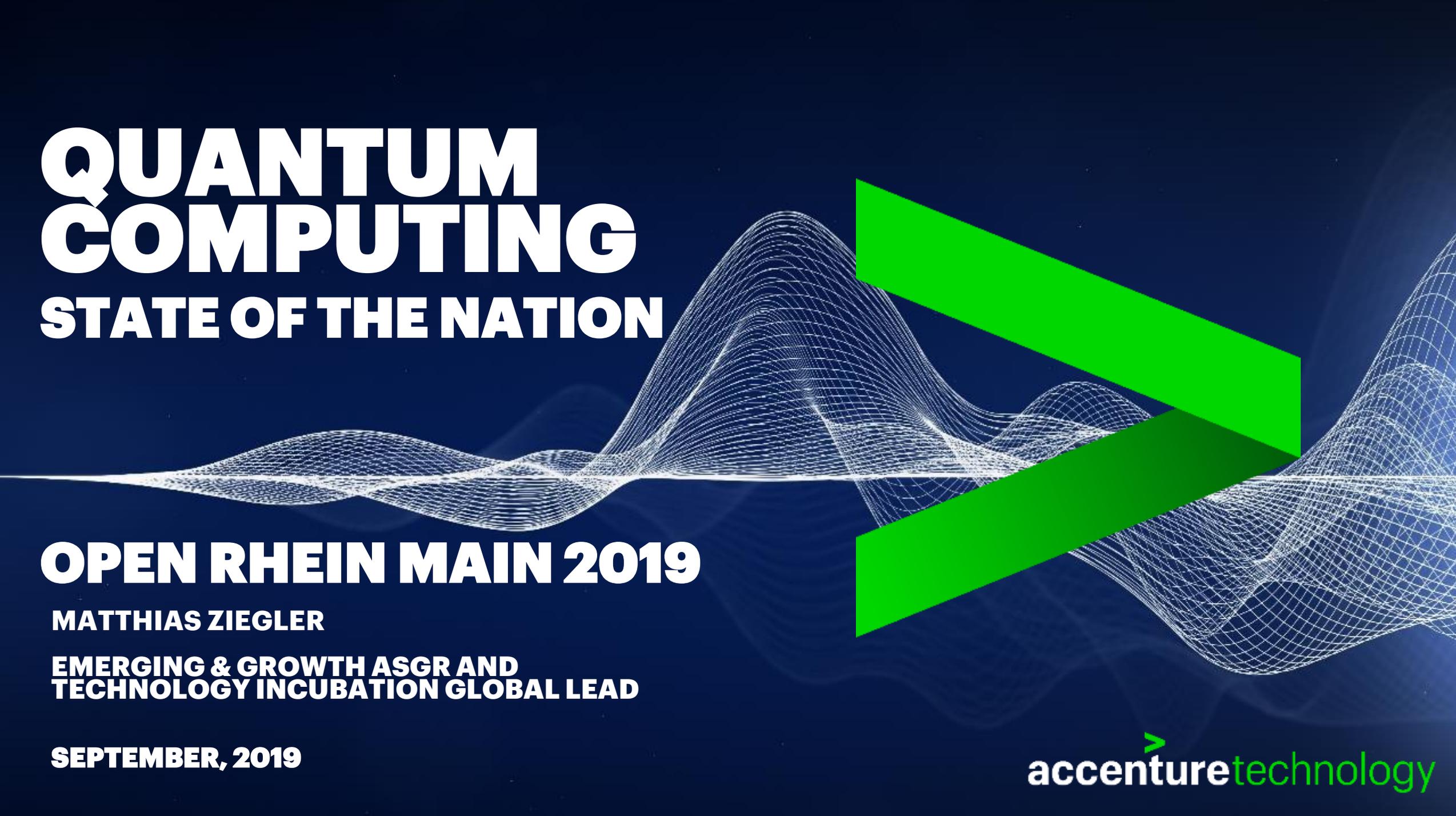


# QUANTUM COMPUTING STATE OF THE NATION



**OPEN RHEIN MAIN 2019**

**MATTHIAS ZIEGLER**

**EMERGING & GROWTH ASGR AND  
TECHNOLOGY INCUBATION GLOBAL LEAD**

**SEPTEMBER, 2019**

 **accenture**technology

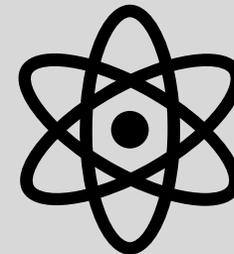
# BEYOND ONES AND ZEROS

**“WE ARE CURRENTLY IN THE  
MIDST OF A **SECOND QUANTUM  
REVOLUTION**:**

**THE FIRST GAVE US **NEW RULES  
THAT GOVERN PHYSICAL REALITY.****

**THE SECOND WILL **TAKE THESE  
RULES AND USE THEM TO  
DEVELOP NEW TECHNOLOGIES.**”**

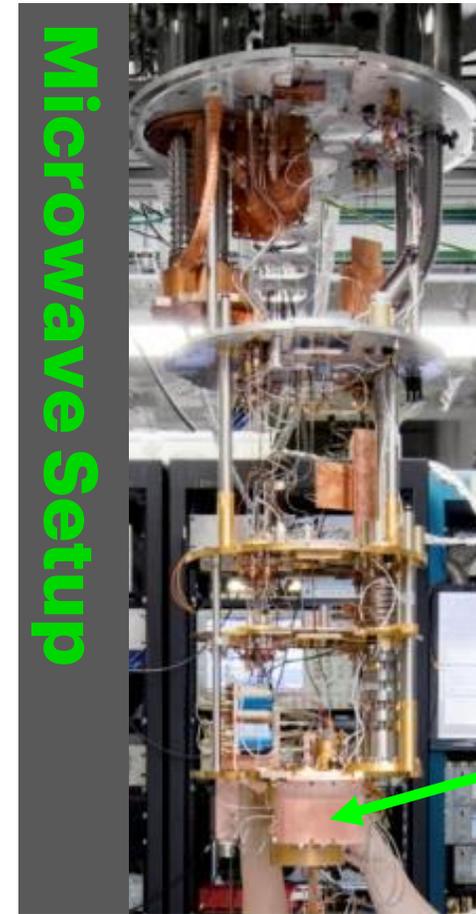
**JONATHAN P. DOWLING**



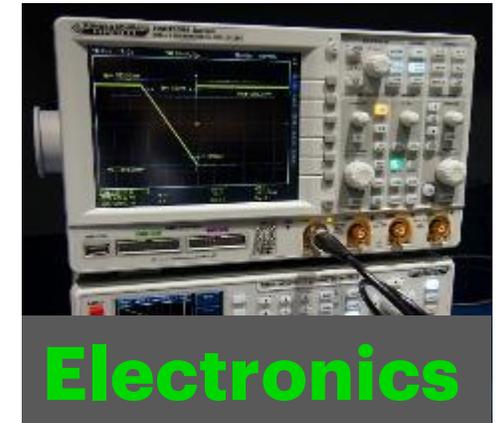
# TAMING QUANTUM PHYSICS – APPLICATION: QUANTUM COMPUTER ON PREMISE AND CLOUD



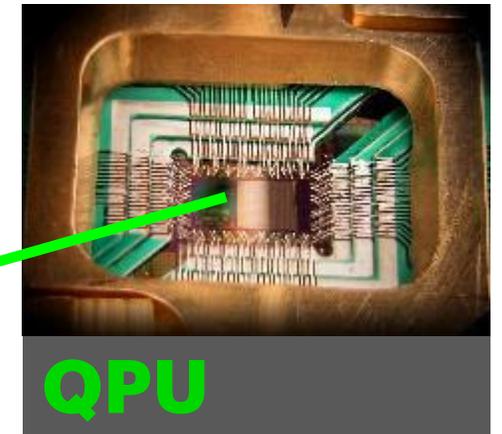
Dilution Refrigerator



Microwave Setup



Electronics

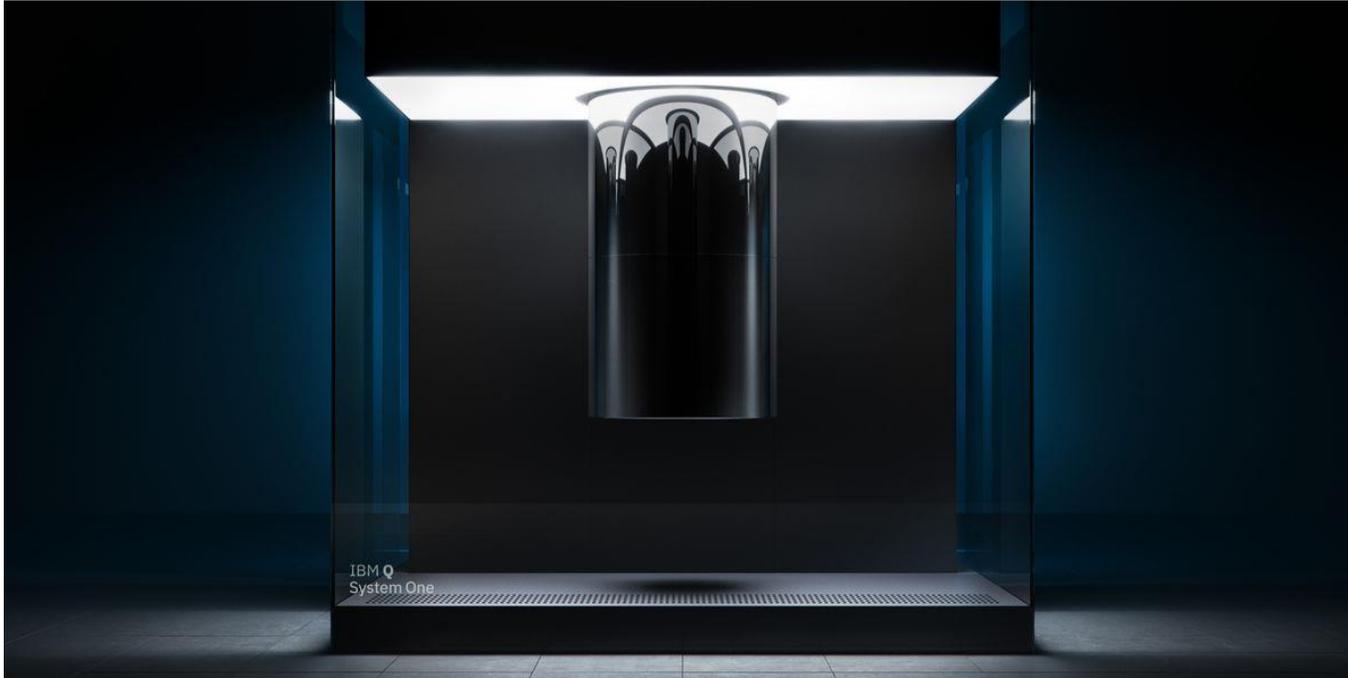


QPU

**cooler than outer space (2.6 K  $\approx$  -270°C): <0.1 K, fast electronics (GHz), the size modern transistors (10 nm)**

# TAMING QUANTUM PHYSICS – APPLICATION: FIRST COMMERCIAL QUANTUM COMPUTING SYSTEMS

## IBM Q System One



Gate QC: 20 High Fidelity Qubits

## D-Wave 2000Q



Annealer: 2000 Qubits

# TAMING QUANTUM PHYSICS - VISION: CLASSICAL **SHORTCUT** BY A **QUANTUM DETOUR**

**CLASSICAL**



**PROBLEM**



**QUANTUM  
TRANSLATION**

**QUANTUM**



**ALGORITHM  
AT WORK**



**QUANTUM  
SOLUTION**

**CLASSICAL**



**SOLUTION**

# PERSPECTIVES ON SOLVING PROBLEMS WITH QUANTUM ADVANCED ANALYTICS



**SIMULATION**



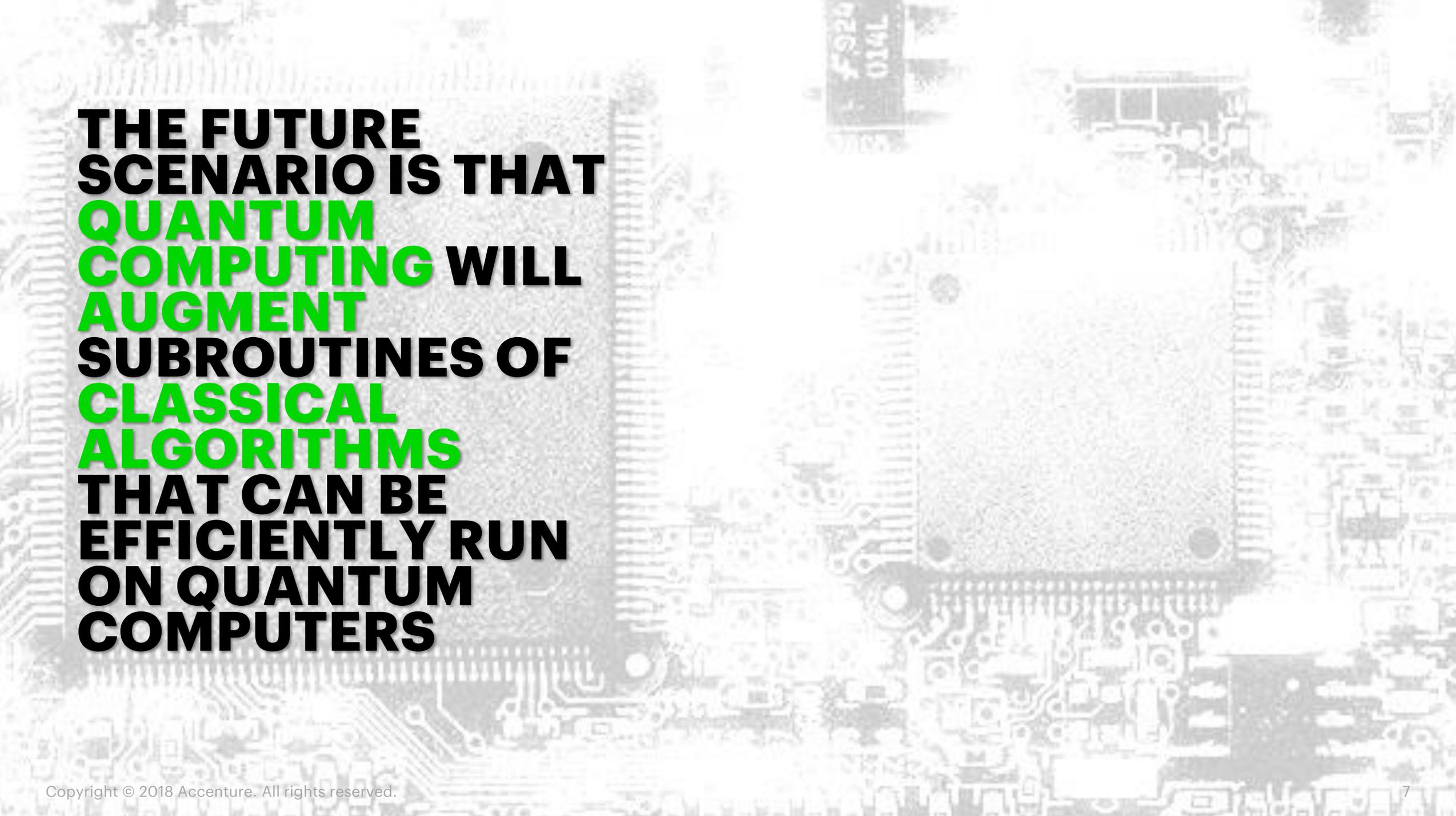
**OPTIMIZATION**



**CRYPTOGRAPHY**



**DATA ANALYSIS  
MACHINE LEARNING**



**THE FUTURE  
SCENARIO IS THAT  
QUANTUM  
COMPUTING WILL  
AUGMENT  
SUBROUTINES OF  
CLASSICAL  
ALGORITHMS  
THAT CAN BE  
EFFICIENTLY RUN  
ON QUANTUM  
COMPUTERS**



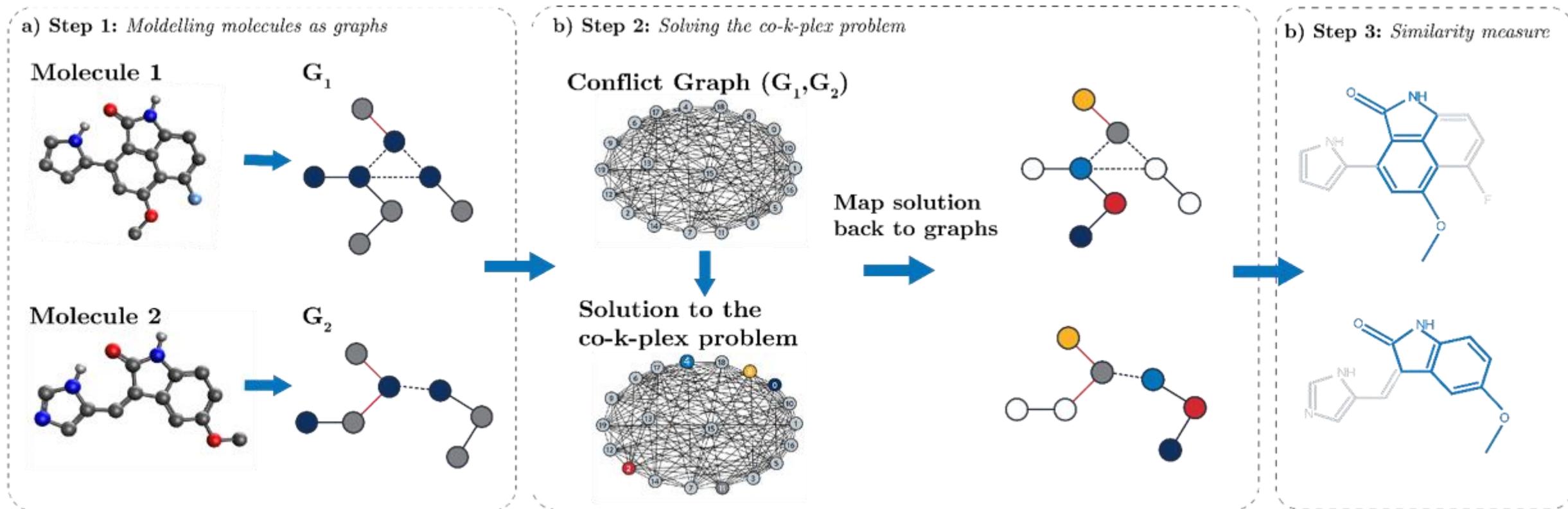
**BIG RACKS IN THE BASEMENT?  
SPINNING HEADS ON THE FLOORS ABOVE?  
YOU FOUND A PLACE WITH QUANTUM  
COMPUTING POTENTIAL**

## Life Sciences

# ACCELERATING DRUG DISCOVERY WITH QUANTUM COMPUTING



# GRAPH BASED MOLECULAR SIMILARITY METHOD



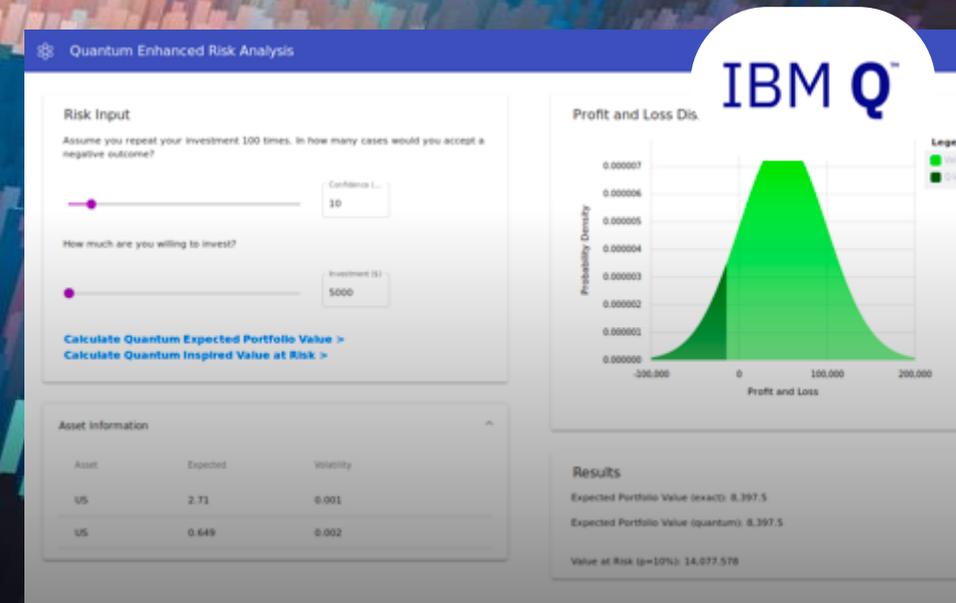
**Financial Services**

# QUANTUM COMPUTING

**MAKES FAST WORK OF  
ARBITRAGE  
OPPORTUNITIES**



# PORTFOLIO RISK ANALYSIS



Risk analysis and its algorithms support the understanding and quantification of potential losses (or gains) e.g. to protect against default.

Discover the potential and current state of quantum risk analysis to support decision making for risk managers.

## TOOLS

- Quantum
- Quantum Simulator
- Classical computer

## RESULTS



### Experiment Data Set

Statistics of a set of financial assets, which are either randomly generated datasets or a collection of historical data\*



### Custom Enablement

Identify challenges along the quantum software stack from gate-level quantum back-end to web-application front-end



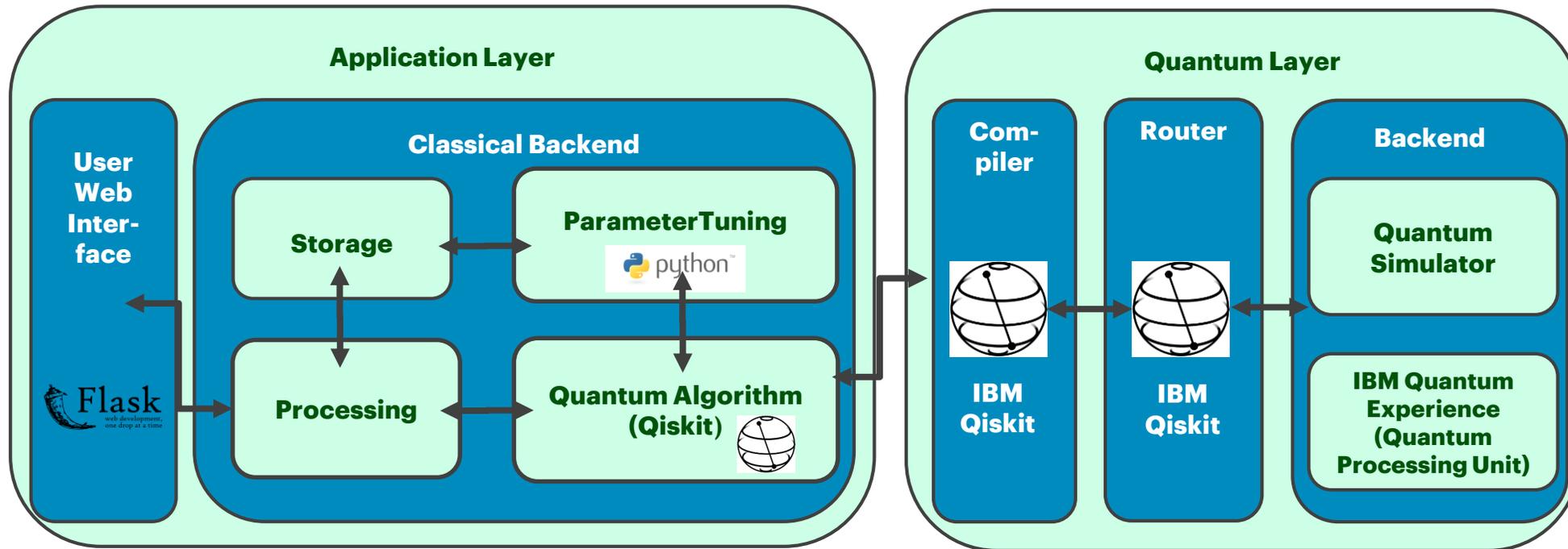
### Problem specification

Quantifying portfolio investment risks to guide investment decisions depending on your risk threshold

\*Historical data of government bond value development (<https://www.investing.com/rates-bonds/germany-10-year-bond-yield-historical-data>)

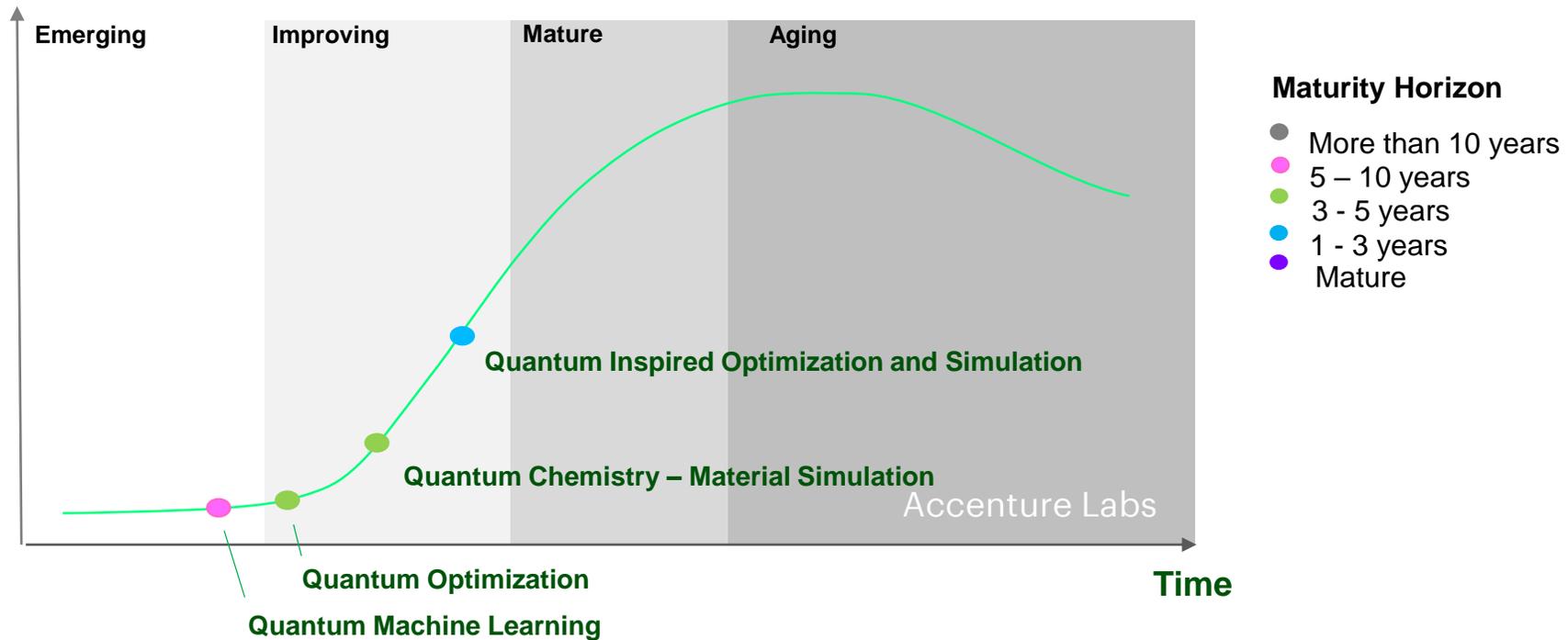
# QUANTUM APPLICATION ARCHITECTURE

## GATE QUANTUM COMPUTING EXAMPLE



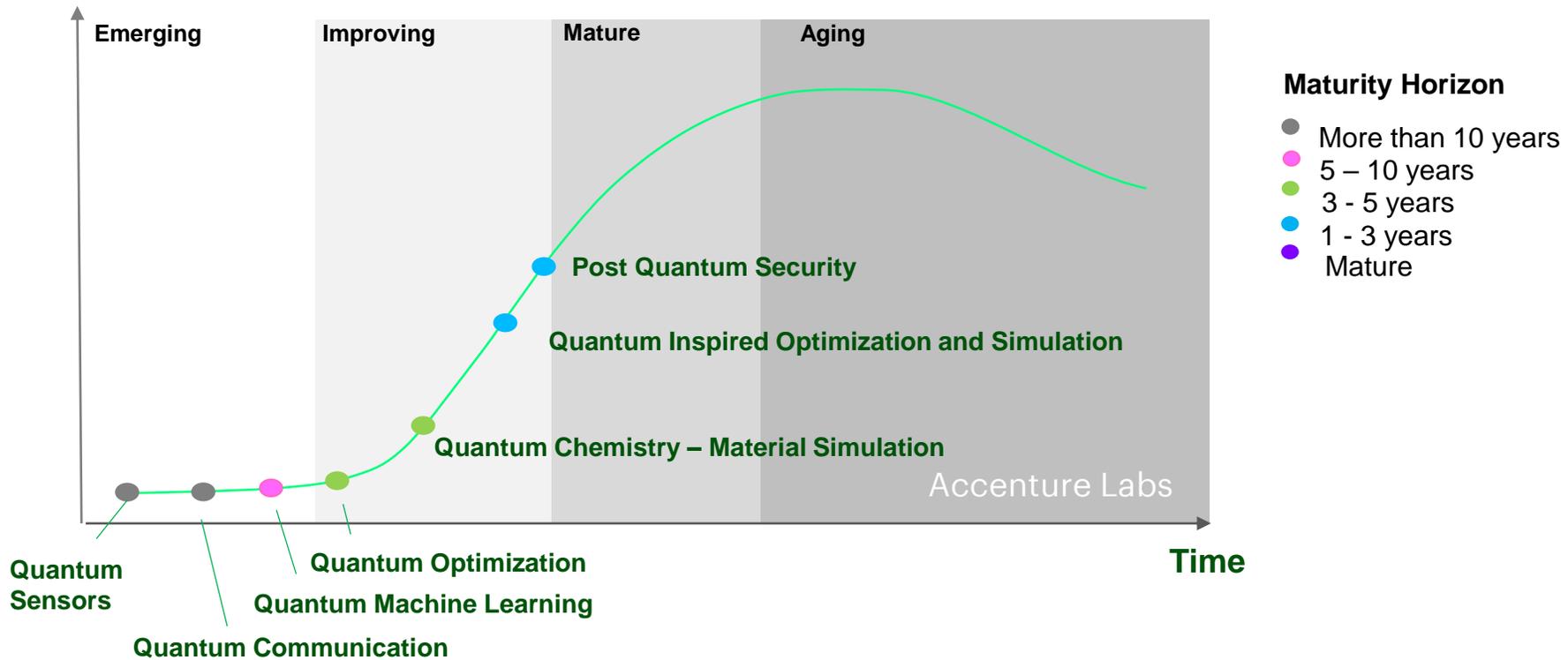
# QUANTUM TECHNOLOGY INCUBATION

Utilization



# QUANTUM TECHNOLOGY INCUBATION

Utilization



# IMPLICATIONS ON SECURITY

**WIRED**

<https://www.wired.co.uk/article/quantum-computers-quantum-security-encryption>

## The quantum clock is ticking on encryption – and your data is under threat

Quantum computers pose a major threat to the security of our data. So what can be done to keep it safe?

### The Cryptography Stack by NIST

<b>Applications</b>	<b>web browsing, cloud services, e-mail, messaging, VOIP, storage encryption,</b>
Protocols (e.g. secure webserver-browser communication)	TLS, SSL, IPSec
Cryptography	Key exchange (RSA), encryption, authentication
Lower Level (Algorithms)	Libraries, block ciphers (AES, DES)

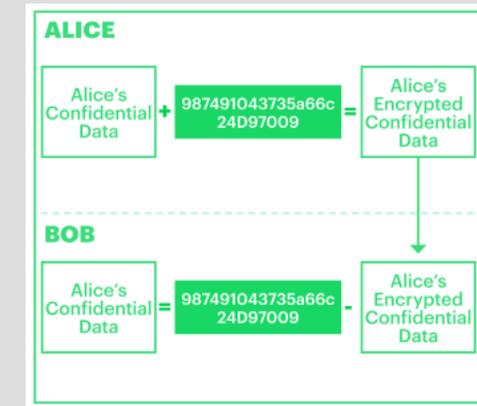
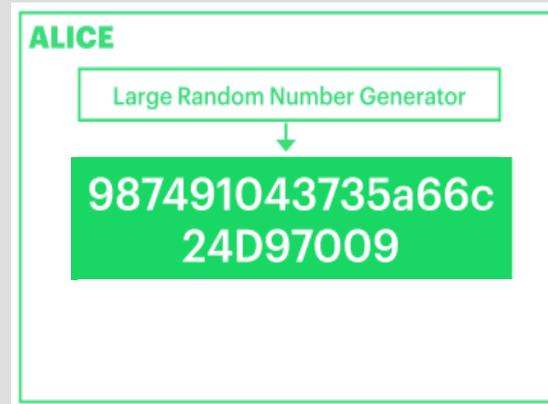
### Is it time for a technology shift?

# CLASSICAL CRYPTOGRAPHY

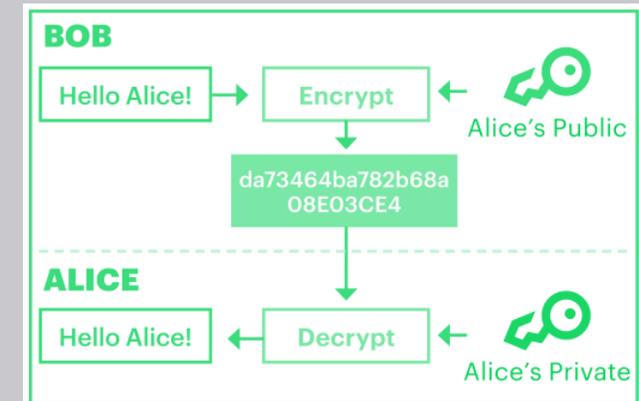
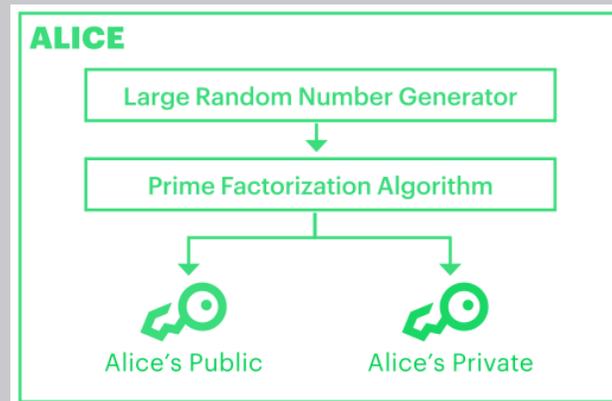
## Key Generation

## En- & Decryption

### Symmetric



### Asymmetric



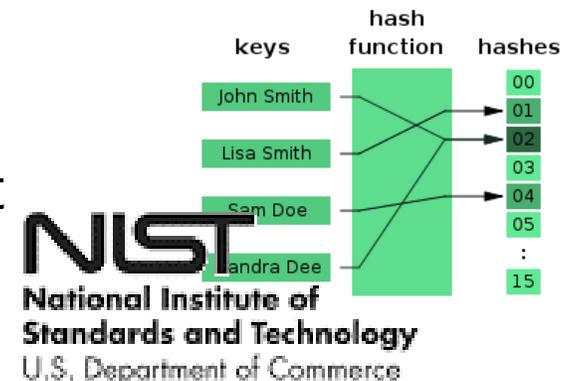
# CLASSICAL CRYPTOGRAPHY - QUANTUM ATTACK CHANNELS

	Quantum Algorithm	Encryption & Decryption
<b>Symmetric</b>	<p><b>Grover Search</b></p> <p><math>\sqrt{N}</math> speed-up for key search</p> <p>AES-128 – 64-80 bit security</p>	<p>The diagram shows two parts: ALICE and BOB. In the ALICE section, a box labeled 'Alice's Confidential Data' is followed by a plus sign and a green box containing the key '987491043735a66c24D97009', which equals another box labeled 'Alice's Encrypted Confidential Data'. In the BOB section, a box labeled 'Alice's Encrypted Confidential Data' is followed by a minus sign and the same key box, which equals a box labeled 'Alice's Confidential Data'. Arrows indicate the flow of data from Alice to Bob and back.</p>
<b>Asymmetric</b>	<p><b>Shor Algorithm</b></p> <p>exponential speed-up for prime factorization</p> <p>RSA – close to 0 bit security</p>	<p>The diagram shows two parts: BOB and ALICE. In the BOB section, a box labeled 'Hello Alice!' has an arrow pointing to a box labeled 'Encrypt'. A key icon labeled 'Alice's Public' has an arrow pointing to the 'Encrypt' box. Below 'Encrypt' is a green box containing the ciphertext 'da73464ba782b68a08E03CE4'. In the ALICE section, an arrow points from the ciphertext box to a box labeled 'Decrypt'. A key icon labeled 'Alice's Private' has an arrow pointing to the 'Decrypt' box. Below 'Decrypt' is a box labeled 'Hello Alice!'. Arrows indicate the flow of data from Bob to Alice.</p>

# PHASE 1: POST QUANTUM CRYPTOGRAPHY

**Theoretical Concept:** e.g. Hash functions

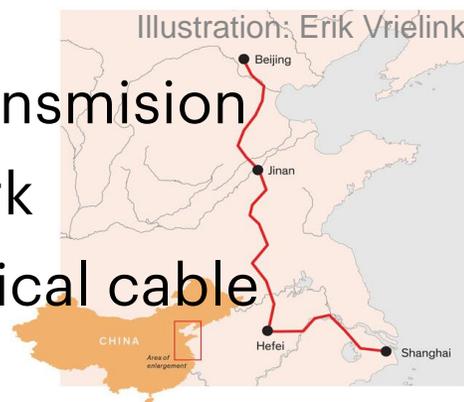
**Implementation:** National Institute of Standards aims for draft standards between 2022-2024



# PHASE 2: QUANTUM COMMUNICATION

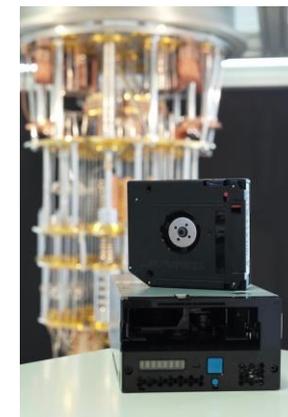
## Proof-of-Concept

- 2700 km Sattelite transmission
- China trusted network
- 1.5 kbps 200 km optical cable



## Industrial Implementation

- **Transmission rates in optical fibre technology:**
  - 10 MBit/s for 10 km
  - 100 kBit/s for 100 km
- **Post-Quantum Encryption**
  - post quantum computing-safe tape drive prototype Credit: IBM

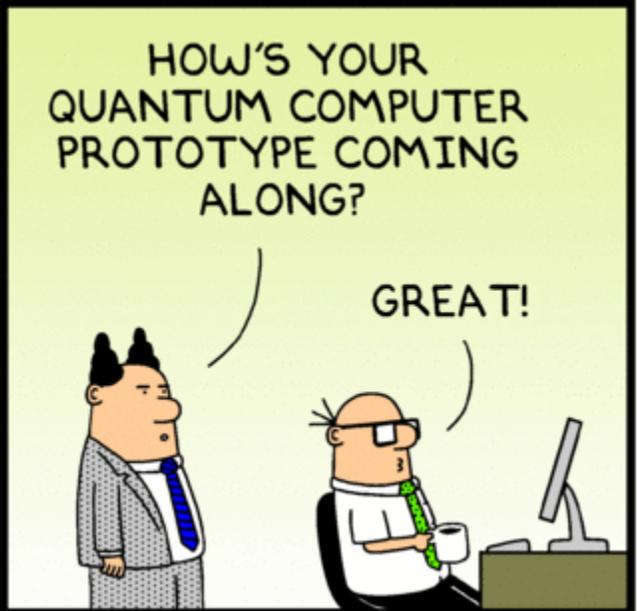


# NEXT STEPS

A set of white concrete steps leading up a light blue wall. The steps are on the right side of the frame, and the wall is on the left. The text 'NEXT STEPS' is overlaid in the center.



**PREPARE FOR THE ARRIVAL  
OF MAINSTREAM QUANTUM  
COMPUTING BY  
CONDUCTING BUSINESS  
EXPERIMENTS USING  
QUANTUM COMPUTATION**

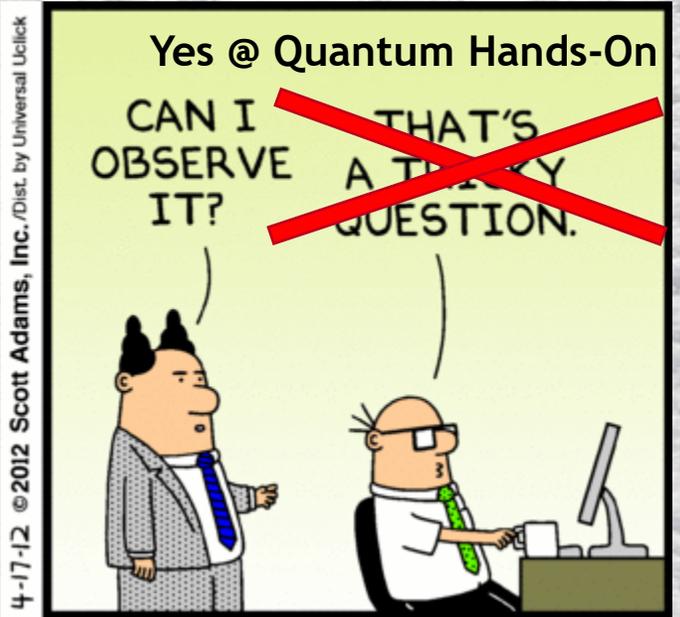
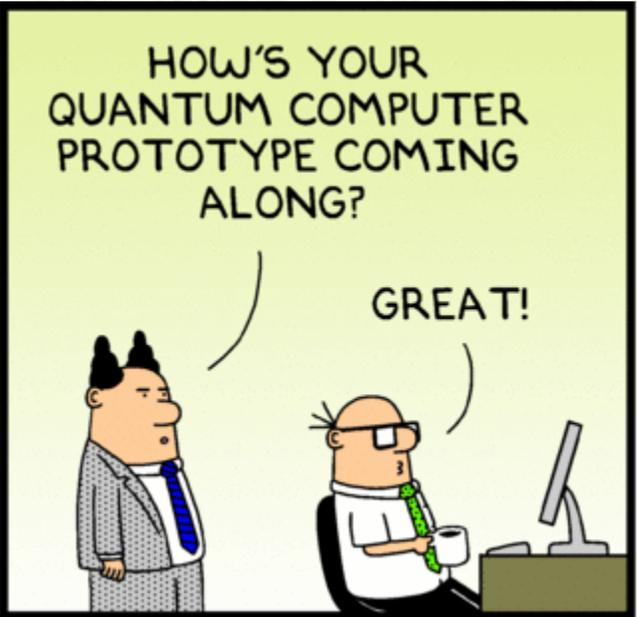


Dilbert.com DilbertCartoonist@gmail.com



4-17-12 © 2012 Scott Adams, Inc./Dist. by Universal Uclick





Dilbert.com DilbertCartoonist@gmail.com

4-17-12 © 2012 Scott Adams, Inc./Dist. by Universal Uclick

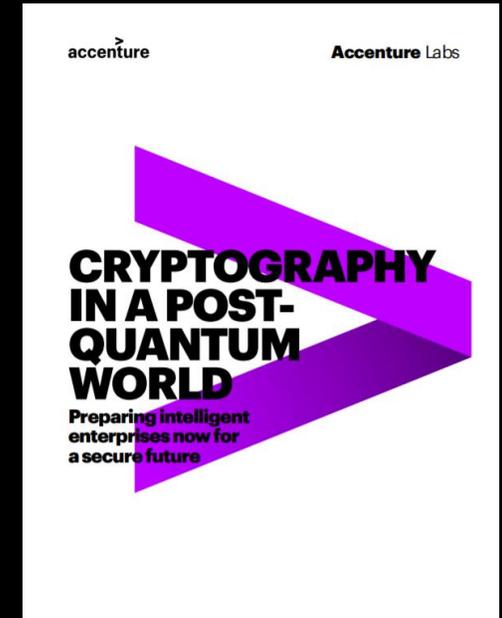
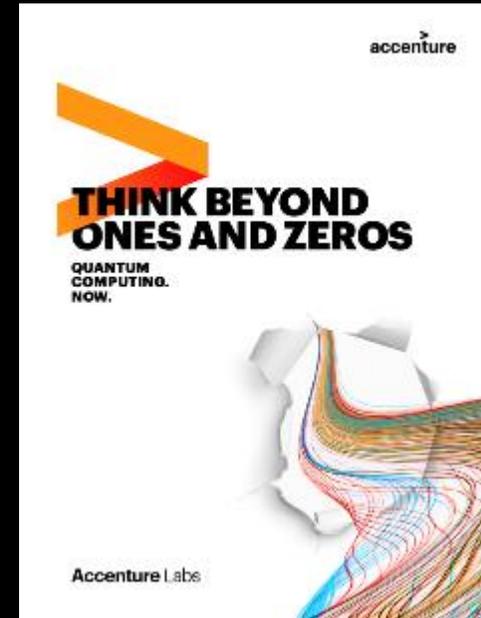
# QUANTUM COMPUTING. APPLIED NOW.

## LEARN MORE

[www.accenture.com/quantum](http://www.accenture.com/quantum)

 [@matthiasziegler](https://twitter.com/matthiasziegler)

 [Matthias Ziegler](https://www.linkedin.com/in/matthiasziegler)



 **accenture**technology