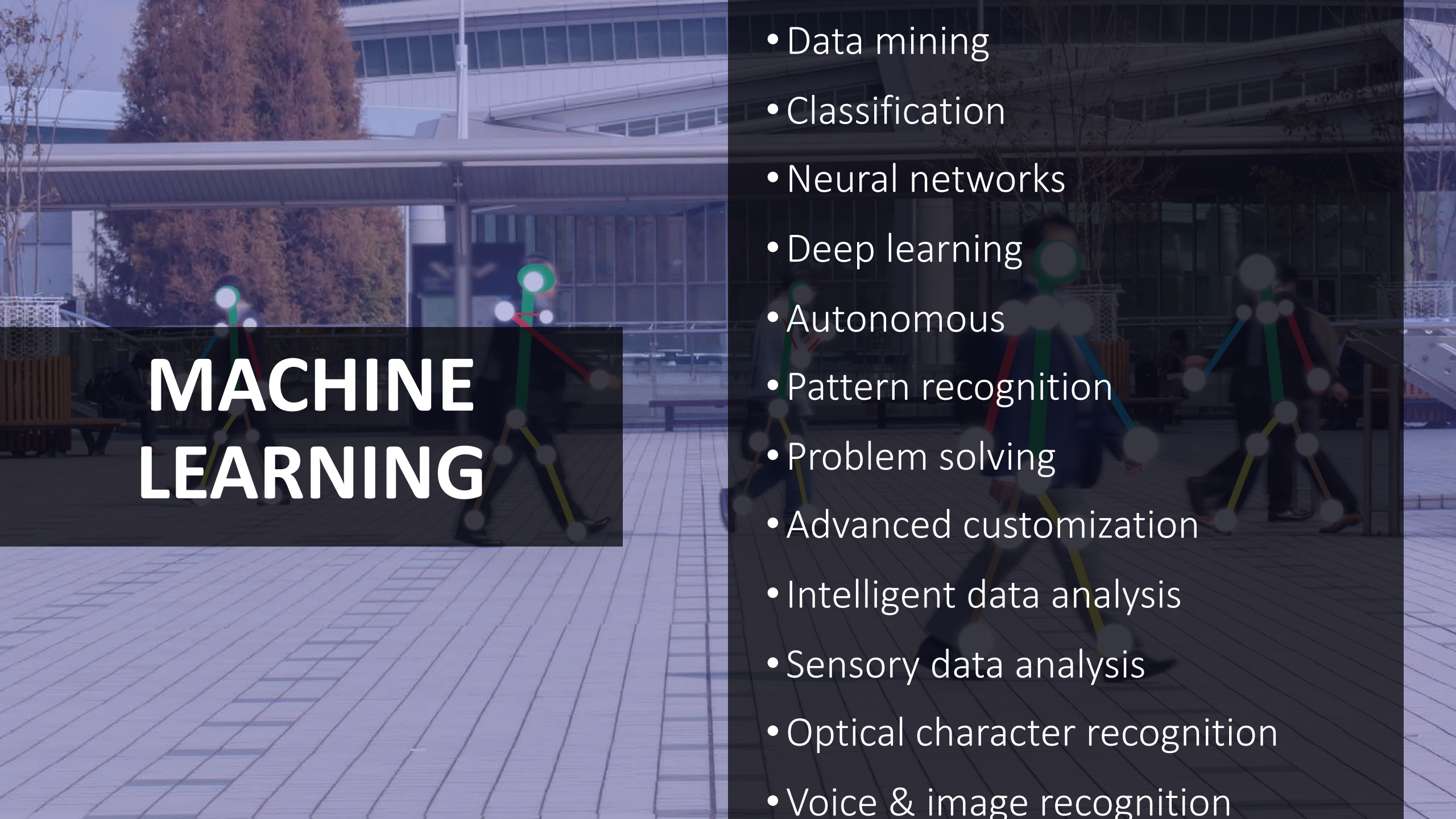
What can quantum computing do?

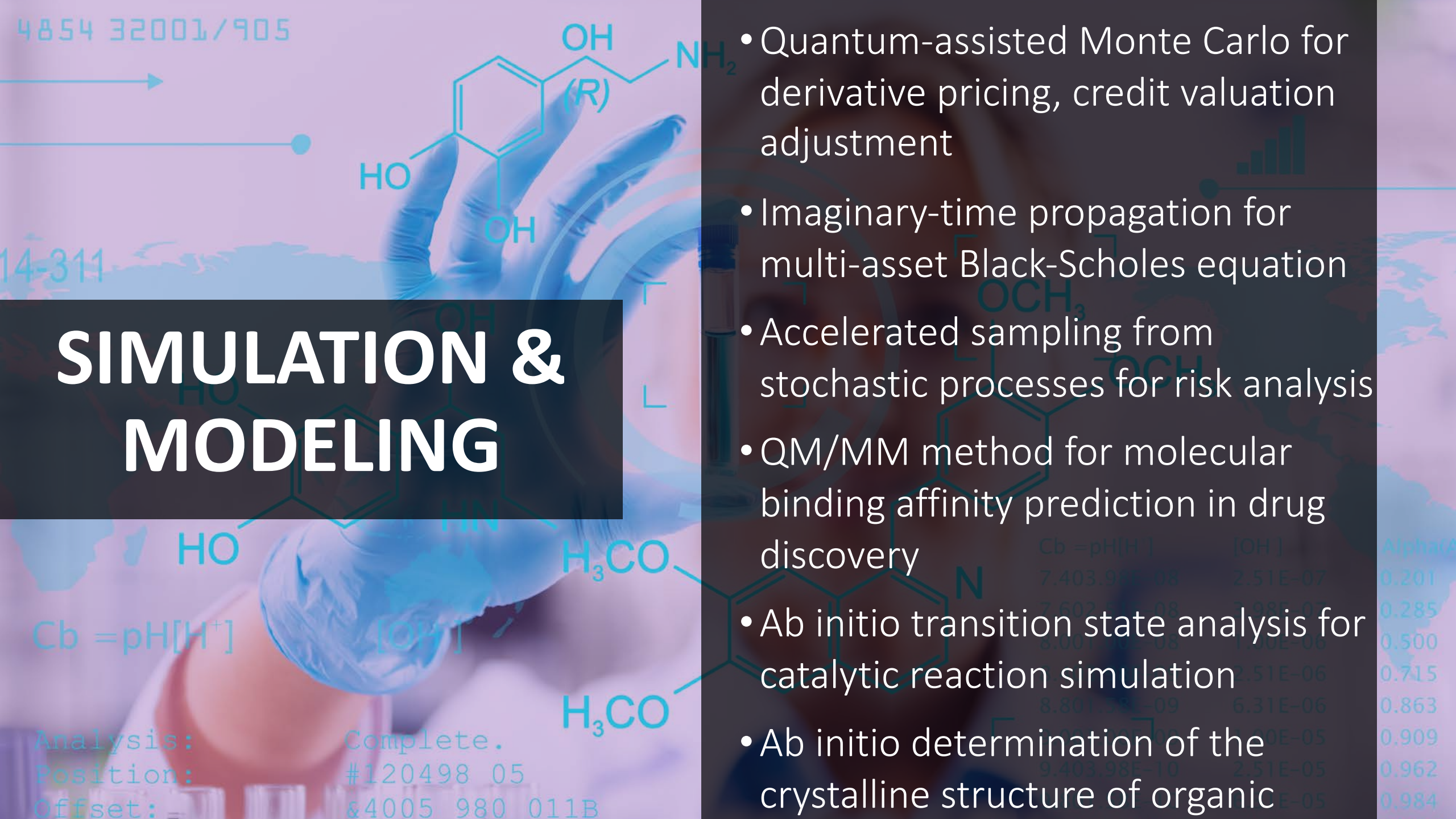
OPTIMIZATION

- Sampling from risk-neutral probability measure for asset pricing
- Portfolio optimization by quantum annealing or gate-model quantum heuristics
- Improved asset allocation by quantum-inspired optimization
- Optimal healthcare resource allocation e.g. patient-treatment matching and priority scheduling of doctors and therapies
- Molecular structure analysis by combinatorial optimization
- Protein design using unconstrained



MACHINE LEARNING

- Data mining
- Classification
- Neural networks
- Deep learning
- Autonomous
- Pattern recognition
- Problem solving
- Advanced customization
- Intelligent data analysis
- Sensory data analysis
- Optical character recognition
- Voice & image recognition



SIMULATION & MODELING

- Quantum-assisted Monte Carlo for derivative pricing, credit valuation adjustment
- Imaginary-time propagation for multi-asset Black-Scholes equation
- Accelerated sampling from stochastic processes for risk analysis
- QM/MM method for molecular binding affinity prediction in drug discovery
- Ab initio transition state analysis for catalytic reaction simulation
- Ab initio determination of the crystalline structure of organic

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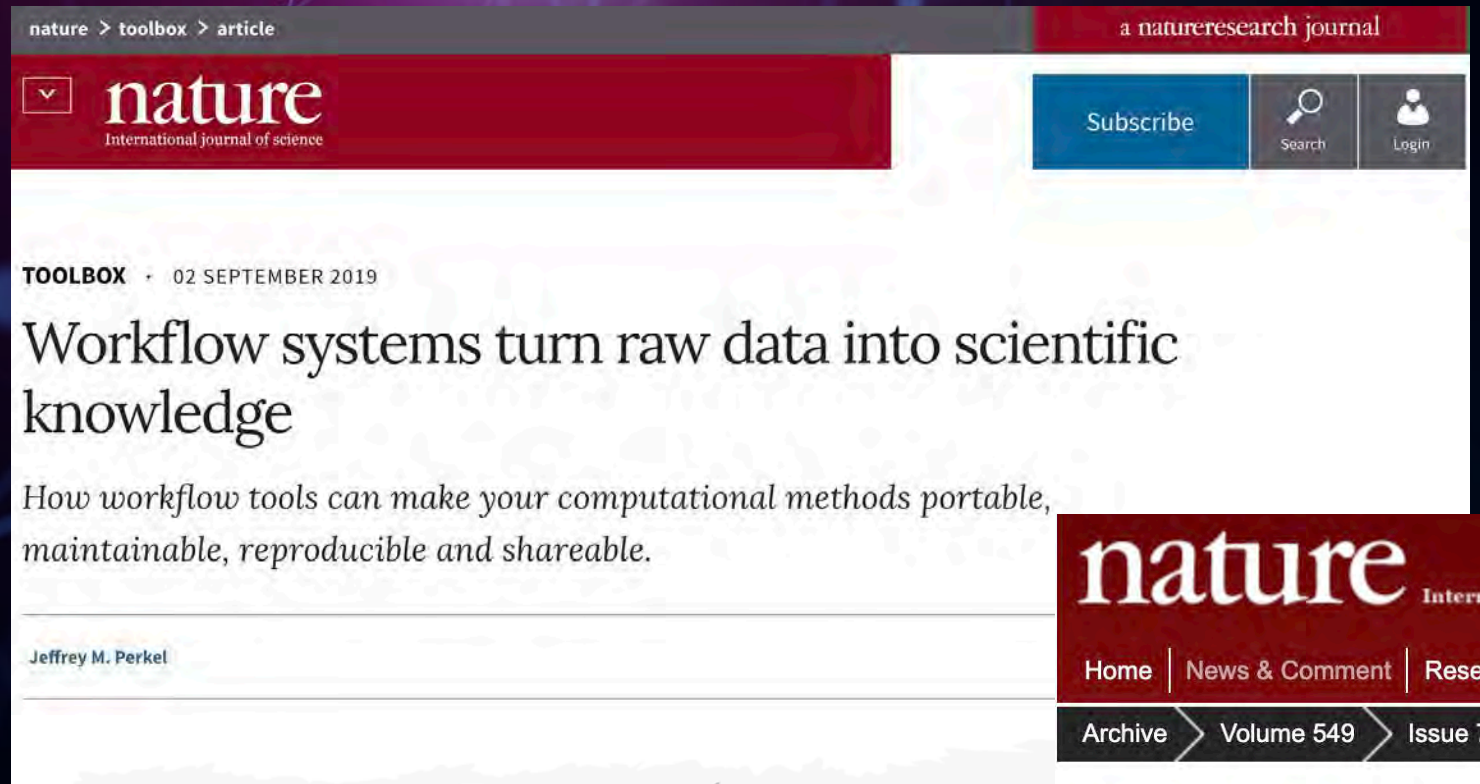
Workflow Management?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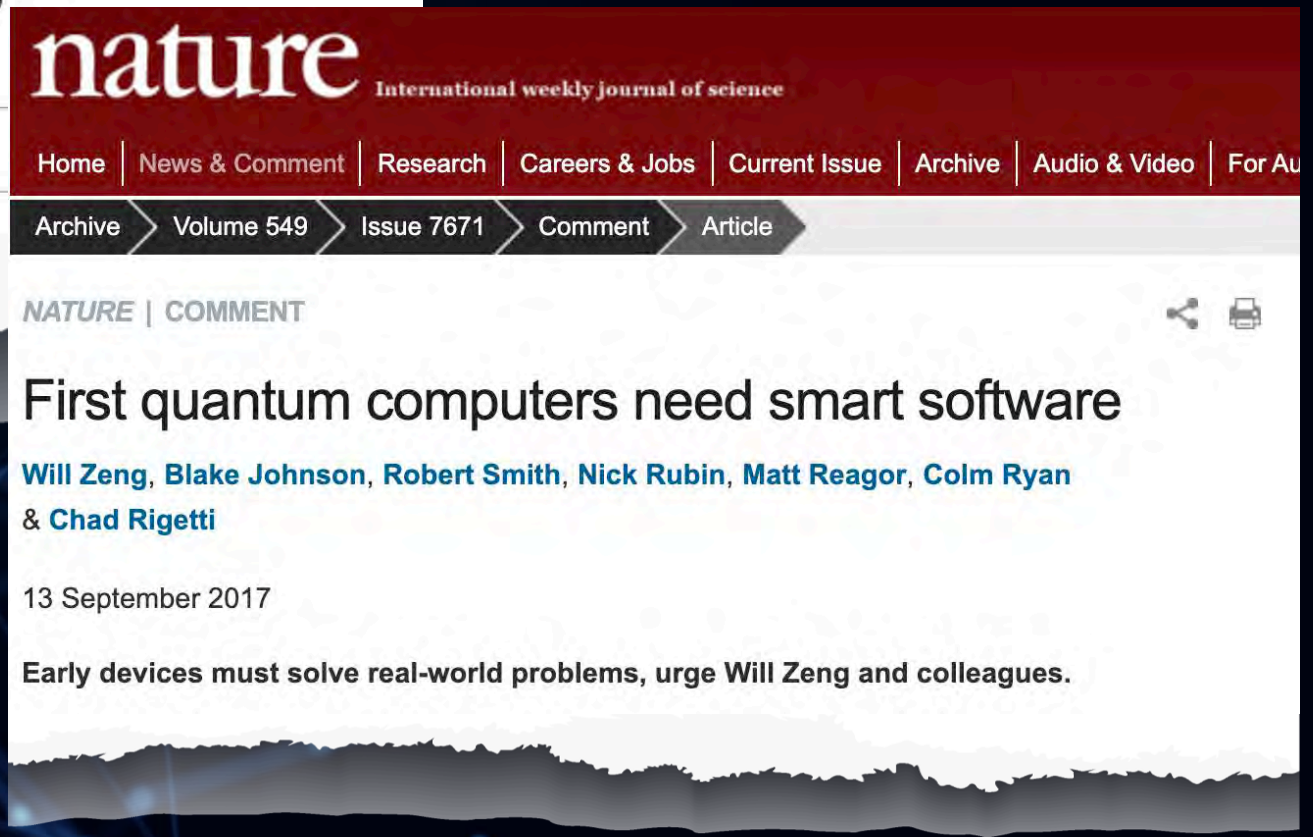
Jeffrey M. Perkel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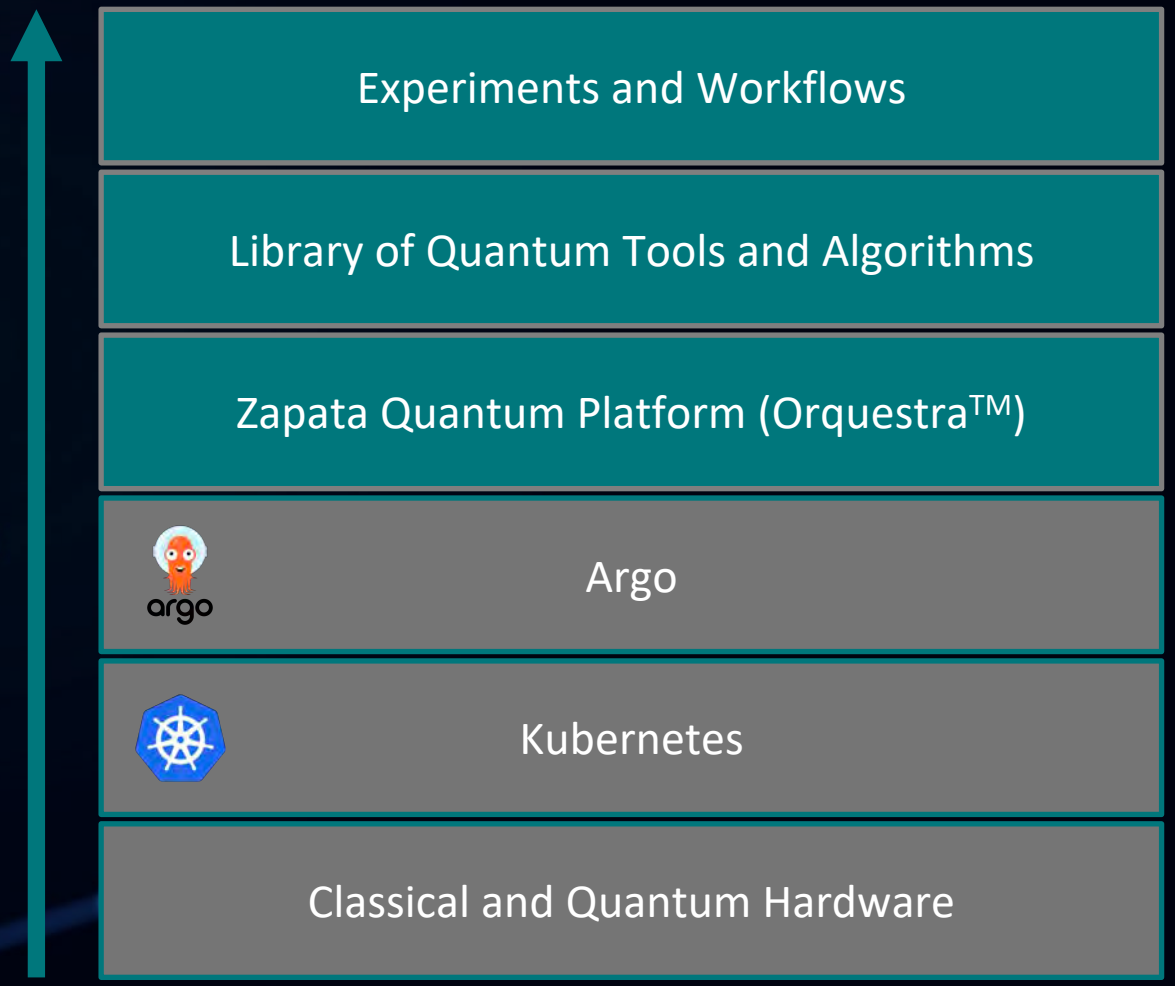
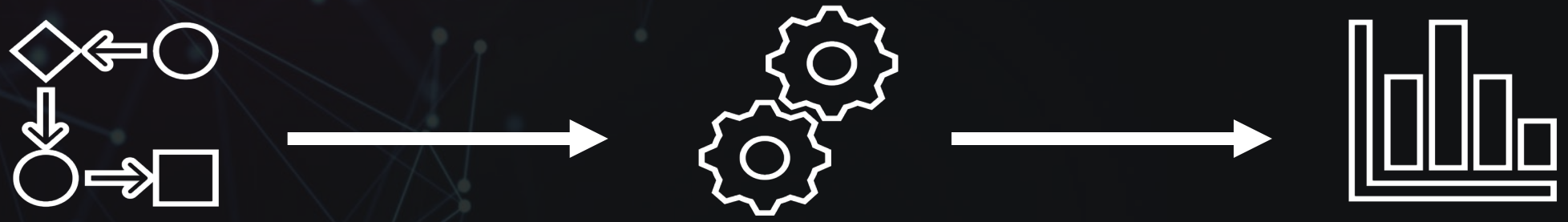
First quantum computers need smart software
Will Zeng, Blake Johnson, Robert Smith, Nick Rubin, Matt Reagor, Colm Ryan & Chad Rigetti
13 September 2017
Early devices must solve real-world problems, urge Will Zeng and colleagues.

Adding Quantum to the Stack

- Code to translate between circuit representations
- Interfaces to common hardware and simulators
- An extensible library of quantum algorithms
- Pre-defined schemas to structure communication between the tasks of a workflow



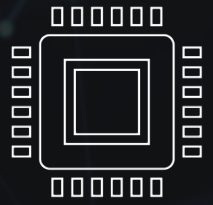
WE CAN SOLVES THESE CHALLENGE WITH A WORKFLOW MANAGEMENT TOOL



RAPID REITERATION

HPC

GPU



QUANTUM

Companies approach these today with different techniques but run into similar bottlenecks

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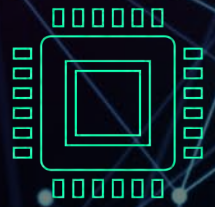
HPC

GPUs



Application specific (ex: FPGAs)

Novel architectures (ex: quantum)

Framework compatibility

Deployment on computing resources

Data management

Reproducibility

Orquestra™ : workflow management tool

Open source components

. . .

Proprietary components

Your organization

. . .

Workflows

Orquestra™ command-line interface (VSCode extension)

Orquestra™ Quantum Engine (OQE)

Orquestra™ Data Correlation Service (ODCS)

Visualization

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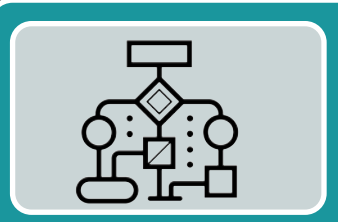
Benefits of defining workflow schema

The schemas express fundamental concepts in quantum computing and enable the development of **modular cross-platform tools**.

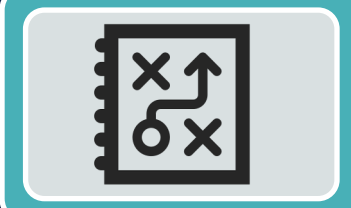
- ✓ Compile time debugging
- ✓ Smart visualizations
- ✓ Predefined function parameters for custom code and algorithms
- ✓ Accelerated internal development cycle and experimentation

Summary

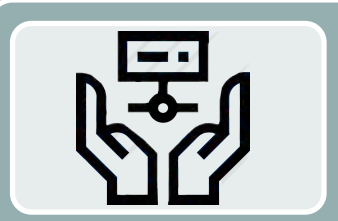
Zapata is building a **toolset** to help accelerate the field of quantum information science.



We are using it to meet needs of customers in industry who want custom **workflows** that solve commercial problems.

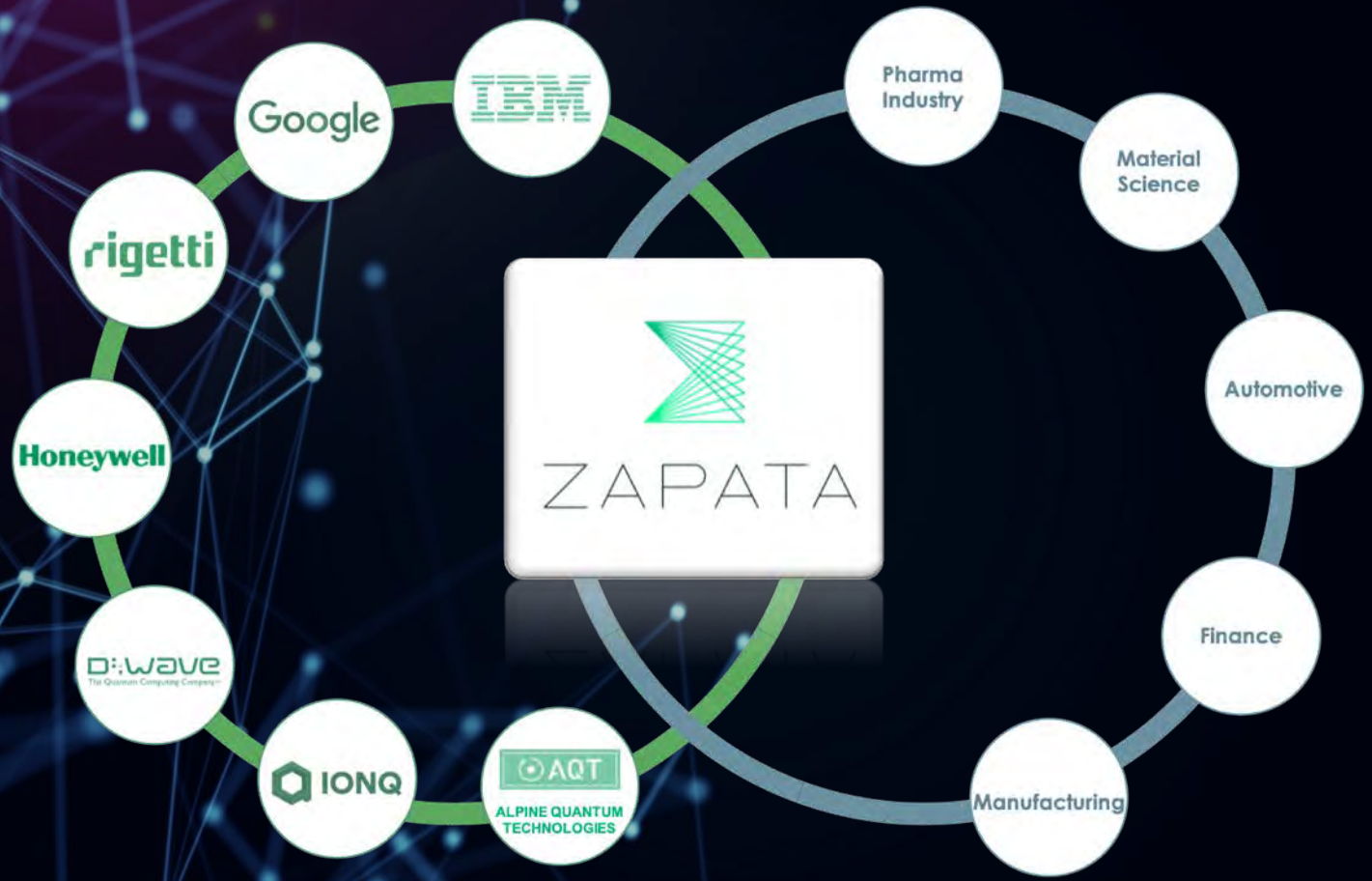


Our customer focused quantum scientists face many of the **same challenges** as the quantum scientists in academia.



Zapata will be making these **tools available** to quantum information scientists in a limited private beta soon with plans for a larger future launch.

Zapata Computing connects industry leaders to a new era of computing.



Together, we will solve the toughest problems.

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About Zapata Computing:

THE LEADER IN QUANTUM COMPUTING ALGORITHMS

ZAPATA

>> ~35 people, with 15 PhDs

>> 4 locations: Boston, Toronto, Europe, Japan

>> Fortune 100 customers

>> $25m+ in funding

>> Harvard spin-off

>> 30+ proprietary algorithms

>> founding team behind the invention of VQE

>> record for largest number factored on a quantum computer

>> over 20,000+ academic citations of our papers in quantum computing

>> the company quantum hardware providers trust

Atos Google Microsoft

Honeywell D-Wave The Quantum Computing Company™

rigetti IBM

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Thank You!

Reach out and schedule a demo:

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