

Artificial Intelligence and Quantum Computing in Action

Masaryk University
25.11.2020

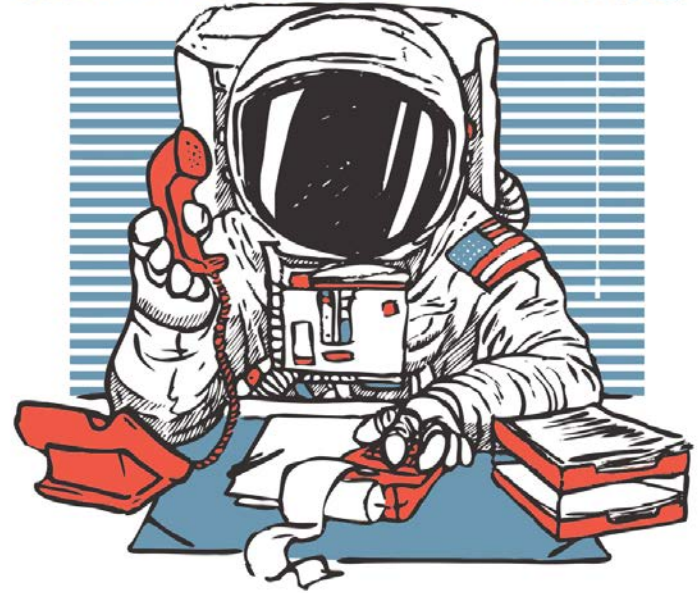
William Carbone

Chairman of TEC.CZ|SK - IBM, Academy of Technology Member

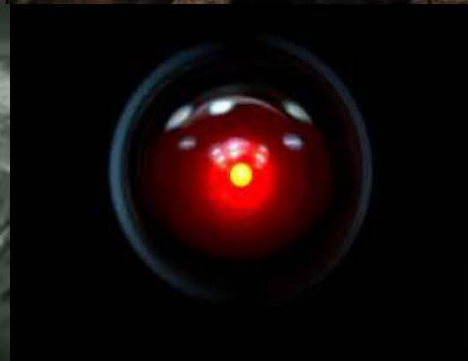


THINK

★ DRESS FOR ★
THE JOB YOU WANT



NOT THE JOB YOU HAVE

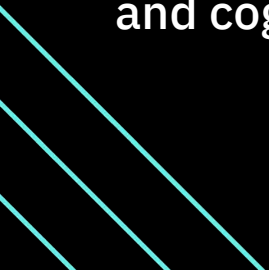




IBM Research Definition of AI

Artificial Intelligence (AI) has a long history at IBM Research, dating back to the 1950s. By AI we mean **anything that makes machines act *more intelligently***.

Our work includes basic and applied research in machine learning, deep question answering, search and planning, knowledge representation, and cognitive architectures.



Famous applications of AI at IBM



Deep Blue

In 1997, the IBM chess-playing computer named **Deep Blue** beat World Chess Champion **Garry Kasparov** in a six-game match.

Watson

In 2011, the IBM Jeopardy!-playing computer named **Watson** beat **Ken Jennings** and **Brad Rutter** in a grand champion challenge.



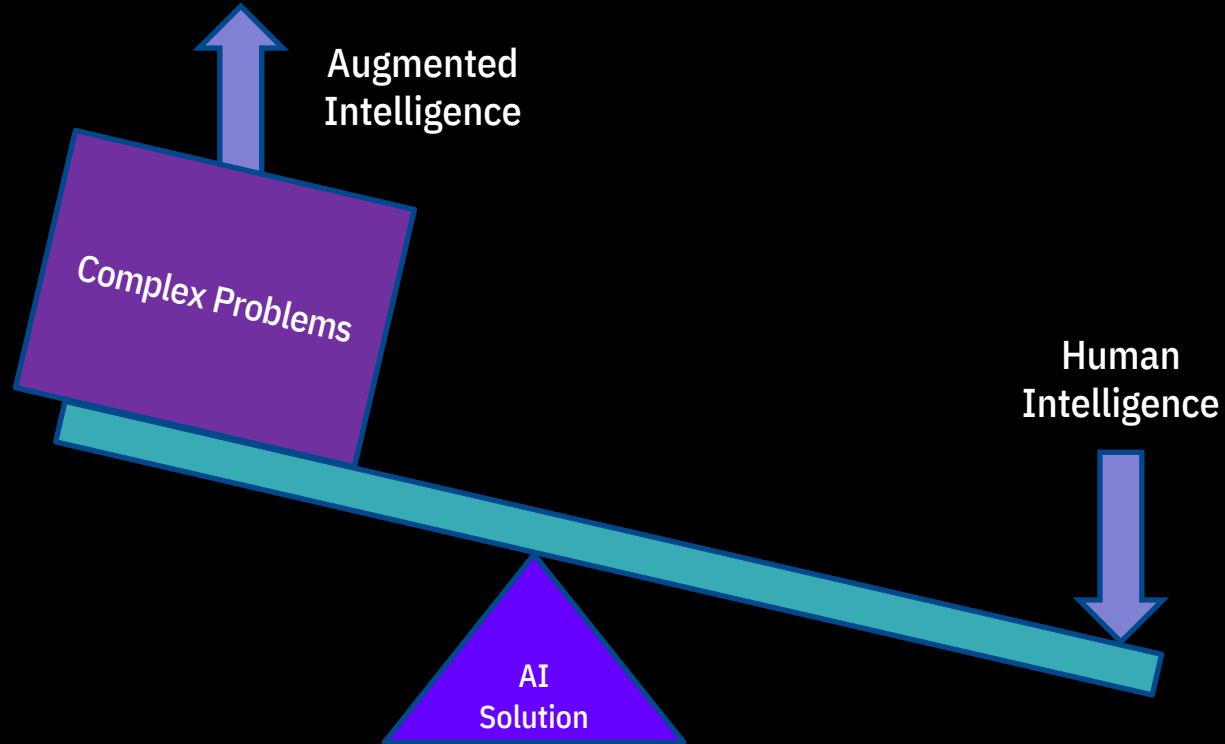
Project Debater



Dan Zafrir




Augmented Intelligence



Ethical Challenges

“AI, like most other technology tools, is most effective when it is used to **extend** the natural capabilities of humans instead of replacing them. That means that AI and humans are best when they **work together** and can **trust** each other.”

Among the many ethical issues are:

- Trust
 - Privacy
- 

Cognitive /'kɒɡ.nə.tɪv/

Connected with thinking or conscious mental processes

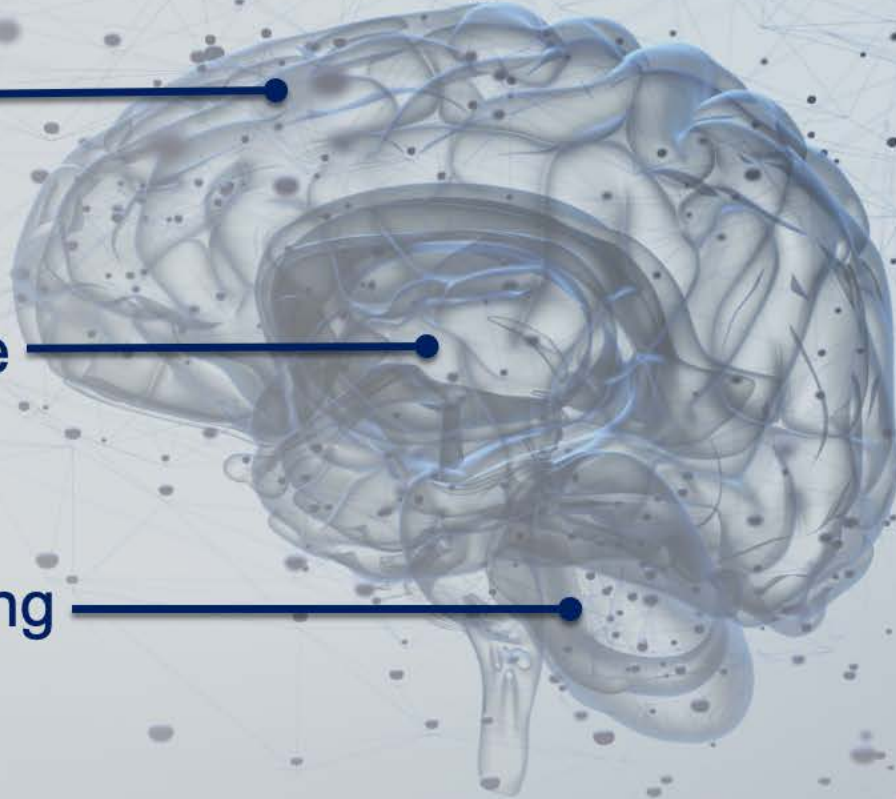
Cognitive Computing



Artificial Intelligence



Machine Learning





Disruption is upon us.

The biggest taxi company
owns no cars.



airbnb

The largest accommodation company
owns no real estate.



Alibaba

The largest retailer
carries no inventory.



facebook

Email or phone number

Password

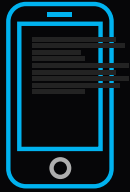
Log In

Sign Up for Facebook

Help Center

The biggest media company
owns no content.

More devices are creating more information.



1,200,000

lines of code
in a
smartphone



80,000

lines of code in
a pacemaker



100,000,000

lines of code in
a new car



5,000,000

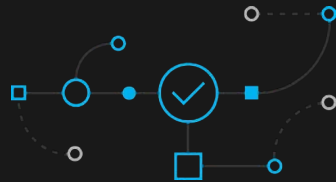
lines of code in
smart appliance

Three capabilities differentiate cognitive systems from traditional programmed computing systems...



Understanding

Cognitive systems understand like humans do.



Reasoning

They reason. They understand underlying ideas and concepts. They form hypothesis. They infer and extract concepts.



Learning

They never stop learning getting more valuable with time. Advancing with each new piece of information, interaction, and outcome. They develop “expertise”.

.... allowing them to interact with humans.

Income Level

Gender

Age

Generation

Education

Marital status

Location

Costal vs Inland

Legal status

Sector

Family Size

ZIPcode

Competitors

Loyalty & Card Activity

City

Lifestyle

Revenue Size

Life Stages

Industry

Source: <https://wallup.net/alexis-ren-women-model-blonde-face/>



Gender Date on Site Generation Followers
Subscriptions Age Following Education
Income Level Wish List Likes Time/Day log in
Size of Network Costal vs Inland Marital status
Check-ins Legal status
Location App usage duration Number of Hashtags used
Sector History of Hashtags Frequency of Search
ZIPcode Number of Apps on Device Competitors Search Strings entered
Deposits/Withdrawals Loyalty & Card Activity Photos liked City Sequence of visits
Lifestyle Videos Viewed Revenue Size
Life Stages Device Usage Time spent on site Industry
Purchase History Time spent on page

Source: <https://wallup.net/alexis-ren-women-model-blonde-face/>

Sentiment Gender Date on Site Subscriptions
Affective Status Income Level Wish List
Euphemisms Size of Network Costal vs Inland
Hedonism Location App usage duration Sector
Extroversion Deposits/Withdrawals Loyalty & Card Activity
Face Recognition Lifestyle Device Usage Life Stages
Openness

Tone Check-ins
Question Analysis Number of Apps on Device
Colloquialism Videos Viewed Purchase History
Reasoning Strategies

Dialog Following Generation Followers Education
Linguistics Likes Marital status Number of Hashtags used
Self-transcendent History of Hashtags Competitors
Language Modeling Time spent on site Revenue Size
Ontology Analysis

Intent Phonemes Time/Day log in
Image Tags Legal status
Latent Semantic Analysis Frequency of Search Search Strings entered
Sequence of visits City Industry

Source: <https://wallup.net/alexis-ren-women-model-blonde-face/>



The Future of You



Compassion

Intuition

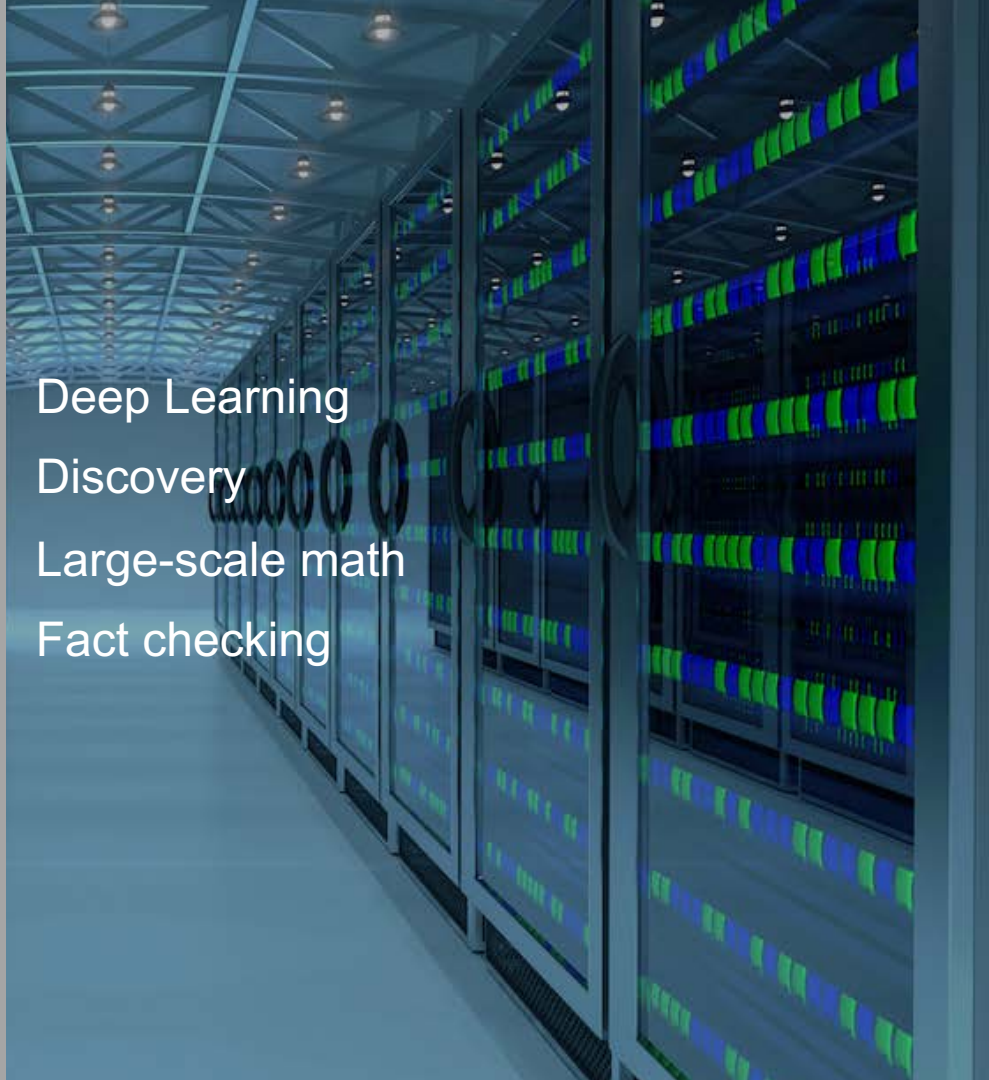
Design

Value Judgments

Common Sense



Compassion
Intuition
Design
Value Judgments
Common Sense



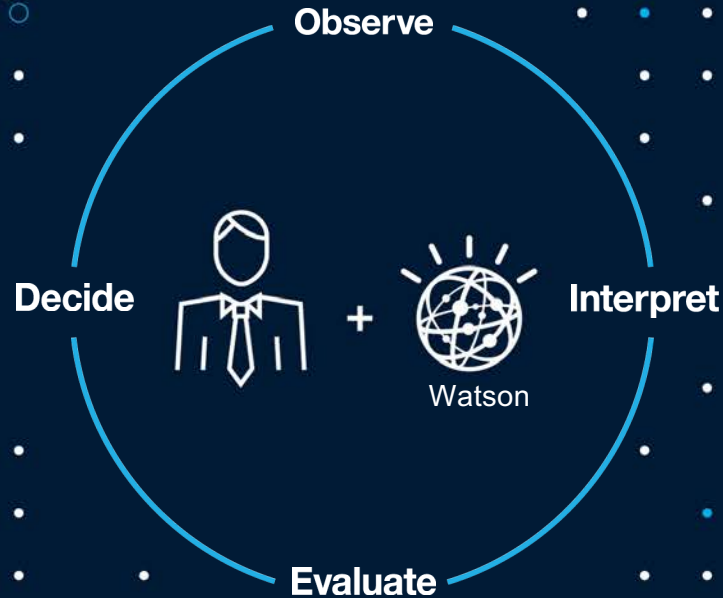
Deep Learning
Discovery
Large-scale math
Fact checking



Human + Machine



New Information Technology challenge is now about the possibility to expand our **WISDOM** options



Toward a **Precise Decision Making** to reduce the wasteful spend as well as the risk in every industry

The price
of not knowing.



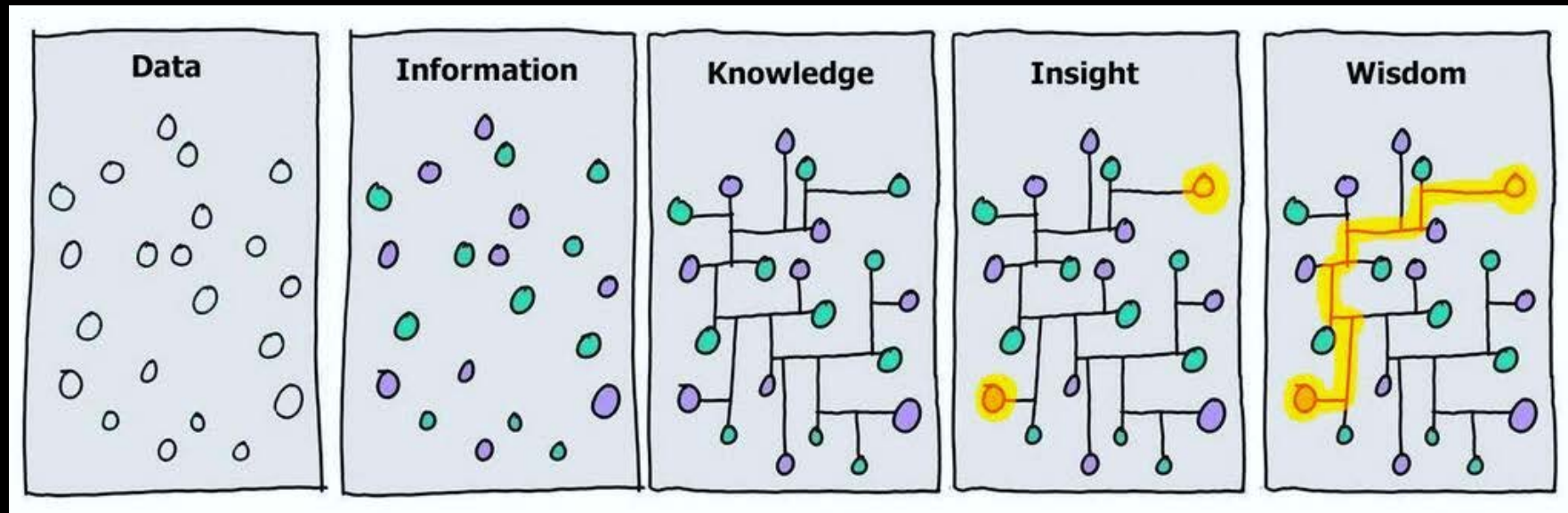
The Journey to Wisdom

Data

Knowledge

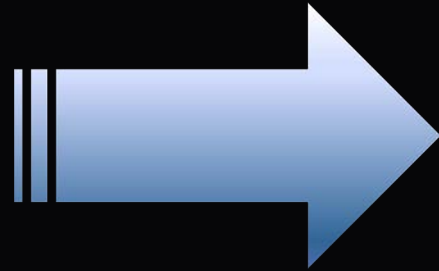
Information

Wisdom



Main Technology Shift

Automating
the
World



Understanding
the
World

Program
Knowledge Workers



Train
Learning Workers

What is the Goal of Digital Cognitive Systems?

Artificial Intelligence = Machine Intelligence



Star Trek: Mr Data

An individual smart machine

The Goal!

*Augmented Intelligence =
Human Intelligence + Machine Intelligence*

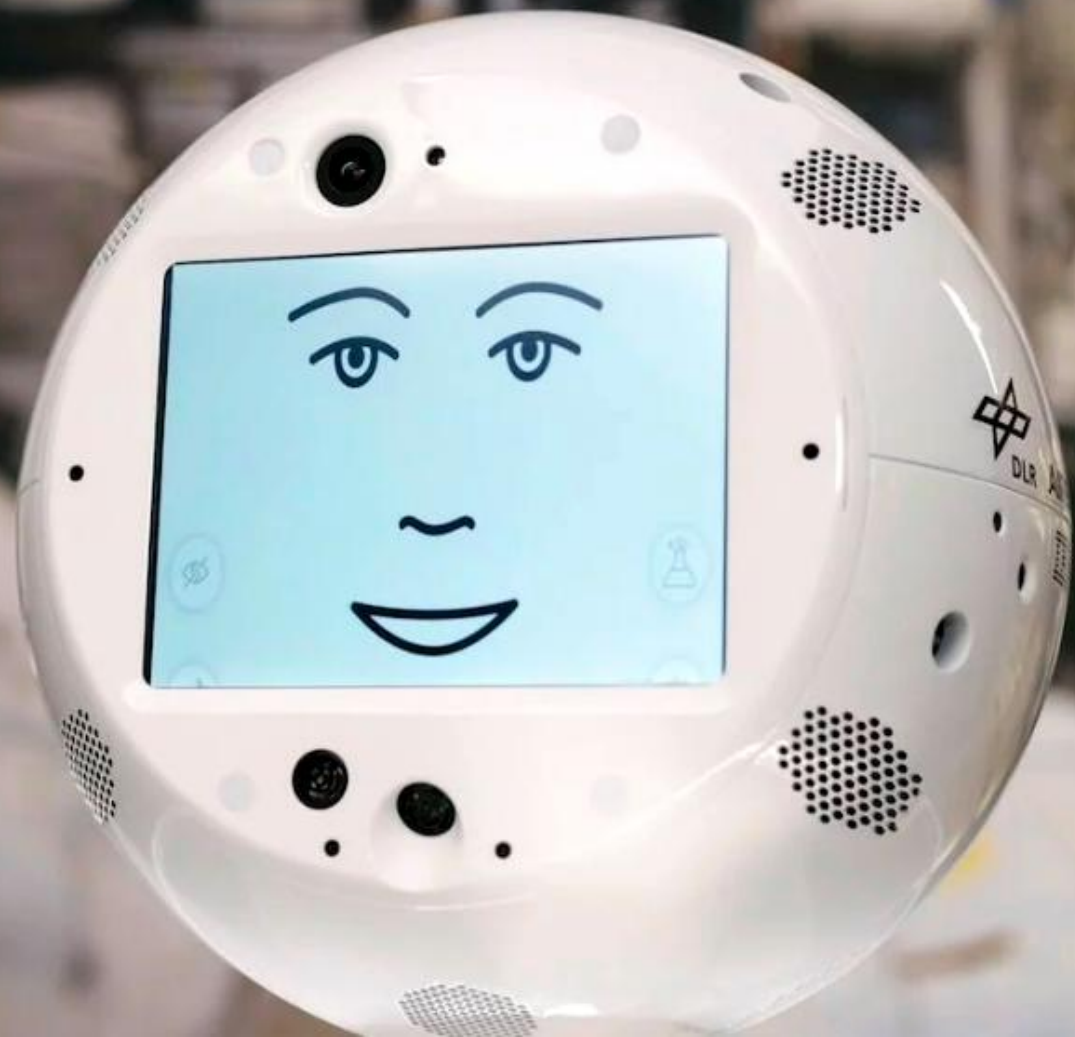


Iron Man: Tony Stark & Jarvis

Man and machine co-operation

VS

“Capability to use language with machines for **coordinating** and **reasoning** for better outcomes. Increases **human intelligence** by use and not diminish it.”

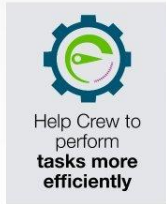


Project CIMON

AIRBUS

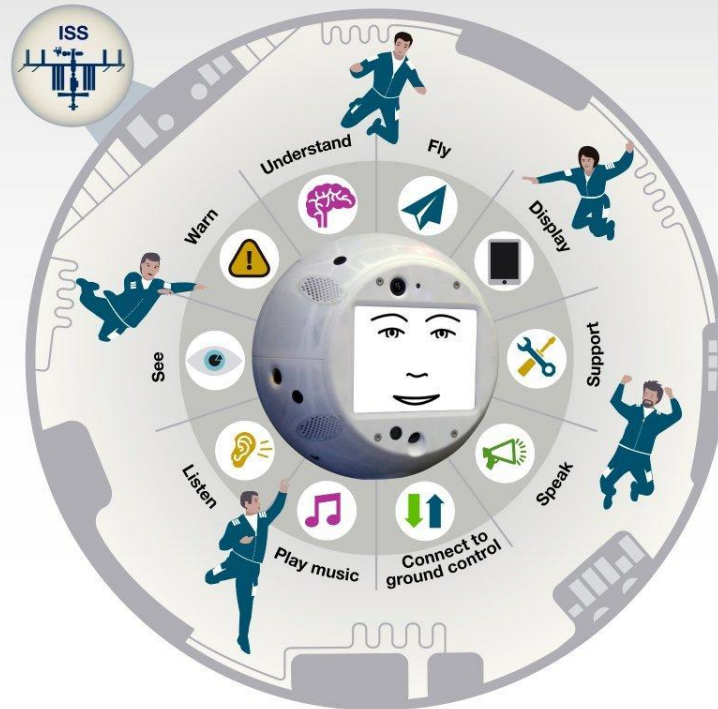
Project *CIMON* (Crew Interactive Mobile Companion) is a mobile and autonomous assistance system helping astronauts aboard the ISS. The first form of artificial intelligence (AI) aboard the ISS will be tested by ESA astronaut Alexander Gerst during the Horizons mission. Airbus, in cooperation with IBM, developed project CIMON for the DLR Space Administration.

Benefits for astronauts



Man-machine interaction

The assistant for complex tasks can:



Diameter



32 cm

Weight



5 kg

Battery runtime



2 h

High tech elements



3D printed structure



Ready for **augmented reality**



Absolute navigation



Artificial intelligence

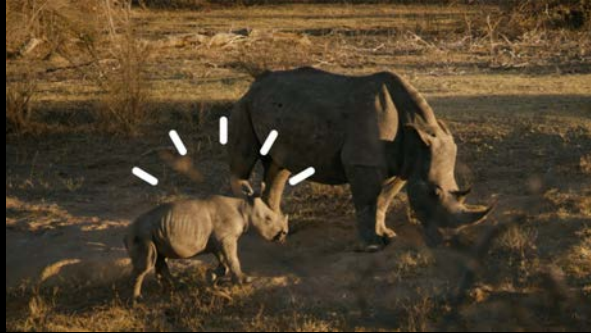


Face detection and recognition



Battery powered propulsion system

IBM Projects



Smart Wildlife



Use The Force - Move a BB-8 with Your Mind



IBM IoT and the Dubai Camel Race

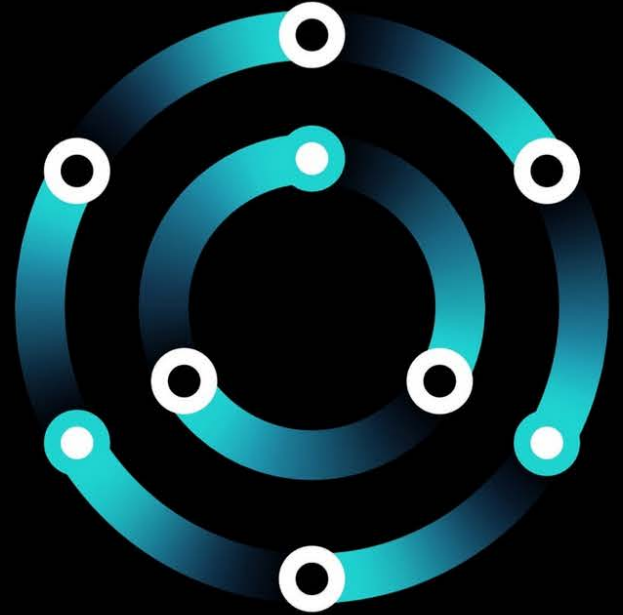


IBM Watson at Wimbledon

How to put AI to work

Learn how you can infuse AI across your enterprise.

[Explore offerings](#)





Data Science and Cognitive Computing Courses

Free Courses Sign Up



<https://cognitiveclass.ai/>

What are the benefits?



IT'S FREE

Our courses are free so
you have nothing to lose!



EARN BADGES

Earn badges for your
portfolio



EXPAND YOUR KNOWLEDGE

We have courses for all
skill levels

Learning Paths

Pick one of our selected learning paths, and get started today!

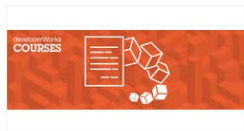


COURSES



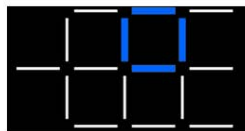
Python for Data Science
PY0101EN

Beginner



Blockchain Essentials
developerWorks BC0101EN

Beginner



Build an IoT Blockchain Network for a Supply Chain

IBM Developer Skills Network
BC0202EN

Intermediate



IBM Cloud Essentials
IBM Developer Skills Network
CL0101EN

Beginner



Building Robots with TJBot

Cognitive Class IT0101EN

Beginner



IBM Blockchain Foundation Developer

IBM Skills Network BC0201EN

Intermediate



Node-RED: Basics to Bots
Skills Network CB0105ENv1

Intermediate



Robots are coming! Build IoT apps with Watson AI, Swift, and Node-RED
IBM Developer Skills Network
ML0201EN

Intermediate



Machine Learning with Python
Cognitive Class ML0101ENv3

Intermediate



Build Your Own Chatbot
Cognitive Class CB0103EN

Beginner



Big Data 101
Cognitive Class / Fireside Analytics Inc. BD0101EN

Beginner



Hadoop 101
Cognitive Class BD0111EN

Beginner



Introduction to Data Science
Cognitive Class / Fireside Analytics Inc. DS0101EN

Beginner

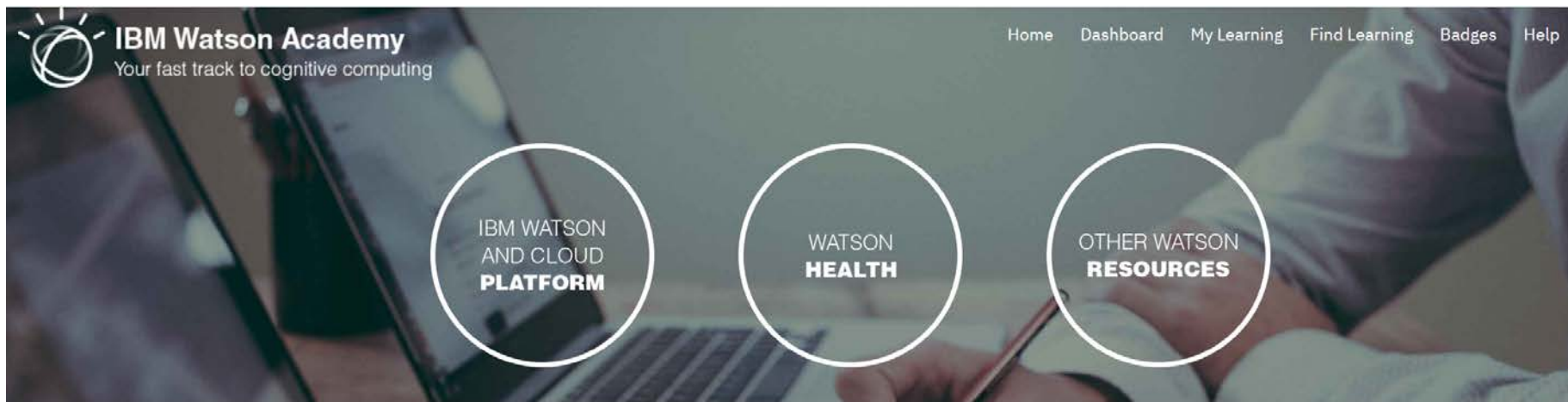


R 101
Cognitive Class RP0101EN

Beginner

Badges

Your fast track to cognitive computing
<https://www.watson-academy.info/>





What are **your** next
steps to becoming
a **cognitive**
professional?

How can we work together?



IBM CLOUD

190+ Cloud
Services at
your disposal



IBM Academic Initiative

Cloud Access,
Software, Courseware



Cognitive Class

Data Science and
Cognitive
Computing
Courses



Startup with IBM

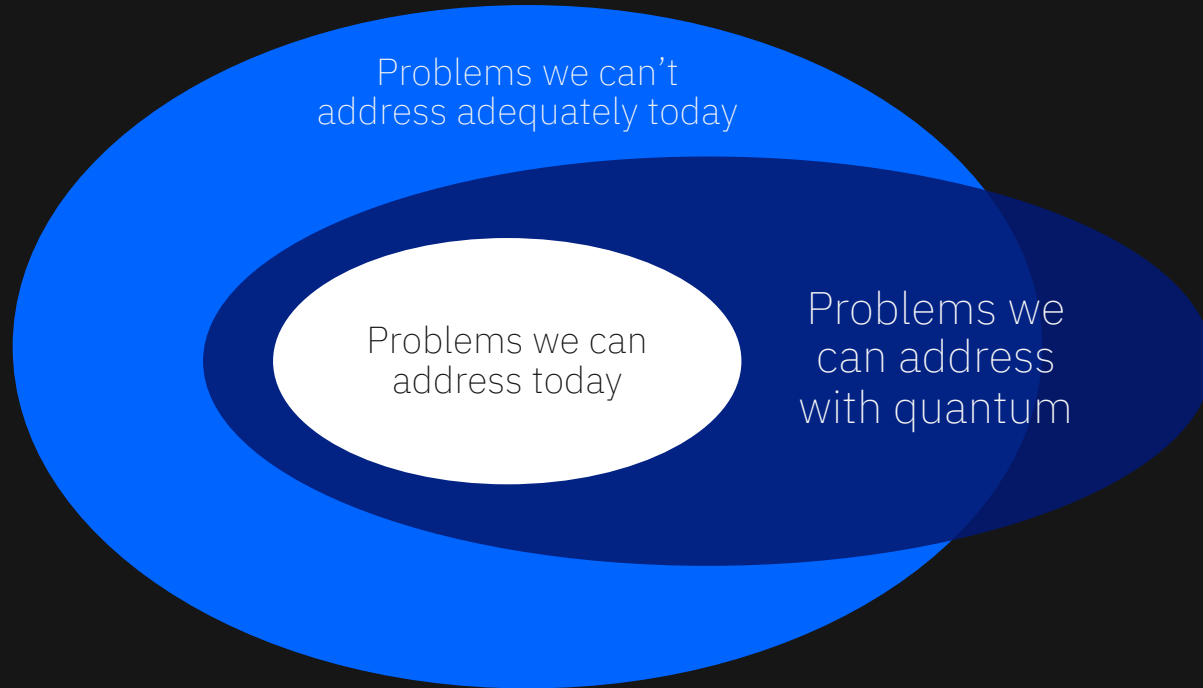
\$120,000 in free
IBM Cloud credits

The Limits of Bits

For decades we've been simplifying nature into 1s and 0s because that was the only way we could manage to create a useful and scalable system of computation.

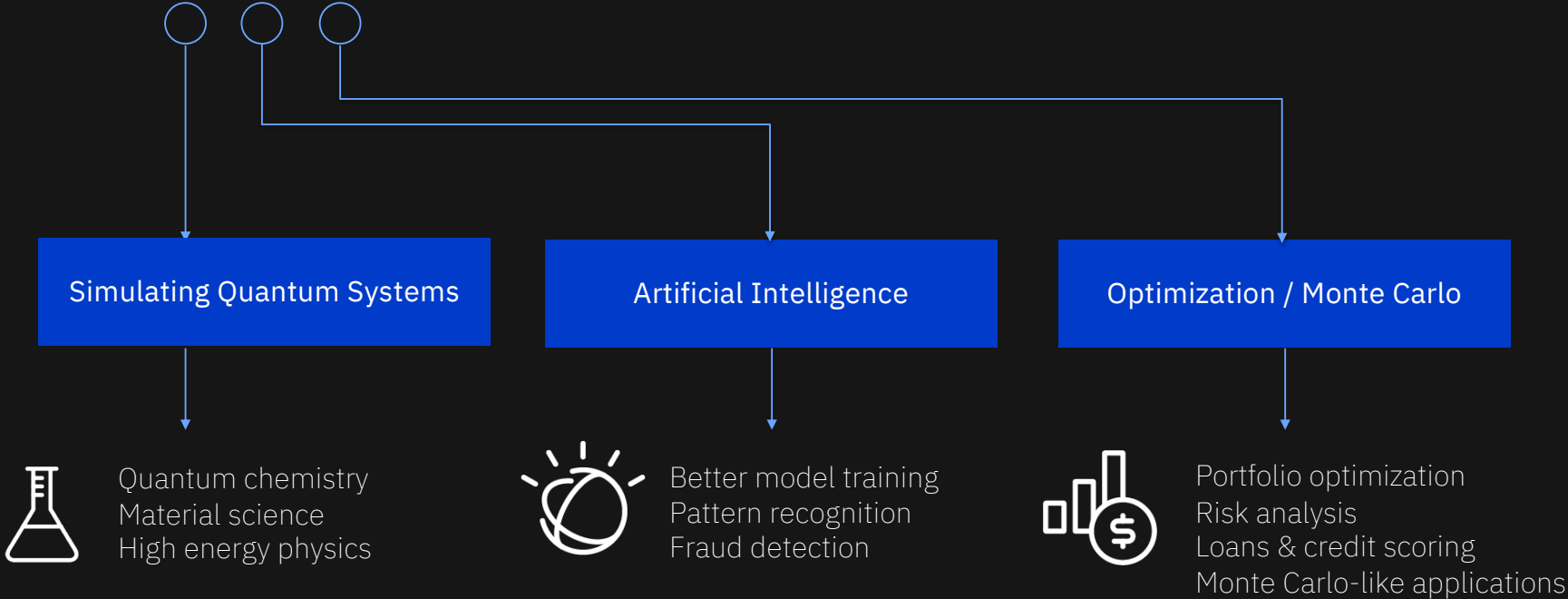
But the future isn't just 1s and 0s.

Why quantum?

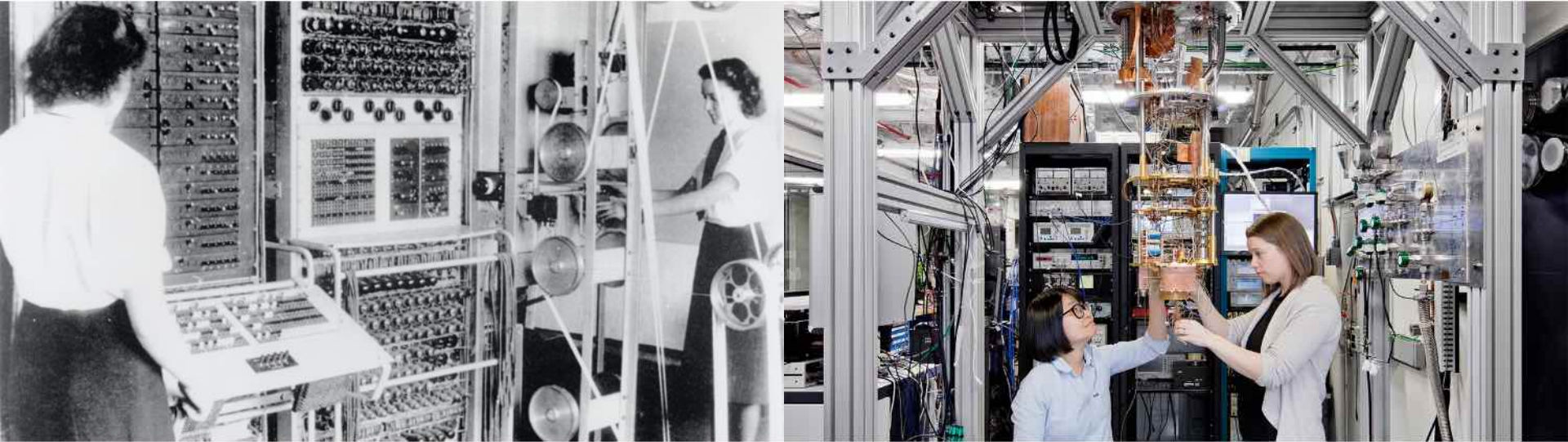


Despite how sophisticated digital computing has become, there are many scientific and business problems for which we've barely scratched the surface.

Quantum applications span three general areas



We are in the early stages of a rapidly advancing new computing technology

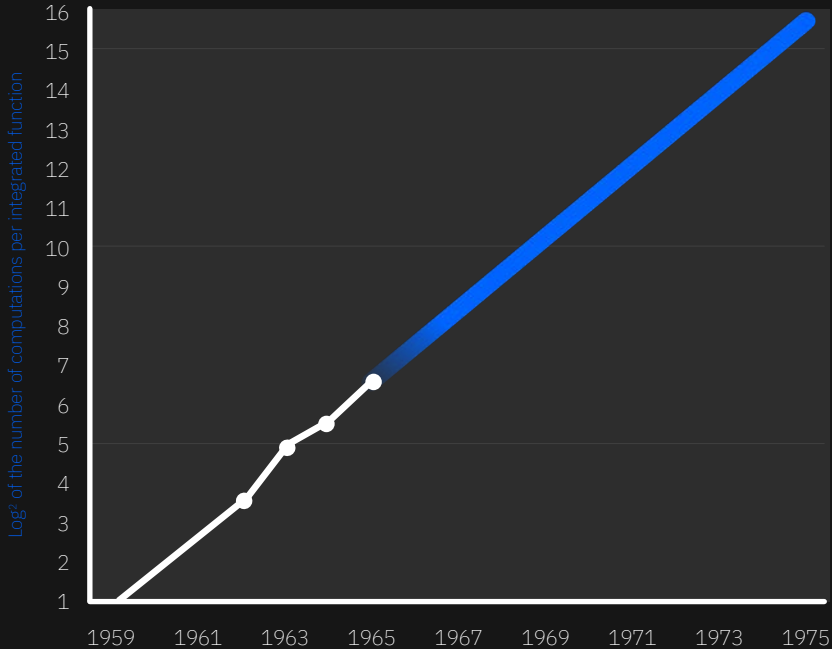


Computer: 1944

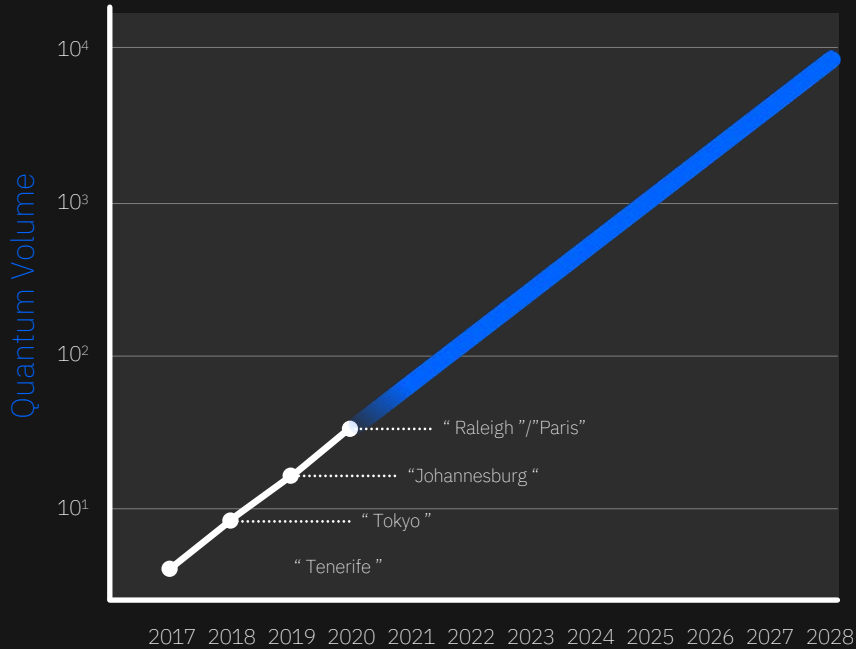
Quantum Computer: 2019

We are in the early stages of a rapidly advancing new computing technology

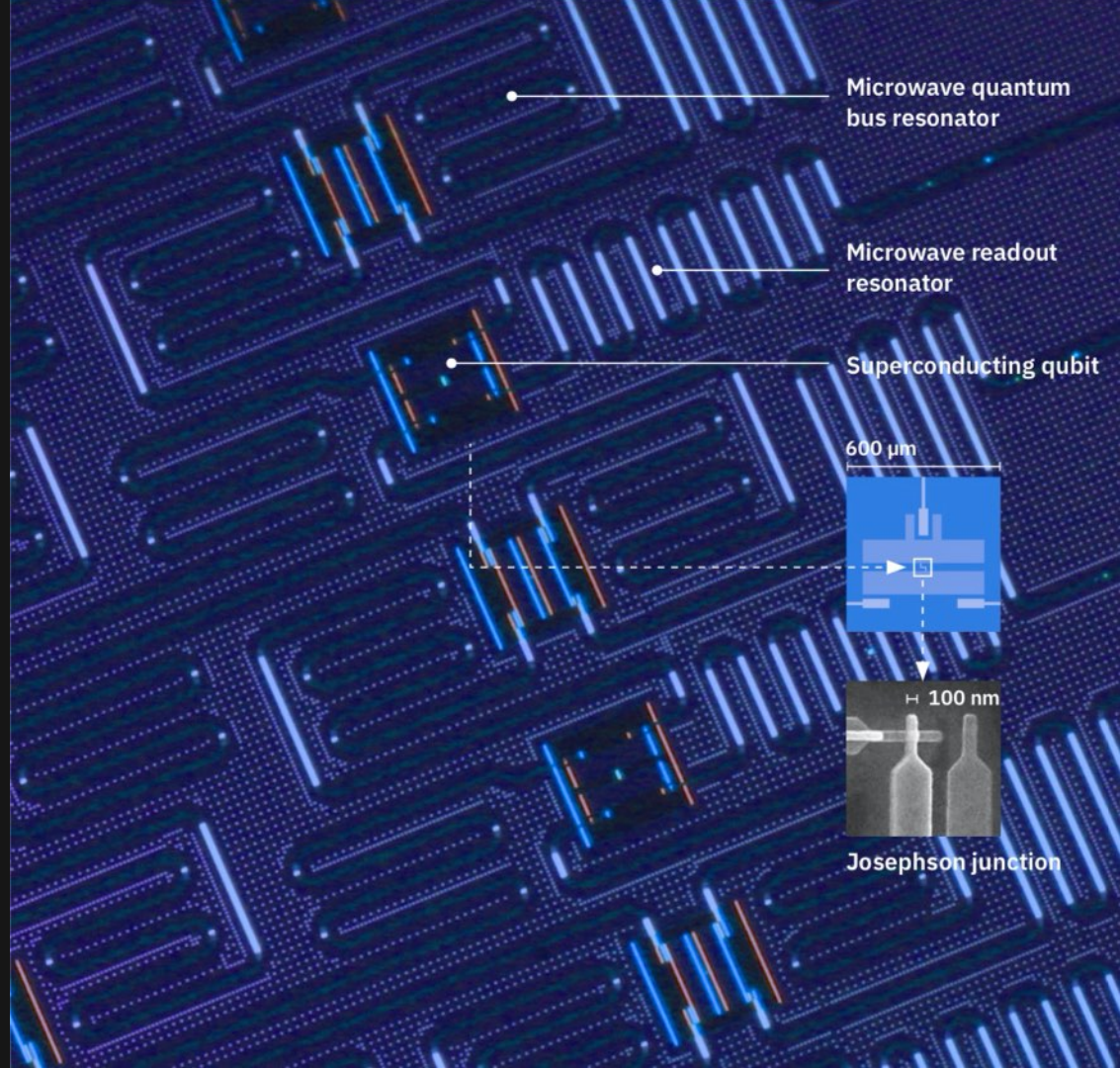
Moore's law



Quantum Volume: The New Moore's Law



Inside an IBM Quantum Chip



Scaling IBM Quantum technology

IBM Q System One (Released)

(In development)

Next family of IBM Quantum systems

2019

2020

2021

2022

2023

and beyond

27 qubits

65 qubits

127 qubits

433 qubits

1,121 qubits

Path to 1 million qubits

Falcon

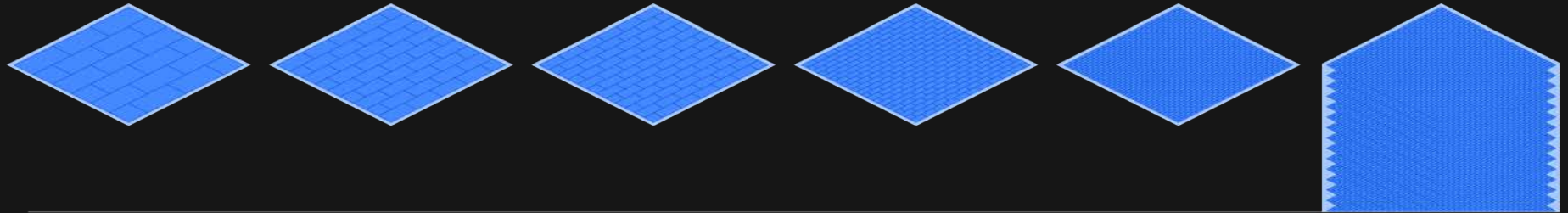
Hummingbird

Eagle

Osprey

Condor

and beyond
Large scale systems



Key advancement

Key advancement

Key advancement

Key advancement

Key advancement

Key advancement

Optimized lattice

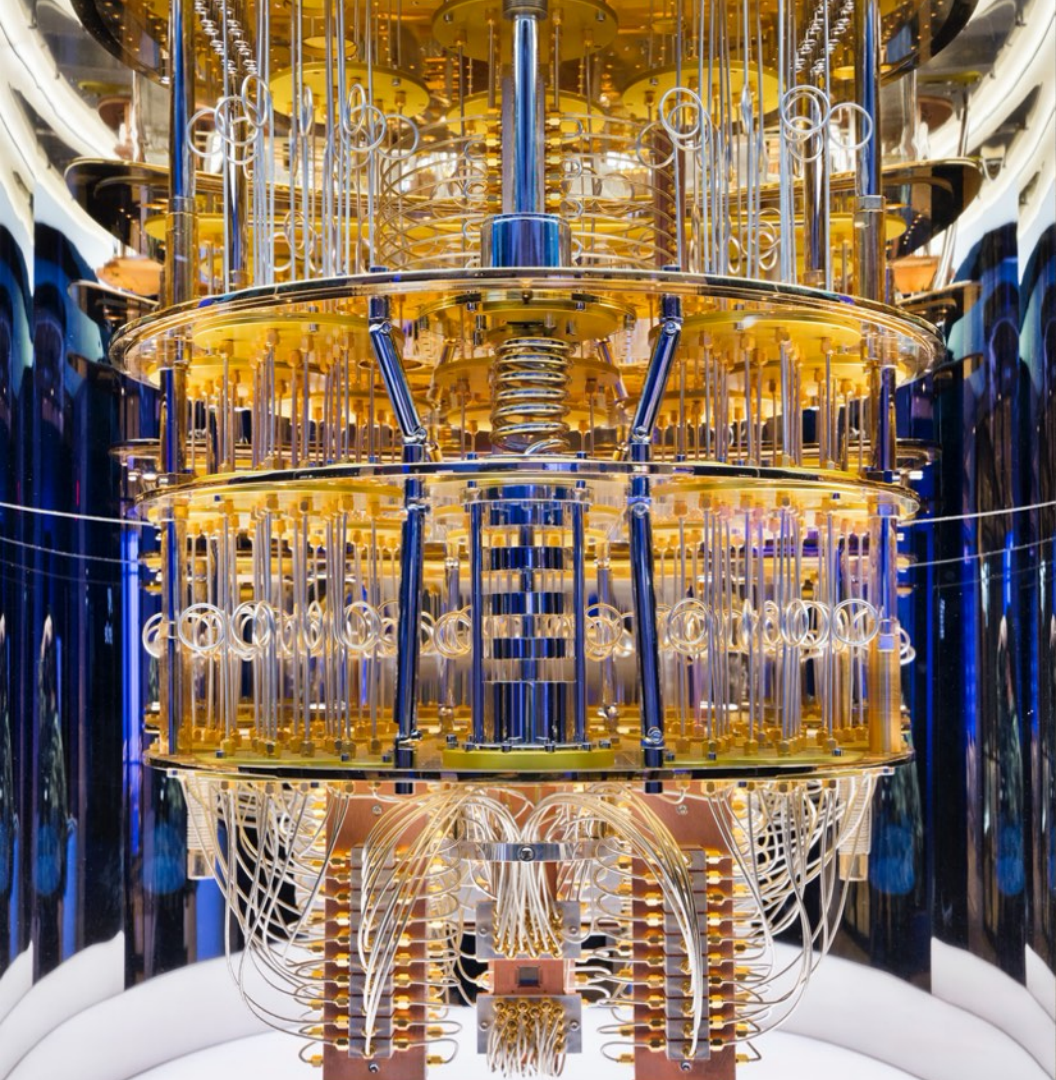
Scalable readout

Novel packaging and controls

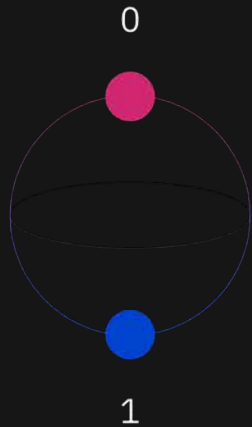
Miniaturization of components

Integration

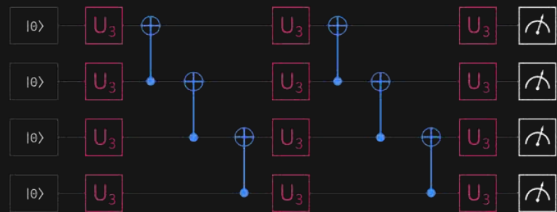
Build new infrastructure,
quantum error correction



Quantum bits and quantum circuits



A quantum bit or **qubit** is a controllable quantum object that is the unit of information



A **quantum circuit** is a set of quantum gate operations on qubits and is the unit of computation

Comparison: Bits versus Qubits

Simulating a set of qubits demonstrates their potential advantage as information carriers.

Qubits	Digital bits required to represent an entangled state
2	512 bits
3	1024 bits
10	16 kilobytes
16	1 megabyte
20	17 megabytes
30	17 gigabytes
35	550 gigabytes
100	More than all the atoms of planet earth
280	More than all the atoms in the universe

Quantum developer



IBM Cloud



IBM Quantum Systems



Quantum Circuits for Applications

Quantum Simulations

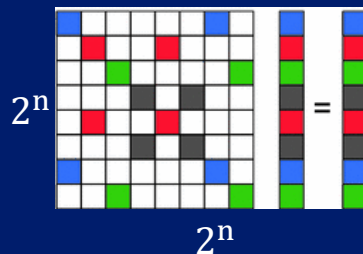


Physics

Chemistry

Materials discovery

Linear Systems ($Ax = b$)



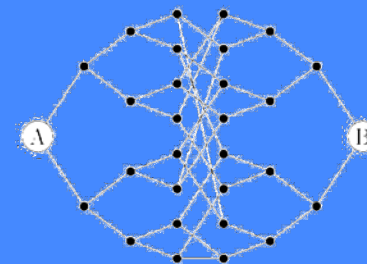
Network analysis

Differential equations

Option pricing, heat transfer

Classification (Machine Learning)

Quantum Walks



Graph properties (network flows, electrical resistance)

Search

Collision finding

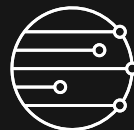
IBM Quantum Network

A collaborative community of discovery

Educate and Train



Accelerate Research



Develop Applications



IBM Quantum Network: A Snapshot

Over 247,000 users have...

Run over 400 Billion quantum circuits

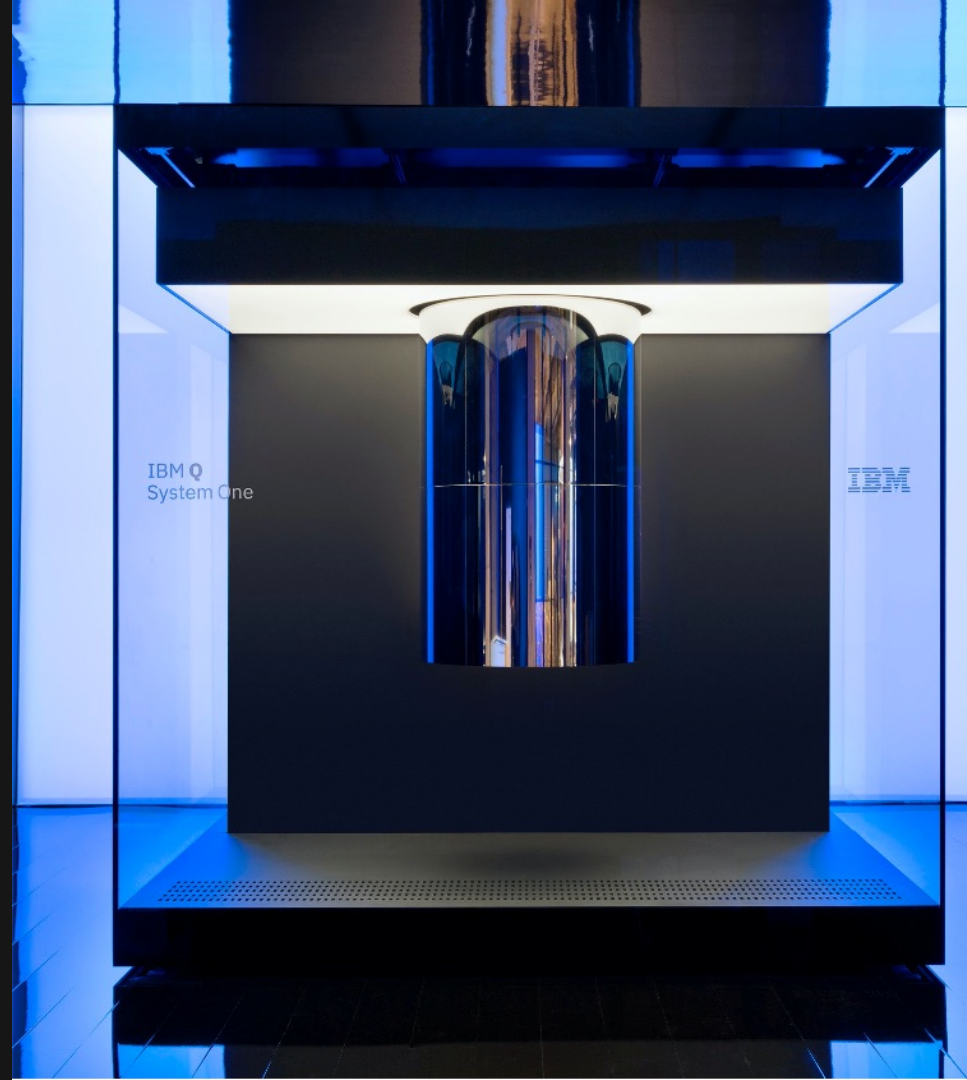
On 29 quantum computers

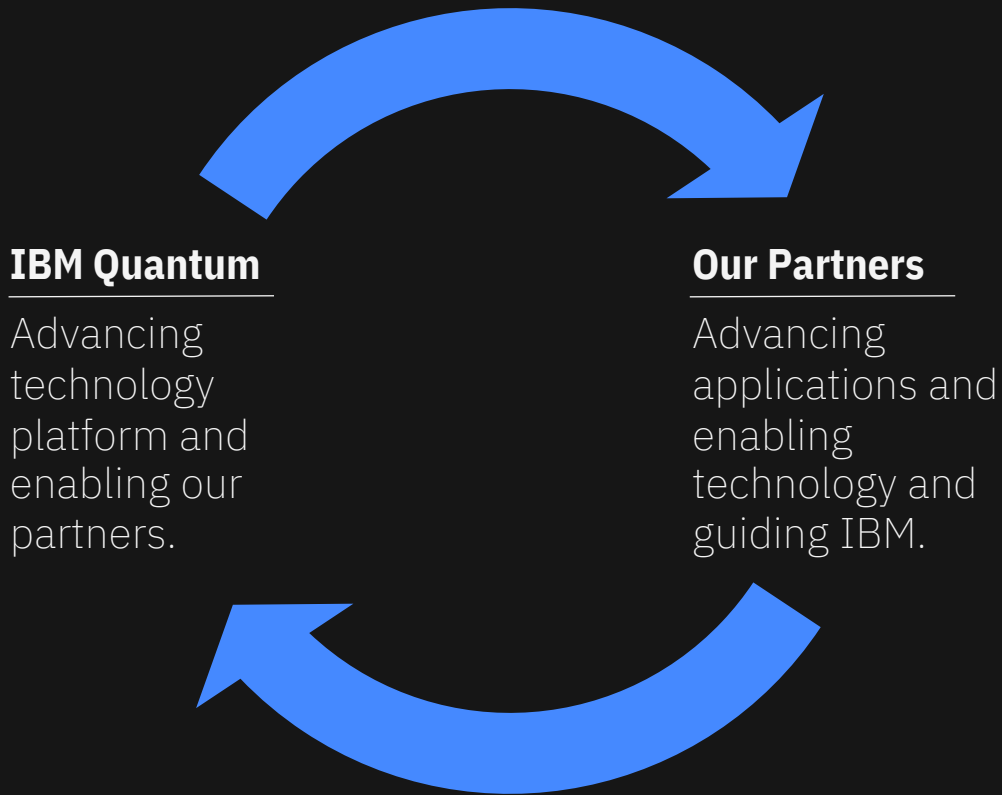
More than 130 Clients and Partners

Collaborating on 30+ applications

Over 300 contributors to Qiskit

Over 400 scientific papers so far





Our Model

Advance the technology and practical implementation of applications and algorithms.

Build a cloud platform for application development and deployment in industry.

Algorithm Families

Quantum Simulation

Linear Systems

Quantum Walks

User Types

Application Developers

Algorithm Developers

Kernel Developers

Our Model

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Build a cloud platform for application development and deployment in industry.

Algorithm Families

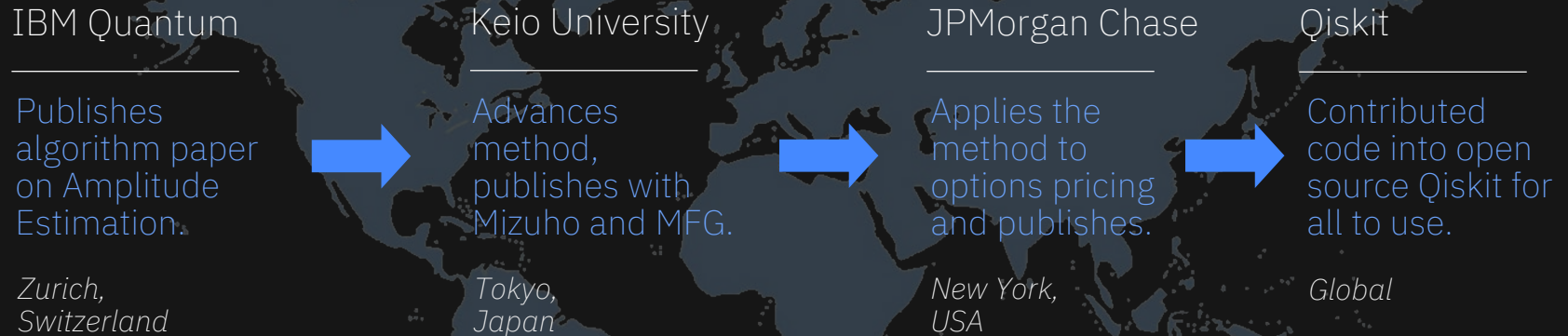
Quantum Simulation
Linear Systems
Quantum Walks

User Types

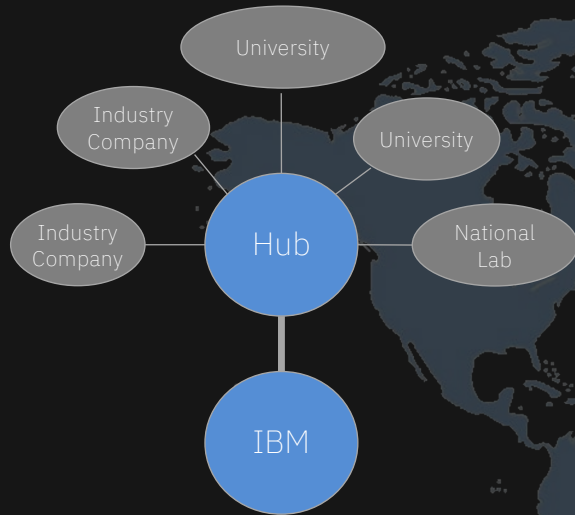
Application Developers
Algorithm Developers
Kernel Developers

New battery materials
Manufacturing optimization
Benchmarking
Electronic materials
Transaction classification
Compilers and transpilers
Product recommendation
Fraud detection
Random Number Generation
Chemical observable prediction
Logistics and routing optimization
Financial transaction settlement
Portfolio optimization
Variational optimization/factoring
Classical control hardware
Risk analysis and options pricing
Material degradation

A Snapshot of Global Collaboration in the IBM Quantum Network

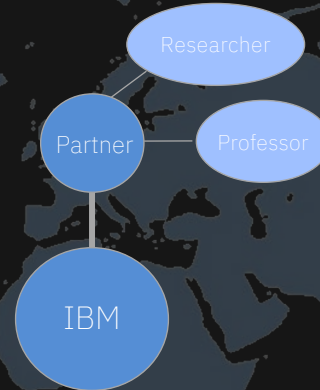


IBM Q Network Partnership Structures



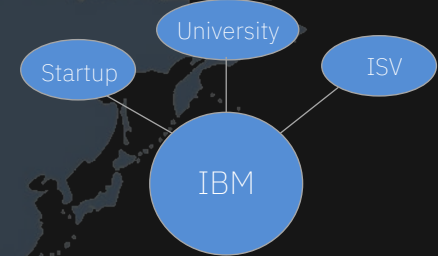
Hubs

Regional centers of quantum R&D and education centered on leading research institutions.



Industry

Deep collaborative research on applications utilizing IBM Quantum systems and collaboration.

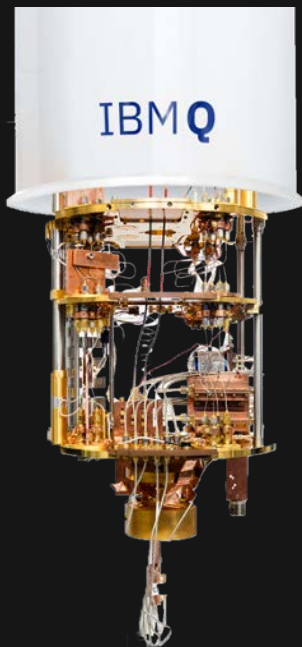


Ecosystem

Enabling organizations to learn and leverage IBM Quantum for their development and products.

IBM Q Network

Program Offerings



Technology Access

Access to the most advanced quantum systems, software and cloud services.

Enablement and Collaboration

Training, support, and joint research, in frameworks that enable collaboration.

Three tiers
of offerings

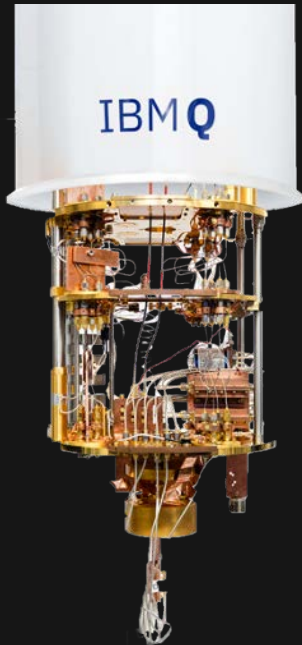
Open \$0

Member \$

Partner \$\$

IBM Q Network

Program Offerings



Quantum Systems on the Cloud

IBM Quantum

Access to quantum systems and cloud-based software

Shared or dedicated systems, direct partner or hub

Enablement

Workshops, tutorials, and consultation

Dedicated team to train, support and guide users

Joint Work

Collaborative research on quantum applications

Use case and business strategy consulting

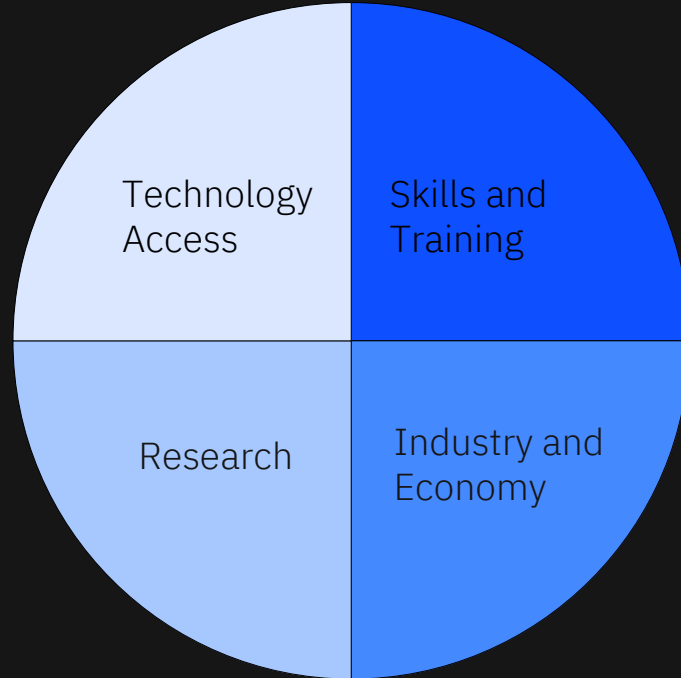
IBM Q Network Community

Membership in the premier network of collaborators

Member-only events, resources, and content

Building a Quantum Industry and Ecosystem

IBM and organizations worldwide are partnering to advance quantum computing with broad-scale, jointly-run programs to advance quantum across all four essential areas.



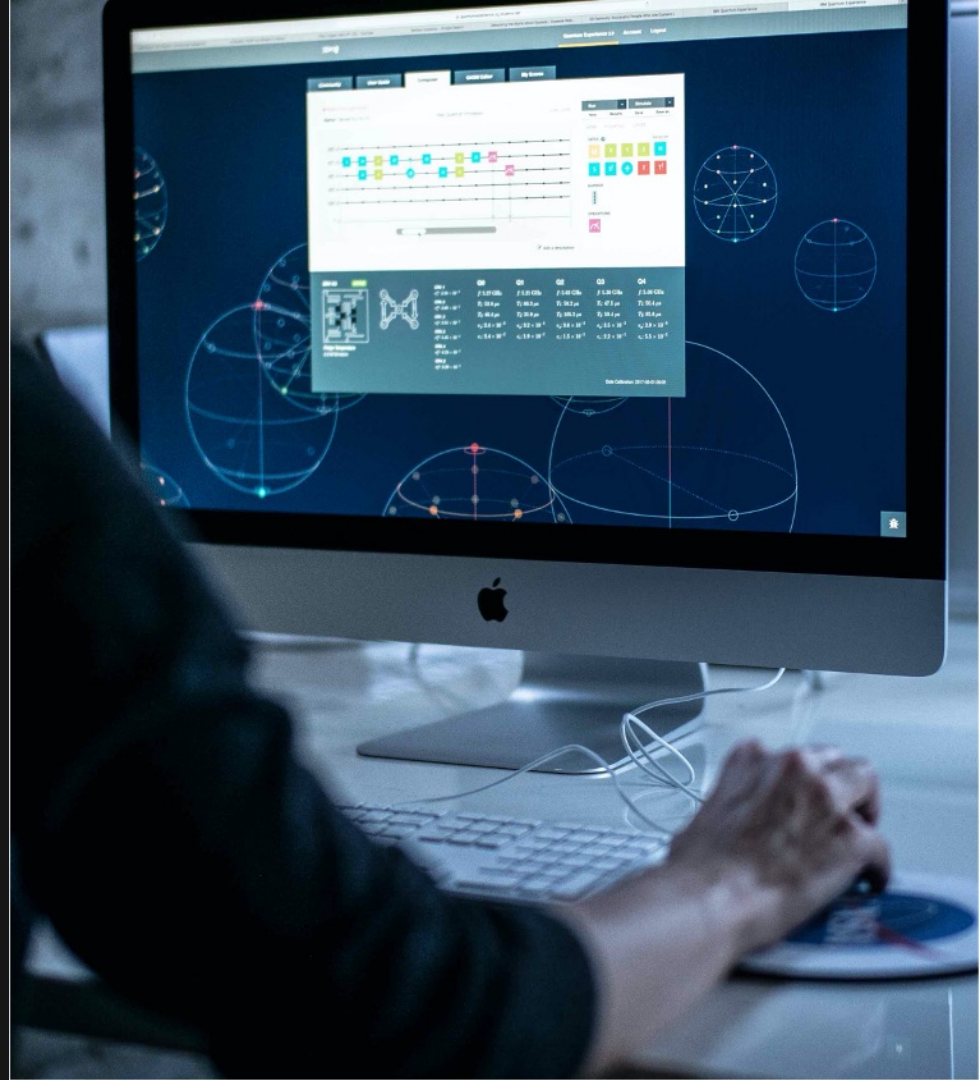
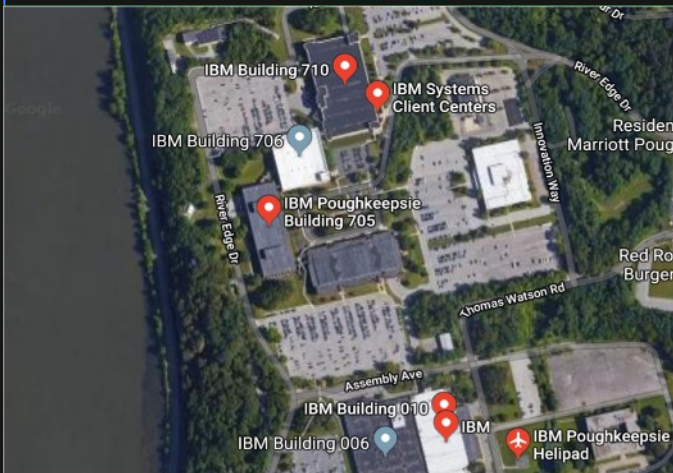
Technology Access

IBM Quantum Computation Center

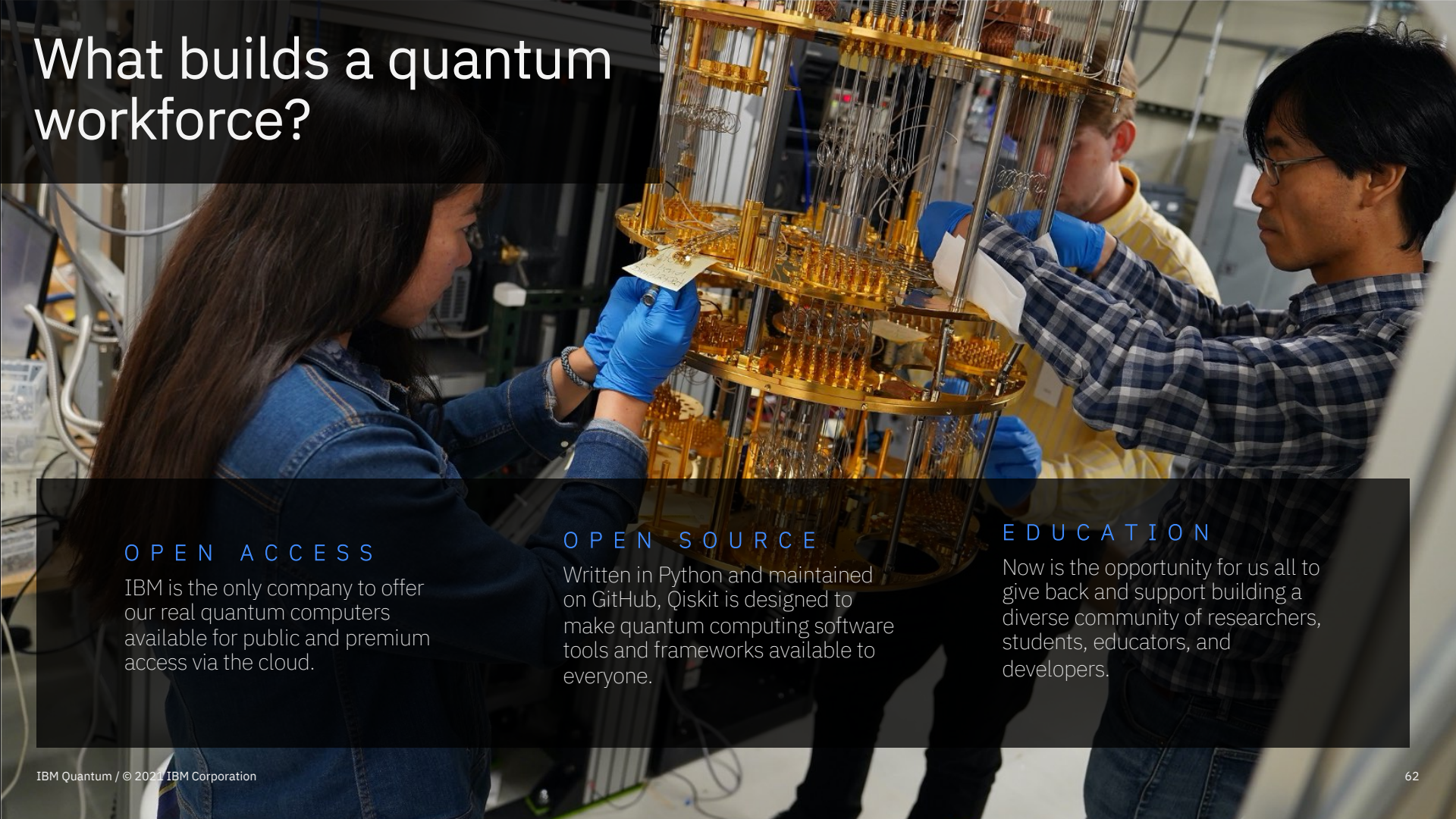
29 quantum computers to date
have deployed on the IBM Cloud.

Spanning 5 to 65 qubits

> 95% system availability to users



What builds a quantum workforce?



OPEN ACCESS

IBM is the only company to offer our real quantum computers available for public and premium access via the cloud.

OPEN SOURCE

Written in Python and maintained on GitHub, Qiskit is designed to make quantum computing software tools and frameworks available to everyone.

EDUCATION

Now is the opportunity for us all to give back and support building a diverse community of researchers, students, educators, and developers.

Learn Quantum Computation using Qiskit



Traditional Quantum Computation Course

Linear Algebra
Quantum Mechanics

Quantum Algorithms

Quantum Hardware

Learn Quantum Computation using Qiskit Textbook

Python
Qiskit

Quantum Programming

Quantum Algorithms on
Today's Hardware

Chapters:

0. Prerequisites
1. Quantum States and Qubits
2. Single Qubits and Multi-Qubit Gates
3. Quantum Algorithms
4. Quantum Algorithms for Applications
5. Investigating Quantum Hardware Using Qiskit
6. Implementations of Recent Quantum Algorithms

Enabling Research: 400+ Papers and Counting... IBM Quantum

Performing Quantum Computing Experiments in the Cloud

Simon J. Devitt

Center for Emergent Matter Science, RIKEN, Wako-shi, Saitama 315-0198, Japan.

(Dated: September 2, 2016)

Quantum computing has become a topic of great interest from both fundamental and applied perspectives. This paper reports on the first experimental demonstration of a quantum computing experiment in the cloud, with users accessing the Qiskit software stack via a web browser. While the results are preliminary, they demonstrate the feasibility of performing quantum computing experiments in the cloud.

PHYSICAL REVIEW A 94, 032314 (2016)

Experimental test of Mermin inequalities on a five-qubit quantum computer

David Ahn and José Ignacio Latorre

Departament d'Àlgebra i Geometria, Universitat de Barcelona, Diagonal 645, 08028 Barcelona, Spain and Institut de Ciències de l'Espai (ICE), CSIC-URCS, Montcada i Reixac 15, 08195 Bellaterra, Spain (Received 25 May 2016; published 11 July 2016)

Violation of Mermin inequalities is tested on the five-qubit IBM quantum computer. For the first time, the violation is observed in a quantum computing experiment in the cloud.

Experimental Comparison of Two Quantum Computing Architectures

N. M. Linke, D. Maslov, M. Bostick, S. Debnath, C. Figgitt, K. A. Landsman, K. Wight, and C. Monroe

¹Joint Quantum Institute and Department of Physics,

Compressed quantum computation using the IBM Quantum Experience

M. Hebenstreit, D. Ahn, J. I. Latorre, and B. Kraus

¹Institute for Theoretical Physics, University of Innsbruck, Innsbruck, Austria
²Dept. Física Quàntica i Astrofísica, Universitat de Barcelona, Diagonal 645, 08028 Barcelona, Spain
³Institut de Ciències de l'Espai, CSIC-URCS, Montcada i Reixac 15, 08195 Bellaterra, Spain

ProjectQ: An Open Source Software Framework for Quantum Computing

Darwin S. Steiger, Thomas Hämmerle, and Matthias Troyer

Institute for Theoretical Physics, ETH Zurich, 8093 Zurich, Switzerland (Dated: December 28, 2016)

We introduce ProjectQ, an open source quantum computing framework. It provides a simple and intuitive interface for writing quantum circuits and simulating them. ProjectQ is designed to be easy to use and to integrate with existing quantum computing software.

Quintuple: a Python 5-qubit quantum computer simulator to facilitate cloud quantum computing

Christine Corbett Moran

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PAPER

Entropic uncertainty and measurement reversibility

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A quantum teleportation experiment for undergraduate students

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With the rapid progress of quantum information these recent years, it becomes more and more

Homomorphic Encryption Experiments on IBM's Cloud Quantum Computing Platform

He-Liang Huang, You-Wei Zhao, Tai Li, Feng-Guang Li, Yu-Tao Du, Xiang-Qin Fu, Shao Zhang, Xiang Wang, and Wan-Su Bao

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Demonstration of entanglement assisted invariance on IBM's Quantum Experience

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Leggett-Garg test of superconducting qubit addressing the clumsiness loophole

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IBM Quantum Computer and the IBM Quantum Experience

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Quantum state reconstruction made easy: a direct method for tomography

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Approximate Quantum Adders with Genetic Algorithms: An IBM Quantum Experience

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state space. It is known and we can never find a system with the same properties. In it should be the Wigner function (GF) and contrast

A Blueprint for a Quantum Hub

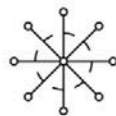
Infrastructure and Resources

Quantum System Access

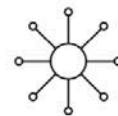
Support and Enablement

Collaboration Center

Engagement Tracks



Industry Applications



Skills and Education



Research



IBM Quantum National Scale Partnership in 2020

IBM, Fraunhofer partner on German-backed quantum computing research push

Douglas Busvine

3 MIN READ



FRANKFURT (Reuters) - IBM is joining forces with a German research institute to explore the potential of quantum computing, backed by a government plan to invest 650 million euros (\$717 million) over two years in wider research in the field.



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IBM News Room



IBM and the University of Tokyo Unveil the Quantum Innovation Initiative Consortium to Accelerate Japan's Quantum Research and Development Leadership
Keio University, Toshiba, Hitachi, Mizuho, MUFG, JSR, DIC, Toyota, Mitsubishi Chemicals and IBM to expand the country-wide quantum computing research, development and education ecosystem



European Researchers' Night

🏠 / European Researchers' Night

<https://www.nocvyskumnikov.sk/european-researchers-night.html>

The festival of science - European Researchers' Night is annually organized event throughout Europe. The ERN is the largest of its kind in Slovakia as well as Europe, bringing together people and researchers in 300 cities in 24 countries on the last Friday of September. **However, this year will be special! Due to coronavirus the organisation of the science festival has been postponed and you will be able to enjoy the science on 27 November 2020. Despite the changed date we are thrilled that the ERN will take place for the 14th time in Slovakia and we are already working on the program. You can be looking forward to new formats and many surprises!**

The main aim of this festival is, above all, to familiarise the general public with science and research. The program activities are designed to bring research out of laboratory and into the city centres, shopping malls, cafés, clubs or museums. The public can try out the latest technologies and instruments under the guidance of scientists, participate in experiments, competitions and quizzes, watch demonstrations and simulations, exchange ideas and party with the researchers.

The project was initiated by the European Commission in 2005. In Slovakia, the European Researchers' Night has been organized since 2007 and is funded by the Horizon 2020, the biggest Research and Innovation EU programme, within the Marie Skłodowska-Curie actions.

The event is traditionally held in five Slovak cities - Bratislava, Banská Bystrica, Žilina, Košice and Poprad and features more than 1,600 researchers from all scientific disciplines and is attended by nearly 160,000 visitors, 72,000 of them young pupils and students. Thus, the Slovak edition of the festival is one of the largest in terms of number of visitors and scientists taking part.

Information

➤ [About festival](#)





Thank you!

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