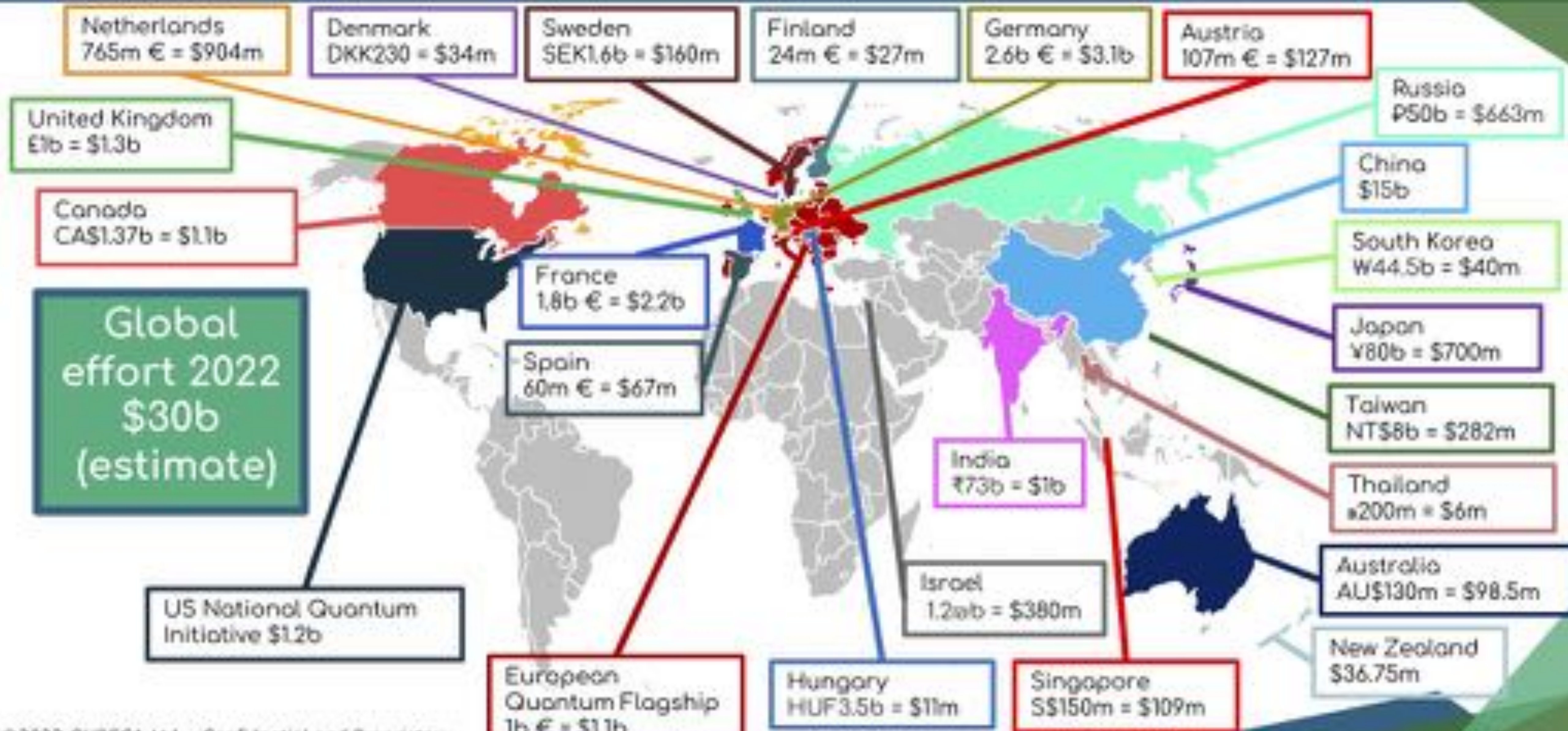
IMPACTO DAS TECNOLOGIAS QUÂNTICAS |NA INDÚSTRIA FINANCEIRA

Samuraí Brito, PhD Física
Head of Quantum
Itaú Unibanco

samurai.brito@itau-Unibanco.com.br
https://www.linkedin.com/in/samurai-brito/

Itaú Quantum Technologies

Quantum effort worldwide



Quantum computing hardware

- rigetti
- D-Wave
- PsiQuantum
- IONQ
- XANADU
- OQC
- atom computing
- ColdQuanta
- Alice & Bob
- Quantum Motion
- Universal Quantum
- qci
- Qilimanjaro
- Oxford Ionics
- seeqc
- Silicon Quantum Computing
- QM Quantum Machines
- bleximo
- ORCA Computing
- AQT

Random number generator

- QUSIDE
- Quantum Dice
- Qrypt
- Crypta Labs
- EYL

Quantum communication

- SPEQTRAL
- Qunnect
- QuantumXchange
- |KETS⟩
- QEYnet
- AuantLR
- quantropi
- IDQ
- CRAFT PROSPECT
- Qubitekk
- VeriQloud
- MagiQ

Quantum computing software

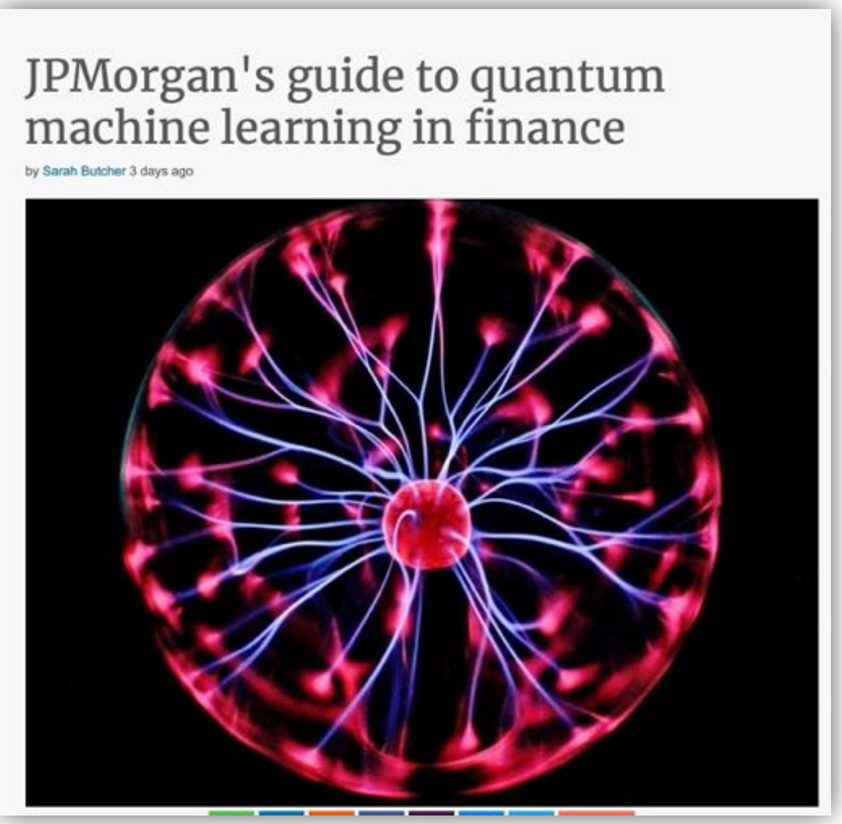
- ZAPATA
- CQC
- Q-CTRL
- 1QBit
- KUANO
- riverlane
- Qu & Co
- ProteinQure
- Aliro Quantum
- menten.AI
- APEXQUBIT
- QCWARE
- Strange Works
- Quantum
- BOXCAT
- QDT
- Quantum Thought
- XOFAA
- HORIZON
- AFT
- NQCO
- QUANTASTICA

Post-quantum cryptography

- ISARA
- cyph
- Ambit
- Post-Quantum
- QuSecure
- evolutionQ
- ZY4
- NXM
- SHIELD

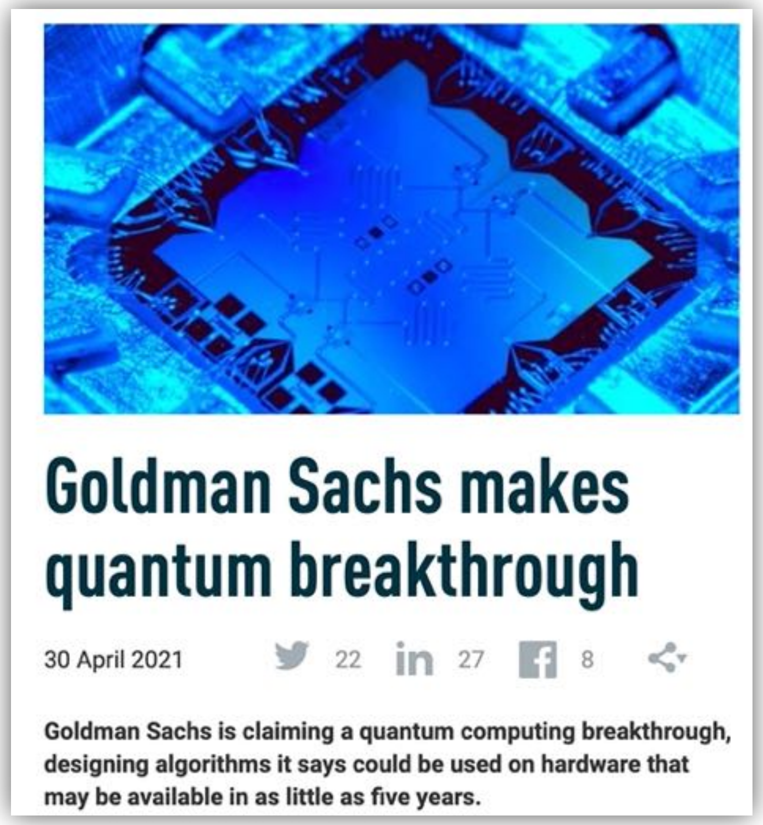
Quantum sensors

- NVISION
- QDTI
- PERATECH
- QLM
- Qnami



JPMorgan's guide to quantum machine learning in finance

by Sarah Butcher 3 days ago



Goldman Sachs makes quantum breakthrough

30 April 2021 22 27 8

Goldman Sachs is claiming a quantum computing breakthrough, designing algorithms it says could be used on hardware that may be available in as little as five years.

Marco Pistoia, head de quantum technologies e head de pesquisa no JPMorgan, junto com alguns membros de seu time, publicaram um artigo enfatizando que a computação quântica irá impactar os serviços financeiros mais cedo que o esperado.

Goldman Sachs e JPMorgan têm construído um forte time de pesquisadores em quantum e Goldman Sachs já tem utilizado alguns métodos para acelerar a precificação de derivativos em cerca de 1000 vezes.

Top 11 Bancos que estão investindo alto em tecnologias quânticas

Wells Fargo
JPMorgan Chase & Co.
ING
Goldman Sachs
HSBC
RBC Royal Bank
Barclays
citi
BNP Paribas
Crédit Agricole
JP Bank ゆうちょ銀行

QC | JPMORGAN É REFERÊCIA EM PESQUISA EM QUANTUM ENTRE BANCOS

10+ Artigos Publicados

Optimizing Quantum Search with a Binomial Version of Grover's Algorithm

Austin Gilliam, Marco Pistoia, and Constantin Gonciulea
JPMorgan Chase
(Dated: July 22, 2020)

The Efficient Preparation of Normal Distributions in Quantum Registers

Arthur G. Rattew, Yue Sun, Pierre Minssen, and Marco Pistoia

On the Exponential Sample Complexity of the Quantum State Sign Estimation Problem

A Domain-agnostic, Noise-resistant, Hardware-efficient Evolutionary Variational Quantum Eigensolver

Arthur G. Rattew,[1,3] Shaohan Hu,[1] Marco Pistoia,[2] Richard Chen[1] and Steve Wood[1]
[1]*IBM T. J. Watson Research Center, Yorktown Heights, NY USA*
[2]*JPMorgan Chase & Co.*

Quantum Machine Learning for Finance

Marco Pistoia, Syed Farhan Ahmad, Akshay Ajagekar, Alexander Buts, Shouvanik Chakrabarti, Dylan Herman, Shaohan Hu, Andrew Jena, Pierre Minssen, Pradeep Niroula, Arthur Rattew, Yue Sun, Romina Yalovetzky
Future Lab for Applied Research and Engineering, JPMorgan Chase Bank, N.A.

CHASE J.P.Morgan

Lab de Pesquisa Aplicada: 31 membros

TECHNOLOGY

Future Lab For Applied Research And Engineering

Conducting applied research focused on frontier technologies to transform scientific findings into business value

Academic Engagements

Offering grants to renowned professors in the academia allows JPMC to be on the forefront of research.

University/Consortium	Professor	Research Area of Focus
Tel Aviv University, Israel	Yaron Oz	Quantum Computing for AI
Chicago Quantum Exchange	David Awschalom	Quantum Algorithms Quantum Key Distribution
University of Waterloo	Michele Mosca	Quantum Key Distribution and Quantum Algorithms

Parceria com pesquisadores renomados de Universidades

Quantum Machine Learning for Finance
Marco Pistoia, Syed Farhan Ahmad, Akshay Ajagekar, Alexander Buts, Shouvanik Chakrabarti, Dylan Herman, Shaohan Hu, Andrew Jena, Pierre Minssen, Pradeep Niroula, Arthur Rattew, Yue Sun, Romina Yalovetzky
Proceedings of the 40th IEEE/ACM International Conference on Computer Aided Design (ICCAD), Munich, Germany. Invited Special Session Paper, November 2021

Clifford Circuit Optimization with Templates and Symbolic Pauli Gates
Sergey Bravyi (IBM), Ruslan Shaydulin (Argonne National Laboratory), Shaohan Hu, Dmitri Maslov (IBM)
Quantum 5, 580 (2021)

Computational Investigations of the Lithium Superoxide Dimer Rearrangement on Noisy Quantum Devices
Qi Gao (Mitsubishi Chemical), Hajime Nakamura (Keio University), Tanvi P. Gujarati (IBM), Gavin O. Jones (IBM), Julia E. Rice (IBM), Stephen P. Wood (IBM), Marco Pistoia, Jeannette M. Garcia (IBM), Naoki Yamamoto (Keio University)
Journal of Physical Chemistry A, 125, 9, 1827-1836, February 2021

Driver Behavior-aware Parking Availability Crowdsensing System Using Truth Discovery
Yi Zhu (SUNY Buffalo), Abhishek Gupta (SUNY Buffalo), Shaohan Hu, Weida Zhong (SUNY Buffalo), Lu Su (Purdue University), Chunming Qiao (SUNY Buffalo)
ACM Transactions on Sensor Networks, Volume 17, Issue 4, Article No. 41, November 2021

Grover Adaptive Search for Constrained Polynomial Binary Optimization
Austin Gilliam, Stefan Woerner (IBM), Constantin Gonciulea
Quantum 5, 428 (2021)

Portfolio Optimization for Near-Term Quantum Hardware
Romina Yalovetzky, Pierre Minssen, Dylan Herman, Marco Pistoia
arXiv:2110.15958, October 2021

The Efficient Preparation of Normal Distributions in Quantum Registers
Arthur Rattew, Yue Sun, Pierre Minssen, Marco Pistoia
arXiv:2009.06601, July 2021

On the Exponential Sample Complexity of the Quantum State Sign Estimation Problem
Arthur Rattew, Marco Pistoia
arXiv:2108.03193, August 2021

Foundational Patterns for Efficient Quantum Computing
Austin Gilliam, Charlene Venci, Sreraman Muralidharan, Vitaliy Dorum, Eric May, Rajesh Narasimhan, Constantin Gonciulea
arXiv:1907.11513, January 2021

2021

Itaú e QC Ware usam algoritmos de computação quântica para fortalecer retenção de clientes

Por **Redação** - 4 de maio de 2022 0

Like 1

O Itaú Unibancoe a QC Ware, líder em software e serviços quânticos, anunciam os primeiros resultados de uma colaboração que explora o uso de algoritmos de computação quântica no setor bancário. O objetivo do projeto conjunto, que durou quatro meses, é investigar se a computação quântica pode ajudar na retenção de clientes. O algoritmo de quantum machine learning proposto pela QC Ware melhora o desempenho dos modelos usados atualmente para prever a perda de clientes.

QCWARE TECHY INSIGHT

QC Ware Applies Quantum Computing Ideas to Improve Buyer Retention at Itaú Unibanco

May 5, 2022 by techyinsight_e6herc

Monetary Quantum Algorithm Identifies Extra At-Danger Banking Clients
Quantum algorithm defines future accuracy and efficiency benefits and evokes enhancements immediately

Itaú Quantum Technologies

QCWARE


Managing a Quantum Computing Team—Insights and Challenges at Itaú Unibanco
Publisher: IEEE
Cite This
PDF
Rafael Sotelo ; Terrill L. Frantz ; Samuraí Brito ; Vanessa Fernandes da Silva ; André Juan Ferreira Martins
All Authors
51 Full Text Views
Abstract
Document Sections
Introduction
Itaú Unibanco
Abstract:
Quantum computing technology is developing rapidly. Technology managers are now faced with pressure to bring the emerging technology in-house, albeit perhaps stealthy. This article presents the story of a large Brazilian financial services firm that is facing the quantum "opportunity" head-on. We provide insights into the challenge of introducing nonproven technology to this one particular organization. In addition to team-level management, other aspects in the realm of organization-level


Quantum Latino
Building a connected Quantum Community in Latin-America
QURECA
Quantum-South
Women in Quantum Panel @Quantum Latino 2022


IV ECMCE
IV ENCONTRO CEARENSE DE MULHERES NAS CIÊNCIAS EXATAS
MULHER ONDE É O SEU LUGAR?


Como fazer ciência na indústria financeira?
CONECTA live
MUSEU CIÊNCIA E VIDA
1:05:18
Como fazer ciência na indústria financeira?
1,8 mil visualizações • Transmitido há 5 meses
Museu Ciência e Vida
Em comemoração ao Dia das Meninas e Mulheres na Ciência, vamos receber Samuraí Brito no espaço virtual do...


PODCAST
THE SHIFT
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EPISÓDIO #129
Prática Quântica
CONVIDADOS
ROBERTO FIGUEIRA ITAÚ
SAMURAÍ BRITO ITAÚ
THE SHIFT #129
PRÁTICA QUÂNTICA
10/06/2022


Samuraí Gomes de Aguiar Brito
South America
IBM Quantum
IBM
Qiskit Advocate
Advanced
Natal, Brazil
@samuraigab


• Palestra: "Computação quântica no Itaú: como a tecnologia pode ser aplicada à indústria financeira"
Universidade Presbiteriana Mackenzie
Palestrante: Samuraí Brito
Especialista em Tecnologias Quânticas no Itaú Unibanco desde janeiro de 2021, atua no estudo e desenvolvimento de novas aplicações com a tecnologia na indústria financeira. A especialista possui licenciatura, mestrado e doutorado em física pela Universidade Federal do Rio Grande do Norte, além de pós-doutorado em teoria da informação quântica pelo Instituto Internacional de Física.

QC | ITAÚ QUANTUM – AÇÕES EXTERNAS 2022

Rede Nacional de Tecnologias Quânticas Computacionais abre os trabalhos na Bahia

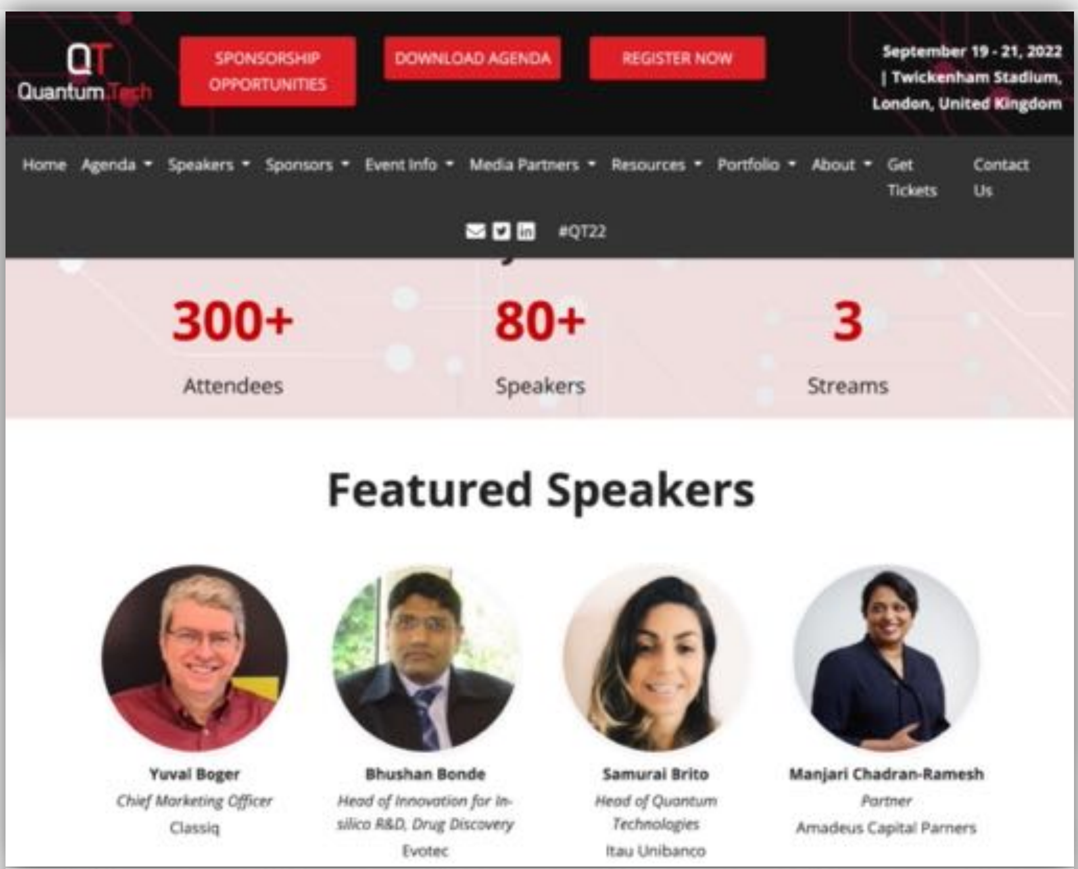
Especialistas se reuniram em Salvador para discutir projetos de desenvolvimento da tecnologia disruptiva

Nos dias 11 e 12 de abril, o SENAI CIMATEC sediou o I Fórum da Rede MCTI Softex de Tecnologias Quânticas Computacionais. O evento marcou a criação da Rede nacional e o início das atividades do grupo, formado pelo Ministério da Ciência e Tecnologia e Inovações, universidades, startups, empresas, associações, institutos de pesquisa em tecnologias quânticas e pelo SENAI CIMATEC, coordenador da iniciativa.

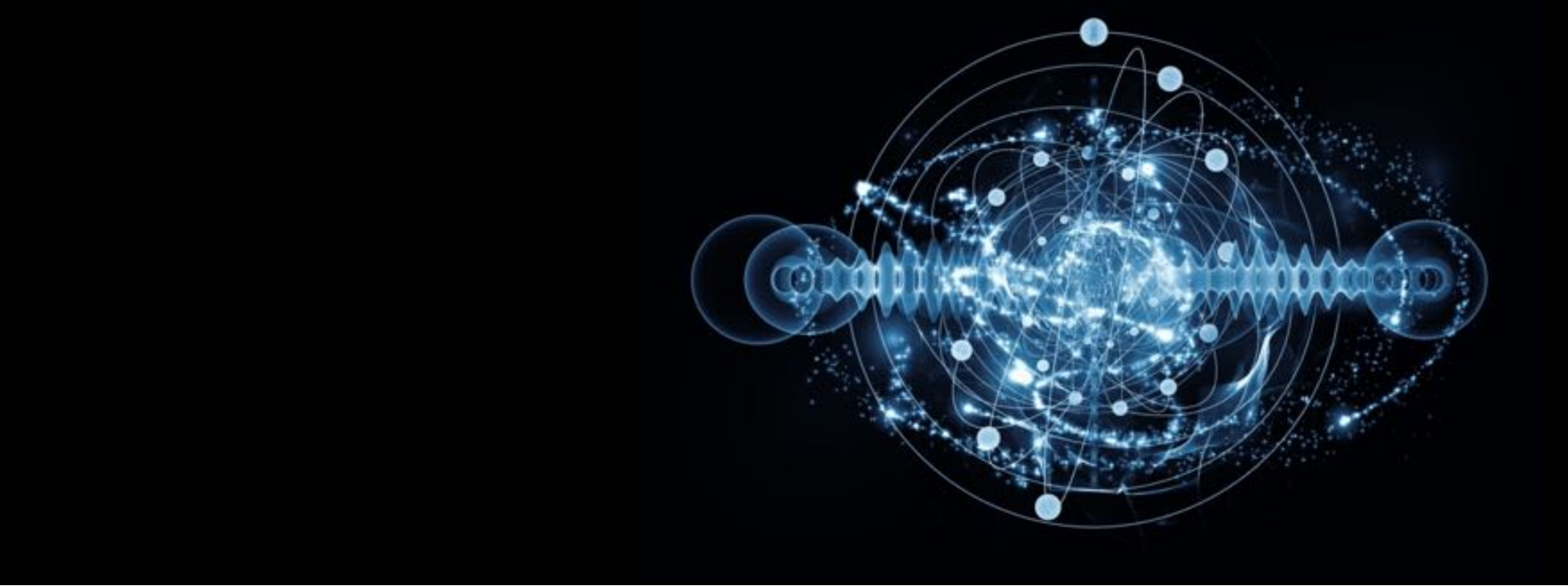
As empresas que participaram do evento e das primeiras iniciativas: Banco BV, Atos, Pitec, Petrobrás, Idea e Itaú. As startups que integram o grupo são: Brazil Quantum, Dobslit, Quantum Loop, KET, DualQ e QuBE.

As tecnologias quânticas, suas aplicações e tendências foram o assunto do Inovação em Foco virtual realizado pelo CPQD nesta segunda-feira, 11 de julho. A live contou com a participação de dois convidados especiais, que apresentaram o tema aos colaboradores da organização: Samuraí Brito, responsável pela área de Tecnologias Quânticas do Itaú-Unibanco, e Gustavo Wiederhecker, físico e professor da Unicamp (Universidade Estadual de Campinas).

Os convidados abordaram as diversa... **See more**



Não



QUANTUM TECHNOLOGIES | Segurança

Itaú Quantum Technologies

IBM → **SUMMIT**
10 mil anos
(2,5 dias) →

→ **SYCAMOR E 3min e 20s**

RSA-2048 (Assimétrica)

CLÁSSICO	QUÂNTICO	PERIGOS
300 milhões de anos	• 10 segundos • 4099 qubits	RSA / ECC / Diffi Hellmann

Criptografia Pós-Quântica

Science

NEWS | PHYSICS

Ordinary computers can beat Google's quantum computer after all

Superfast algorithm put crimp in 2019 claim that Google's machine had achieved "quantum supremacy"

2 AUG 2022 · 5:05 PM · BY ADRIAN CHO

nétrica)

PERIGOS

RSA / ECC / Diffi Hellmann

(2,5 dias)

Quântica

NOMURA NICT TOSHIBA Orchestrating a brighter world NEC SIP

December 21, 2020
Nomura Holdings, Inc.
Nomura Securities Co., Ltd.
National Institute of Information and Communications Technology
Toshiba Corporation
NEC Corporation

Beginning Joint Verification Tests on Quantum Cryptography Technology to Enhance Cybersecurity in the Financial Sector

-Testing practicality in large-capacity and low-latency communications in stock transactions-

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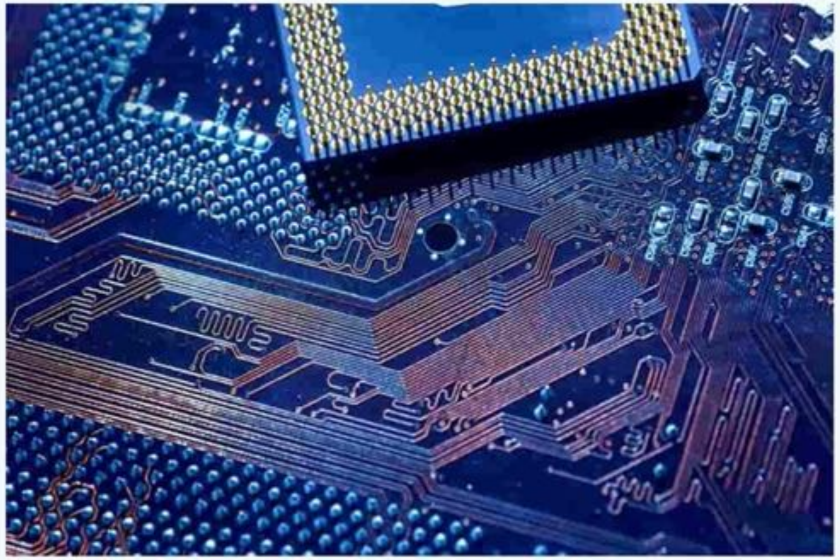
CIO JOURNAL

Visa, JPMorgan Are Already Preparing for Potential Quantum Cyberattacks

A powerful quantum computer could be capable of breaking the internet's most commonly used cryptography

TECHNOLOGY NEWS

Quantum computers could crack Bitcoins security in the next decade, scientists estimate



1,9 bilhões de qubits – 10 min
347 milhões de qubits – 1h
13 milhões de qubits – 1 dia

[The impact of hardware specifications on reaching quantum advantage in the fault tolerant regime](#)

Jan 11, 2022, 09:30am EST | 517 views

The Quantum Threat To Cryptography: Don't Panic, But Prepare Now

"2030 – full-scale quantum computers"

Forbes Technology Council

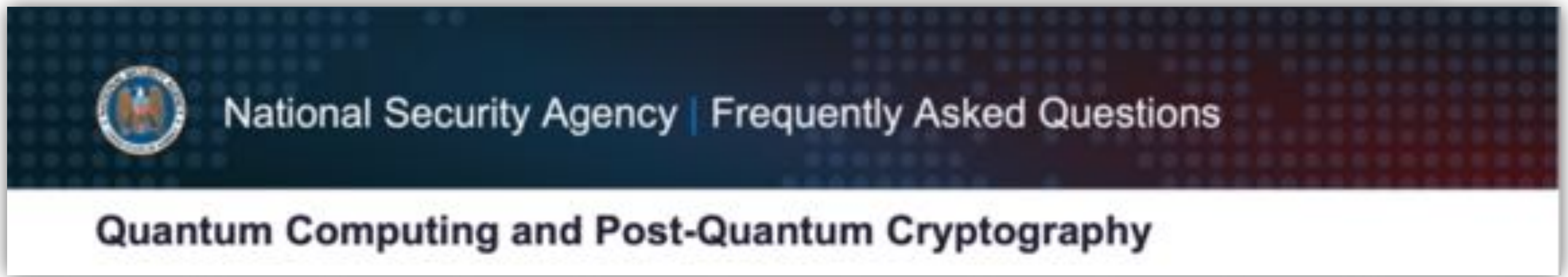
Mike Brown Forbes Councils Member
Forbes Technology Council
COUNCIL POST | Membership (Fee-Based)
Innovation

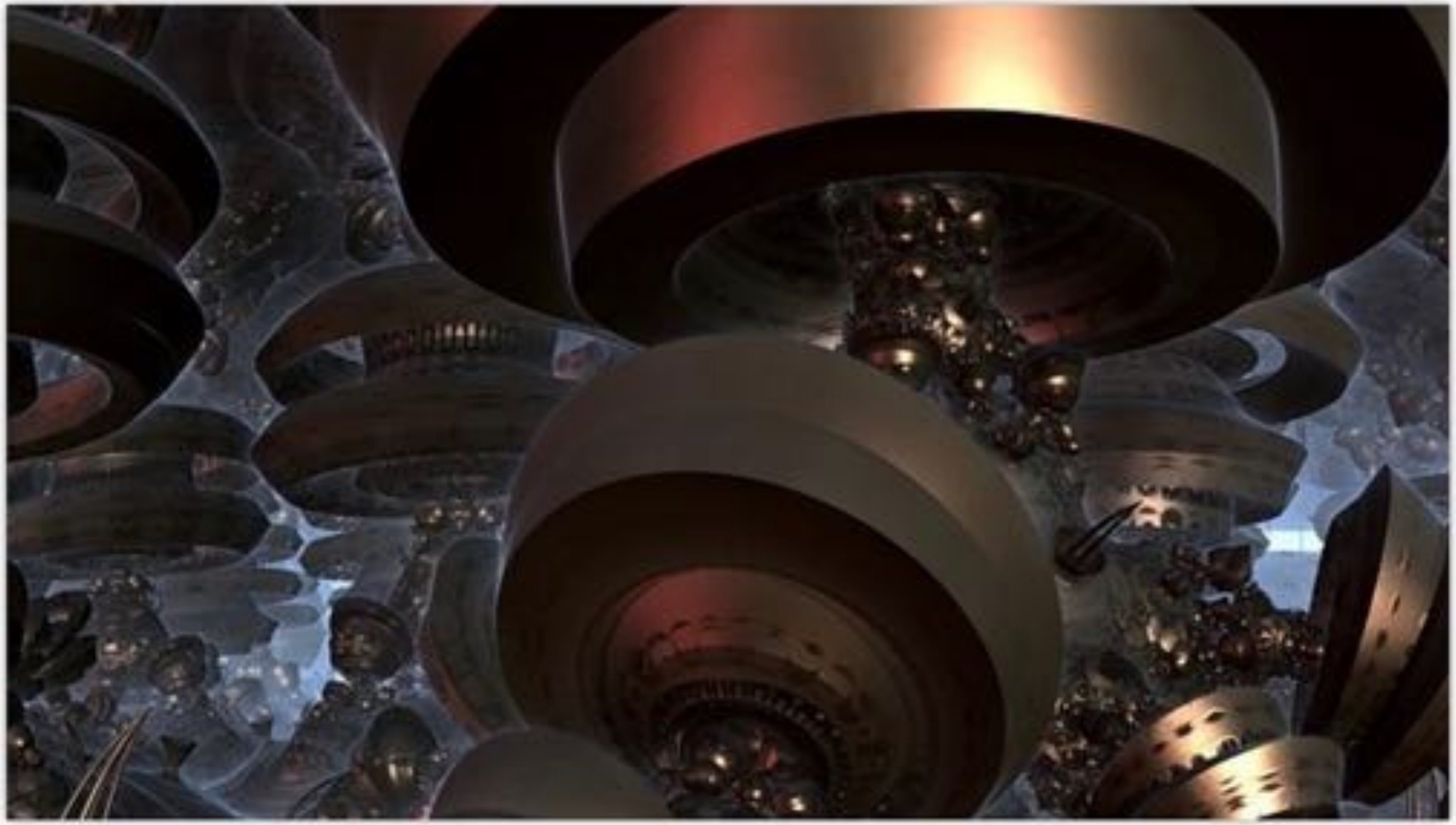
CTO and co-founder at ISARA Corporation. Focused on technology for crypto agility and quantum safety.

The National Institute of Standards and Technology (NIST) is a government agency that helps set standards for technology. Lily Chen, who heads NIST's cryptographic technology group, said we will probably be dealing with the practical implications of quantum computers within 10 years.

"Experts predict that, around 2030, we'll have full-scale quantum computers that can break asymmetric key cryptography," Chen said. "So that will give us *some* time."

QC | PREPARAÇÃO PARA O FUTURO PÓS-QUÂNTICO





EUA criam roteiro para transição para criptografia pós-quântica

Governo americano desenvolveu um roteiro para ajudar as organizações a realizarem a transição para a criptografia pós- computador quântico


PRIVACY AND SECURITY

Supposedly Quantum-Proof Encryption Cracked by Basic-Ass PC

An encryption algorithm that was supposed to stand up to attacks from the future's most powerful computers was recently laid low by a much simpler machine.

By Lucas Ropek

Tuesday 5:05PM | Comments (19) | Alerts

CRIPTOGRAFIA DESTAQUES NOTÍCIAS

NIST anuncia os primeiros quatro algoritmos criptográficos resistentes ao computador quântico


THE QUANTUM INSIDER
Post-Quantum Safe Algorithm Candidate Cracked in an Hour on a PC
BY MATT SWAYNE
AUGUST 5, 2022
RESEARCH
CRIPT
NIST
comp

THE QUANTUM INSIDER

Post-Quantum Safe Algorithm Candidate Cracked in an Hour on a PC

BY MATT SWAYNE

AUGUST 5, 2022

RESEARCH

CRIPT

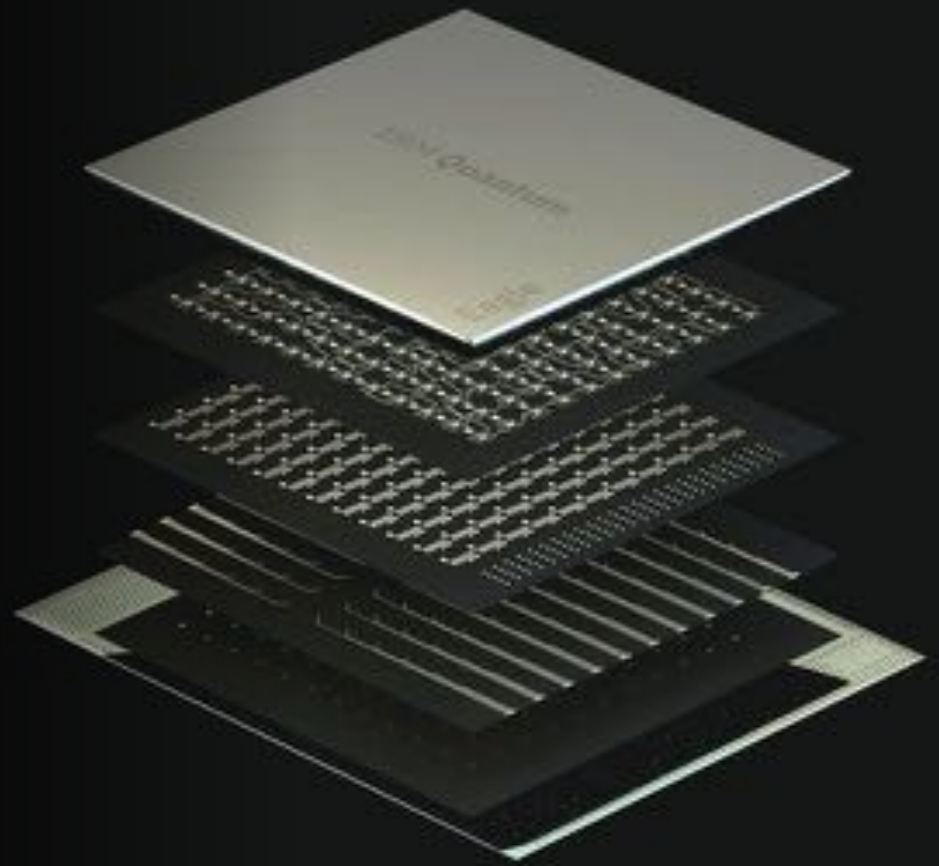
NIST

comp

Startingly, the hack was performed on a classical computer — and took about an hour to complete.

They write: "A run on the SIKEp434 parameters, previously believed to meet NIST's quantum security level 1, took about 62 minutes, again on a single core. We also ran the code on random instances of SIKEp503 (level 2), SIKEp610 (level 3) and SIKEp751 (level 5), which took about 2h19m, 8h15m and 20h37m, respectively."

SIKE was among several algorithms that passed a NIST competition to identify and define standardized post-quantum algorithms. Because quantum computers represent a threat to current measures for securing information and data, the organization wanted to pinpoint algorithms that stood the best chance of withstanding attacks from quantum computers.



QUANTUM TECHNOLOGIES | Computação Quântica

Itaú Quantum Technologies

Que linguagem utilizar para programar em um computador quântico?

Machine learning interfaces

Quantum hardware and simulators

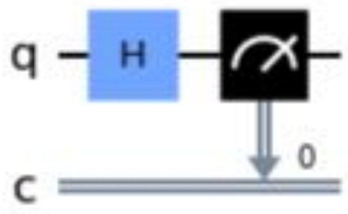
In [15]:

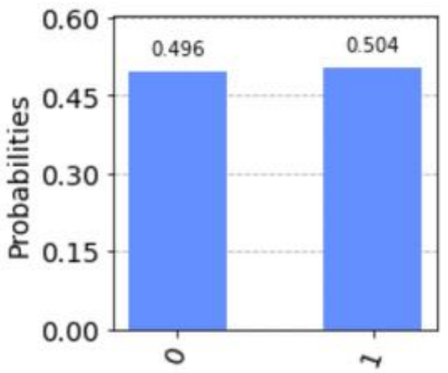
```python
from qiskit import *
from qiskit.visualization import *


qubit = QuantumRegister(1,'q')
bit = ClassicalRegister(1,'c')

circuito = QuantumCircuit(qubit, bit)
circuito.h(qubit)
circuito.measure(qubit, bit)
circuito.draw('mpl')
```

Out[15]:





Matrizes, vetores, Álgebra linear e noção de mecânica quântica

QC - Casos de Uso Potenciais

- ✓ **Inteligência artificial mais rápida e eficaz**
  - ✓ **Processar grandes quantidades de dados em velocidades incomparáveis e simular redes neurais de tamanhos enormes.**
- ✓ **Baterias para carros elétricos que são mais eficientes em termos de energia**
  - ✓ **A computação quântica pode proporcionar melhorias nas áreas de simulação celular e no envelhecimento das células da bateria**
- ✓ **Desenvolvimento de novos medicamentos**
  - ✓ **Os computadores quânticos são adequados para resolver esse problema, pois a interação de átomos dentro de uma molécula é um sistema quântico. De fato, os especialistas acreditam que os computadores quânticos serão capazes de modelar até as moléculas mais complexas em nossos corpos. Usando computação quântica, as empresas farmacêuticas podem modelar moléculas maiores e mais complexas, melhores interações de mapear entre um medicamento e seu paciente -alvo e reduzir o tempo e os custos dos processos de desenvolvimento. Isso pode levar a melhores diagnósticos, medicamentos e vacinas que chegam mais cedo e com mais eficiência ao mercado.**
- ✓ **Otimização de tráfego**
  - ✓ **Usando computação quântica, as empresas farmacêuticas podem modelar moléculas maiores e mais complexas, melhores interações de mapear entre um medicamento e seu paciente -alvo e reduzir o tempo e os custos dos processos de desenvolvimento. Isso pode levar a melhores diagnósticos, medicamentos e vacinas que chegam mais cedo e com mais eficiência ao mercado.**
- ✓ **A criação de novos materiais**
- ✓ **Modelagem problemas em finanças**
- ✓ **Cyber segurança**
- ✓ **Previsão de Mudanças Climáticas**
- ✓ **Manufacturing Processes**

QC | BIG BANKS WORKING WITH QUANTUM

J.P.Morgan

JPMorgan Chase & Co. is an American multinational investment bank and financial services holding company headquartered in New York City which is now making efforts to scale its quantum tech effort. Realizing quantum computing (QC) will be important for use cases in banking, the bank established a quantum engineering team, with Marco Pistoia head of quantum technology.

Very enthusiastic about developing quantum algorithms that the bank can use in AI, optimization and cryptography, in 2020 it began a partnership with a quantum technology hub called the Chicago Quantum Exchange, a quantum technology hub, and said that its research team is "actively working in the area of post-quantum cryptography."

BARCLAYS

Barclays plc is a British multinational universal bank, headquartered in London, England. Its journey into quantum computing began in 2017. Spending a long period of time learning about the technology until they felt confident in it, Barclays came to the conclusion that "quantum computing's potential was so great that we should commit to an initial programme of research and development."

Since then, the bank has conducted in-depth experimentation using the technology, mainly to gauge how it could be used to make improvements in the banking industry.

Currently, Barclays is leading experiments centred on some very specific challenges they come across in the banking industry, like initial tests focused on how quantum computing could potentially help them to optimize the settlement of batches of securities transactions.

WELLS FARGO

Wells Fargo is an American multinational financial services company with corporate headquarters in San Francisco, California and operational headquarters in Manhattan. Back in 2019, Wells Fargo's technology chief, Saul Van Beurden, started the bank's venture into quantum computing by signing an agreement with IBM and MIT to collaborate on quantum computing and artificial intelligence technology. His attitude on quantum technology is clear:

"THERE ARE THREE CAMPS IN THE INDUSTRY. THERE'S THE CAMP THAT SAYS QUANTUM WILL NEVER COME TO PRODUCTION. THERE IS THE CAMP OF PEOPLE WHO BELIEVE IT WILL TAKE A LONG TIME BEFORE IT WILL GET IN PRODUCTION, A LONG TIME DEFINED AS 10 OR 15 YEARS, MAYBE LONGER. AND THERE IS A CAMP THAT SAYS, WELL, THINGS MIGHT GO FASTER. YOU'D BETTER TEST AND LEARN AND BE ON IT, BECAUSE IF THIS WAVE STARTS TO TAKE OFF, IT MIGHT HAVE GAME-CHANGING IMPACT FOR THE INDUSTRY. WE ARE IN THE THIRD CAMP. THAT'S WHY WE SIGNED UP. WE DON'T WANT TO BE THE BANK THAT HAS REGRETS IN A FEW YEARS."

HSBC

HSBC Bank plc is a British multinational banking and financial services organization. Like others, it is aware how important QC will be for the financial sector in the coming years in areas such as risk analytics, ML and cybersecurity. Because of this, it has got the ball rolling with collaborations with other companies and research laboratories to investigate the potential of this state-of-the-art technology.

HSBC will work alongside The European NEASQC (Next Applications of Quantum Computing) project to develop practical use cases in fields as diverse as drug discovery, breast cancer detection, carbon capture and energy infrastructure risk assessments. The four-year project, working with a budget of EUR4.7 million (USD5.5 million) and fully funded from the European Union's Horizon 2020 research and innovation programme, harnesses the expertise of specialists in quantum computing.

Gustavo Ordonez-Sanz, Head of Economic Capital Analytics and Global Risk Innovation Lead, HSBC, said:

citi

Citigroup Inc. or Citi is an American multinational investment bank and financial services corporation headquartered in New York City. Citigroup named quantum computing as one of the five tech trends to watch in 2019, as "quantum computing can help revolutionize financial services by improving trading algorithms, reducing fraud, optimizing portfolios, and managing risk."

The bank has also invested in quantum computing software startups like 1QBit and QC Ware, proving Citigroup is taking the quantum revolution seriously, with William Hartnett, the managing director at Citigroup, even saying the technology will transform risk assessment and trading for the financial industry and remarked that "banks need to start learning how to harness it now."

Goldman Sachs

One of the more high-profile adopters of quantum technology, the Goldman Sachs Group, Inc. is an American multinational investment bank and financial services company headquartered in New York City. The bank has been working with Silicon Valley startup QC Ware for a few years now to investigate the use of quantum algorithms in finance, exploring how the technology will eventually outperform classical computers for finance applications.

William Zeng, head, quantum research, Goldman Sachs, believes:

"QUANTUM COMPUTING COULD HAVE A SIGNIFICANT IMPACT ON FINANCIAL SERVICES, AND OUR NEW WORK WITH QC WARE BRINGS THAT FUTURE CLOSER."

Quantum Computing | Exemplos de Casos de Uso em Finanças

		Cases	Experimentando
Optimization	1	Portfolio selection alloc. & optimization	Natwest, BBVA, CBA, Standard Chartered,
	2	Optimal execution	
	3	Capital allocation	
	4	Asset liability management	
	5	Transaction settlement	Barclays
	6	Yield curve fitting	
Machine Learning	7	Credit scoring / clutering	CaixaBank
	8	Default early warnings	
	9	Fraud detection/ AML	
Pricing & Simulation	10	Derivative Pricing	JP Morgan, Goldman Sachs, BMO, Scotiabank
	11	Valuation and regulatory ratios	HSBC
	12	Risk assessment & tail risk simulations	CaixaBank
	13	Multi-fator interest rate models	

Monte Carlo

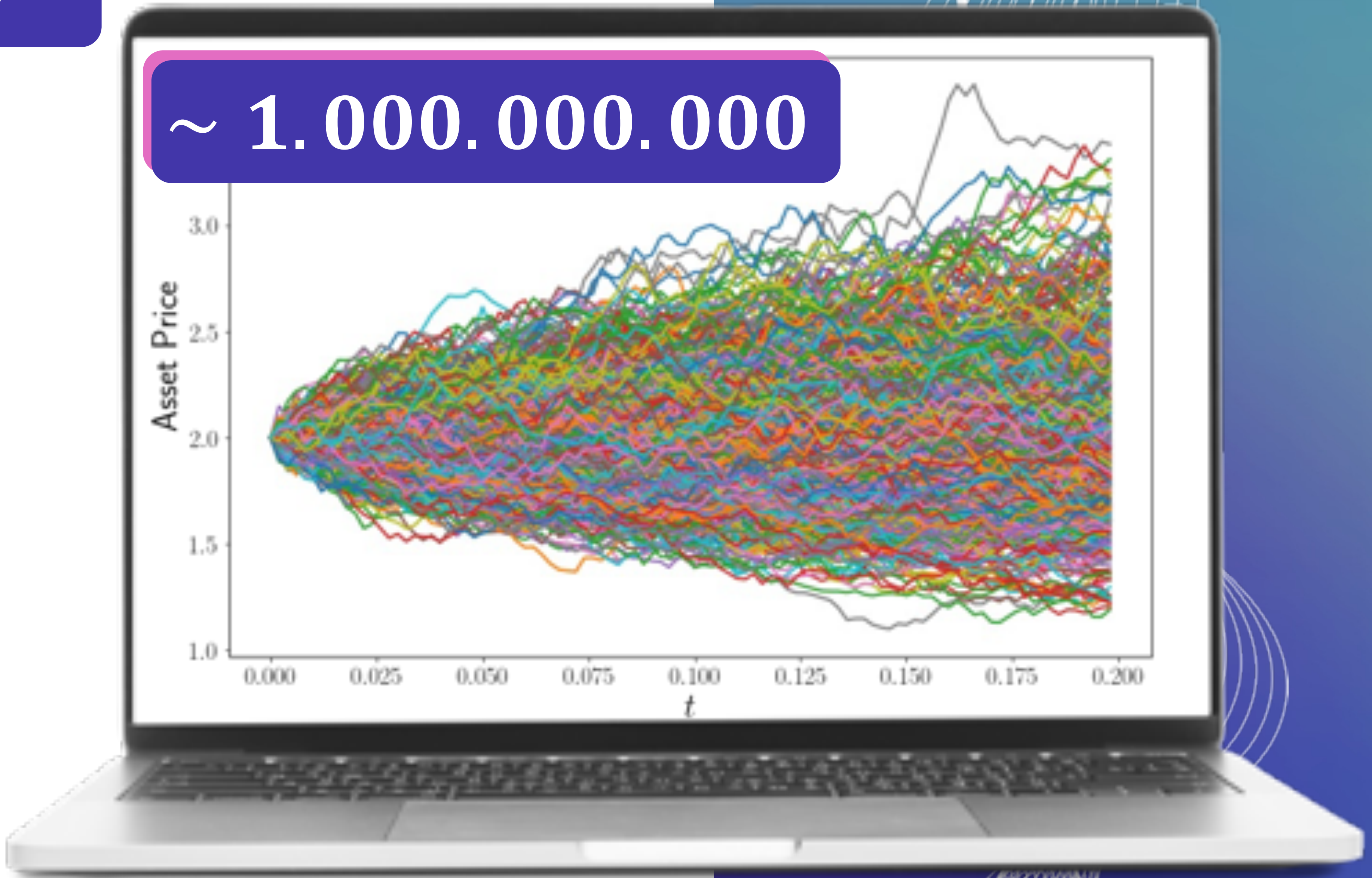
Quantum Monte Carlo

Será?

"Redução do número de simulações diárias."

~ 35.000

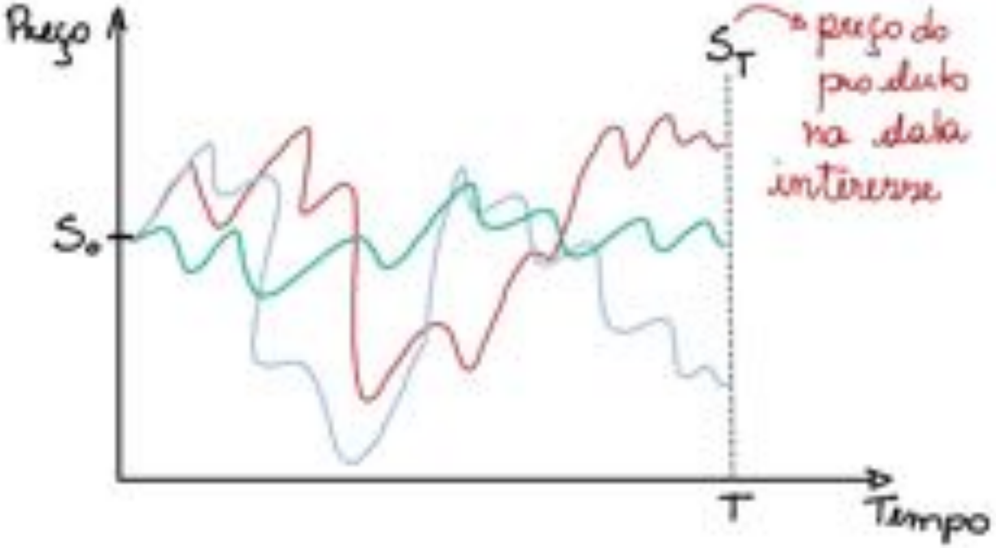
~ 1.000.000.000



Precificação De Derivativos

Precificar um produto no futuro, dados as inforções que temos hoje

Simulamos diversos cenários



Objetivo: "Estimar o valor da esperado da função Payoff na data de vencimento."

$$\mathbb{E}[f(S)] = \frac{1}{M}\sum_{i=1}^{M} f(S_i)$$

onde,

$$f(S_T) = \begin{cases} \max(0, S_T - K) & \text{if } S_T > K \\ 0 & \text{otherwise} \end{cases}$$

CLÁSSICO: $\epsilon \sim O(M^{-1/2})$

QUÂNTICO: $\epsilon \sim O(M^{-1})$

$M_C \sim \frac{1}{\epsilon^2}$ $\quad M_Q \sim \frac{1}{\epsilon}$ $\quad M_Q \sim \sqrt{M_C}$

https://ibm-q-financial-demo.mybluemix.net/#simulator

Quantum Information Processing (2020) 19:75
https://doi.org/10.1007/s11128-019-2565-2

npj Quantum Information www.nature.com/npjqi

ARTICLE OPEN

Iterative quantum amplitude estimation

Dmitry Grinko[1,2,3], Julien Gacon[1,2], Christa Zoufal[1,2] and Stefan Woerner[1] ✉

We introduce a variant of *Quantum Amplitude Estimation (QAE)*, called *Iterative QAE* (IQAE), which does not rely on *Quantum Phase Estimation* (QPE) but is only based on *Grover's Algorithm*, which reduces the required number of qubits and gates. We provide a rigorous analysis of IQAE and prove that it achieves a quadratic speedup up to a double-logarithmic factor compared to classical Monte Carlo simulation with provably small constant overhead. Furthermore, we show with an empirical study that our algorithm outperforms other known QAE variants without QPE, some even by orders of magnitude, i.e., our algorithm requires significantly fewer samples to achieve the same estimation accuracy and confidence level.

npj Quantum Information (2021)7:52 ; https://doi.org/10.1038/s41534-021-00379-1

form. However, the whole procedure is hard to implement with current and near-term

portional to $1/\sqrt{a}$, assuming algorithm $\mathcal{A}$ makes no measurements.

Option Pricing using Quantum Computers

Nikitas Stamatopoulos[1], Daniel J. Egger[2], Yue Sun[1], Christa Zoufal[2,3], Raban Iten[2,3], Ning Shen[1], and Stefan Woerner[2]

[1]Quantitative Research, JPMorgan Chase & Co., New York, NY,
[2]IBM Quantum, IBM Research – Zurich
[3]ETH Zurich

We present a methodology to price options and portfolios of options on a gate-based quantum computer using amplitude estimation, an algorithm which provides a quadratic speedup compared to classical Monte Carlo methods.

A Threshold for Quantum Advantage in Derivative Pricing

Shouvanik Chakrabarti[1,2], Rajiv Krishnakumar[1], Guglielmo Mazzola[3], ... William J. Zeng[1]

... required for valuable quantum advan- ... the first complete resource estimates for ... callable and Target Accrual Redemption ... cases. We uncover blocking challenges ... method for quantum derivative pricing - ... them. This method combines pre-trained ... computing to dramatically reduce re- ... mark use cases we examine require 8k ... We estimate that quantum advantage ... order of a second. While the resource ... current systems, we hope they will pro- ... gorithms, implementations, and planned

PHYSICAL REVIEW A **103**, 032414 (2021)

Editors' Suggestion

Quantum unary approach to option pricing

Sergi Ramos-Calderer,[1,2,*] Adrián Pérez-Salinas,[1,3] Diego García-Martín,[1,3,4] Carlos Bravo-Prieto,[1,3] Jorge Cortada,[5] Jordi Planagumà,[5] and José I. Latorre[1,2,6]

[1]*Departament de Física Quàntica i Astrofísica and Institut de Ciències del Cosmos (ICCUB), Universitat de Barcelona, Martí i Franquès 1, 08028 Barcelona, Spain*
[2]*Quantum Research Centre, Technology Innovation Institute, Abu Dhabi, United Arab Emirates*
[3]*Barcelona Supercomputing Center (BSC), 08034 Barcelona, Spain*
[4]*Instituto de Física Teórica, UAM-CSIC, Madrid, Spain*
[5]*Caixabank, Barcelona, Spain*
[6]*Center for Quantum Technologies, National University of Singapore, Singapore*

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We present a quantum algorithm for European option pricing in finance, where the key idea is to work in the unary representation of the asset value. The algorithm needs novel circuitry and is divided in three parts: first, the amplitude distribution corresponding to the asset value at maturity is generated using a low-depth circuit; second, the computation of the expected return is computed with simple controlled gates; and third, standard amplitude estimation is used to gain quantum advantage. On the positive side, unary representation remarkably simplifies the structure and depth of the quantum circuit. Amplitude distributions use quantum superposition to bypass the role of classical Monte Carlo simulation. The unary representation also provides a postselection consistency check that allows for a substantial mitigation in the error of the computation. On the negative side, unary representation requires linearly many qubits to represent a target probability distribution, as compared to the logarithmic scaling of binary algorithms. We compare the performance of both unary vs binary option pricing algorithms using error maps, and find that unary representation may bring a relevant advantage in practice for near-term devices.

DOI: 10.1103/PhysRevA.103.032414

npj | Quantum Information

ARTICLE OPEN

Quantum risk analysis

Stefan Woerner[1] and Daniel J. Egger[1]

We present a quantum algorithm that analyzes risk more efficien... computers. We employ quantum amplitude estimation to price ... Conditional Value at Risk on a gate-based quantum computer. Add... trade-off the convergence rate of the algorithm and the circuit dep... the number of qubits representing the uncertainty—leads to a c... This is already faster than classical Monte Carlo simulations which... grow faster, but still polynomially, the convergence rate quickly ... circuit depths our algorithm provides a near quadratic speed-up ... algorithm using two toy models. In the first model we use real ... (T-bill) faced by a possible interest rate increase. In the second model, we simulate our algorithm to illustrate how a quantum computer can determine financial risk for a two-asset portfolio made up of government debt with different maturity dates. Both models confirm the improved convergence rate over Monte Carlo methods. Using simulations, we also evaluate the impact of cross-talk and energy relaxation errors.

npj Quantum Information (2019)5:15 ; https://doi.org/10.1038/s41534-019-0130-6

... A **98**, 022321 (2018)

... Carlo pricing of financial derivatives

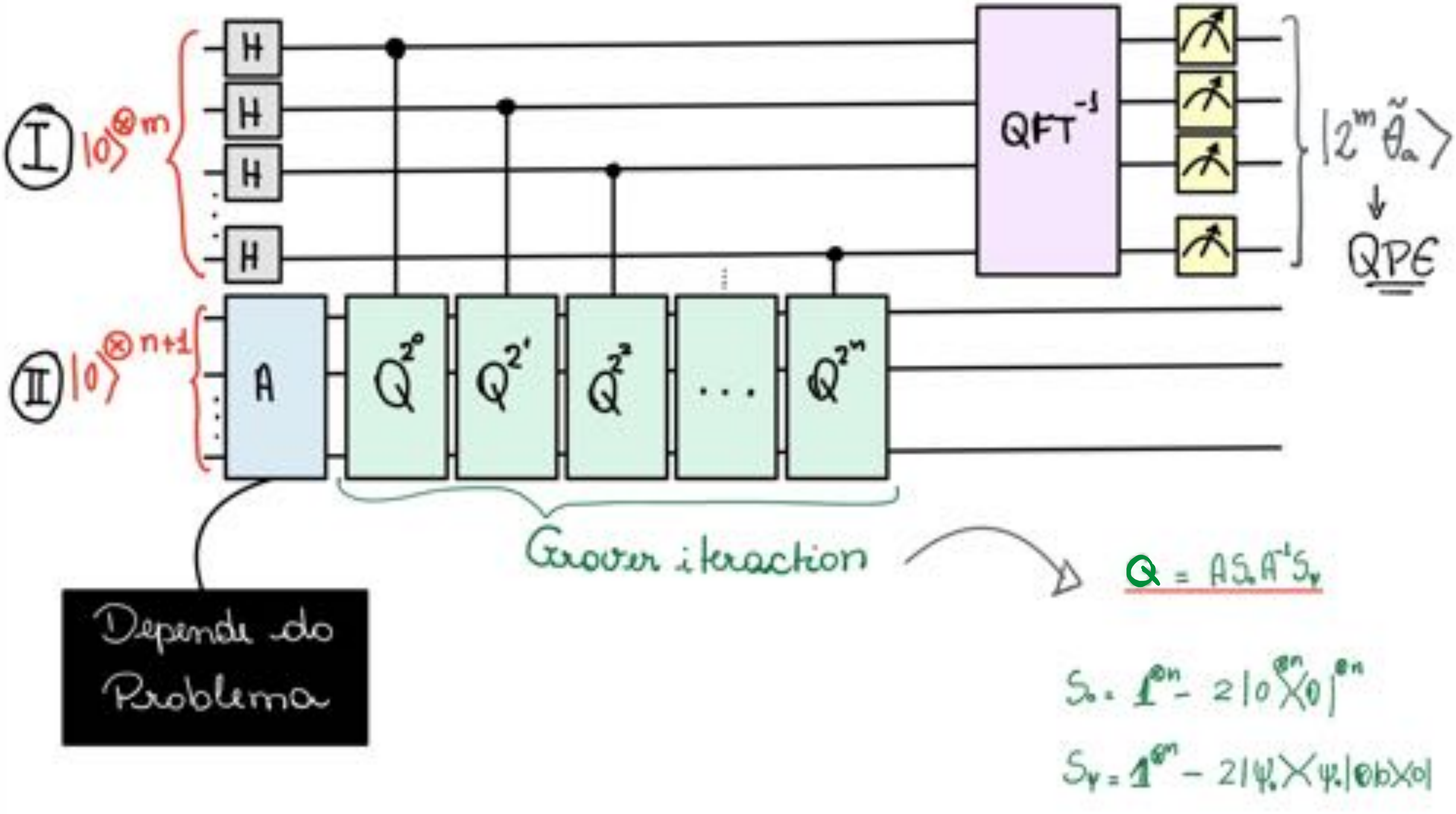
...,[†] and Thomas R. Bromley[†]
...oronto, Canada M5V 2L7*

...ublished 20 August 2018)

This work presents a quantum algorithm for the Monte Carlo pricing of financial derivatives. We show how the relevant probability distributions can be prepared in quantum superposition, the payoff functions can be implemented via quantum circuits, and the price of financial derivatives can be extracted via quantum measurements. We show how the amplitude estimation algorithm can be applied to achieve a quadratic quantum speedup in the number of steps required to obtain an estimate for the price with high confidence. This work provides a starting point for further research at the interface of quantum computing and finance.

DOI: 10.1103/PhysRevA.98.022321

Estrutura do Circuito – Quantum Amplitude Estimation with Quantum Phase Estimation



- Atuação do operador A

$$A|0\rangle^{\otimes n+1} = \sqrt{1-a}\,|\psi_0\rangle_n|0\rangle + \sqrt{a}\,\underbrace{|\psi_1\rangle_n|1\rangle}_{\text{God State}}$$

$$a = \sum_{i=1}^{2-1} f(S_i)p_i = \underbrace{\mathbb{E}[f(S)]}$$

Valor Esperado do payoff

- Reescrevendo Estado

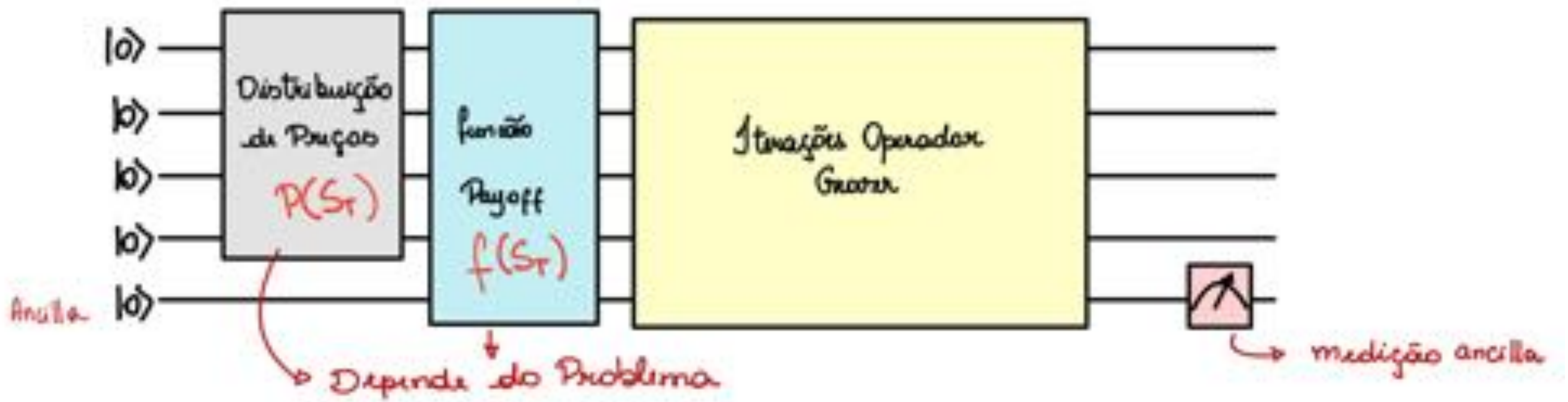
$$|\psi\rangle \equiv A|0\rangle^{\otimes n+1} = \cos(\theta_a)|\psi_{bad}\rangle + \sin(\theta_a)|\psi_{Good}\rangle$$

onde $\sin(\theta_a) = \sqrt{a}$ $\quad \theta_a = \arcsin(\sqrt{a})$

- Operador Grover

$$Q^k|\psi\rangle = \cos[(2k+1)\theta_a]|\psi_{bad}\rangle + \sin[(2k+1)\theta_a]|\psi_{Good}\rangle$$

Algoritmo Maximum Likeliwood Amplitude Estimation



Para problema payoff:

Distribuição

$$P(S_T) = \frac{1}{S_T\sigma\sqrt{2\pi T}} \exp\left[-\frac{(\ln S_T - \mu)^2}{2\sigma^2 T}\right]$$

$$A \equiv f(S_T)P(S_T)$$

$$Q = A S_0 A^{-1} S_{\psi_0}$$

Quantum Computing | Exemplos de Casos de Uso em Finanças


D:Wave

Multiverse Computing: Optimizing Financial Portfolios with Quantum Computing

CASE STORY

Every investment entails some measure of risk—the fundamental question is whether the reward justifies the gamble.

Seeking Maximum Reward at Lowest Risk

Every investment entails some measure of risk—the fundamental question is whether the reward justifies the gamble. Accordingly, managing a diverse portfolio of financial assets entails a challenging balancing act in order to achieve the maximum reward with the lowest possible risk. This can be a feat of staggering complexity. For example, the number of possible configurations for a portfolio of eight assets in which transactions are performed every month for four years is far greater than the number of atoms in the known universe.

"I've seen a real transition in published papers from 'toy', model-type problems, to real commercial products...I think we're really reaching that breaking point

Multiverse <> BBVA Study

Problem
Maximize the portfolio's return for a given risk.

Solution
Solutions are given by Modern Portfolio Theory

$$H_0 = \sum_t -\mu_t^T \omega_t + \frac{\gamma}{2}\omega_t^T \Sigma_t \omega_t + \lambda(\Delta\omega_t)^2.$$

Constraints
1. Diversification constraint.
2. Invest all available resources.

A Speedy Solution for Predicting Profitability

10^{139} solutions | 10^{382} solutions

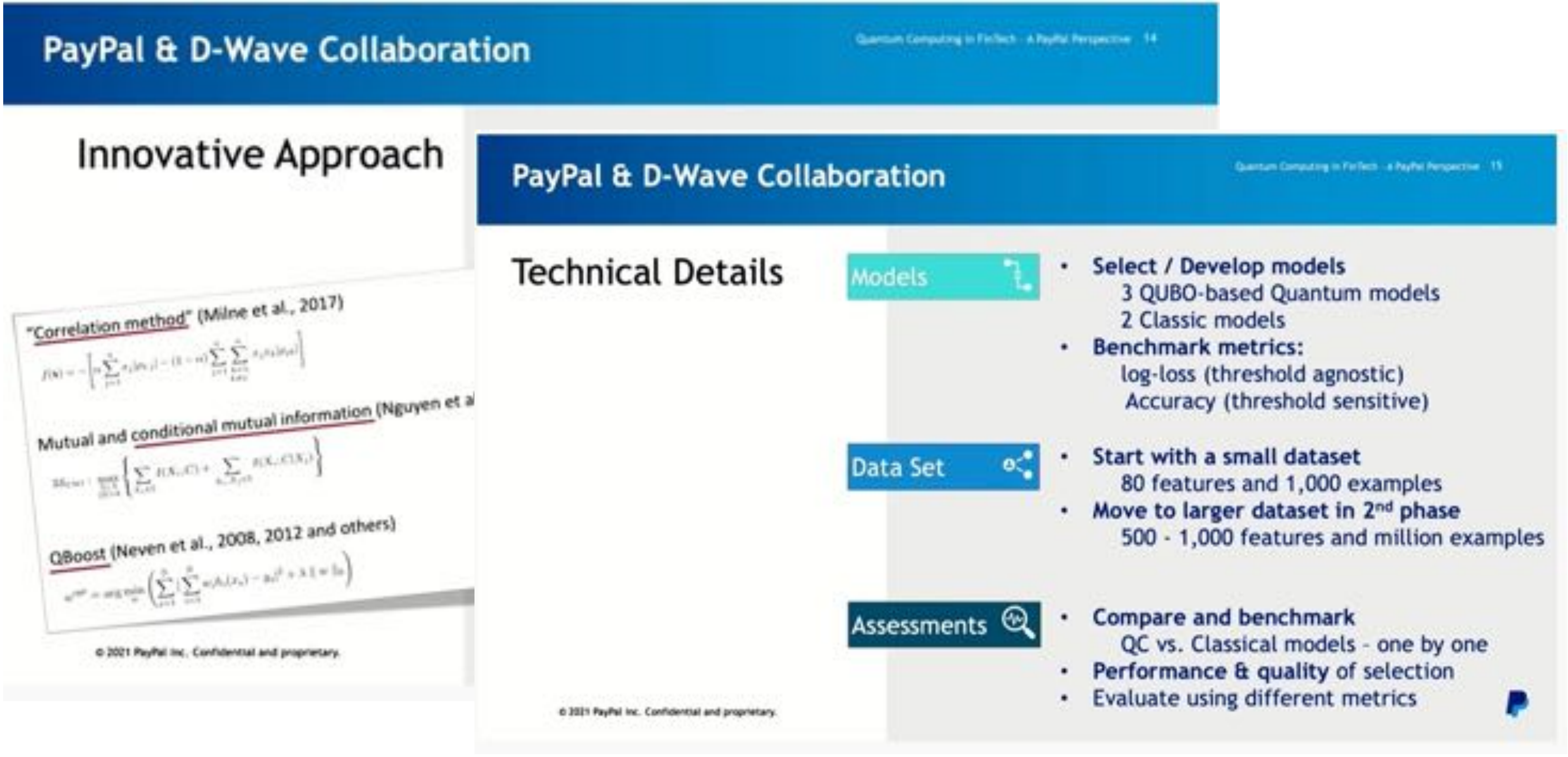
Method	XS	S	M	L	XL	XXL
VQE	3.59					
Exhaustive	6.31	8.90				
VQE Constrained	6.31	6.04	4.81			
Gekko	5.98	8.90	8.39	15.83	20.76	
D-Wave Hybrid	5.98	8.90	8.39	7.47	9.70	12.16
Tensor Networks	5.98	8.90	9.54	16.36	15.77	15.83

Sharpe ratios computed by the different methods for the different datasets and time periods.

Method	XS	S	M	L	XL	XXL
VQE	278					
Exhaustive	0.005	34				
VQE Constrained	123	412	490			
Gekko	24	27	21	221	261	
D-Wave Hybrid	8	39	19	52	74	171
Tensor Networks	0.838	51	120	26649	82698	116833

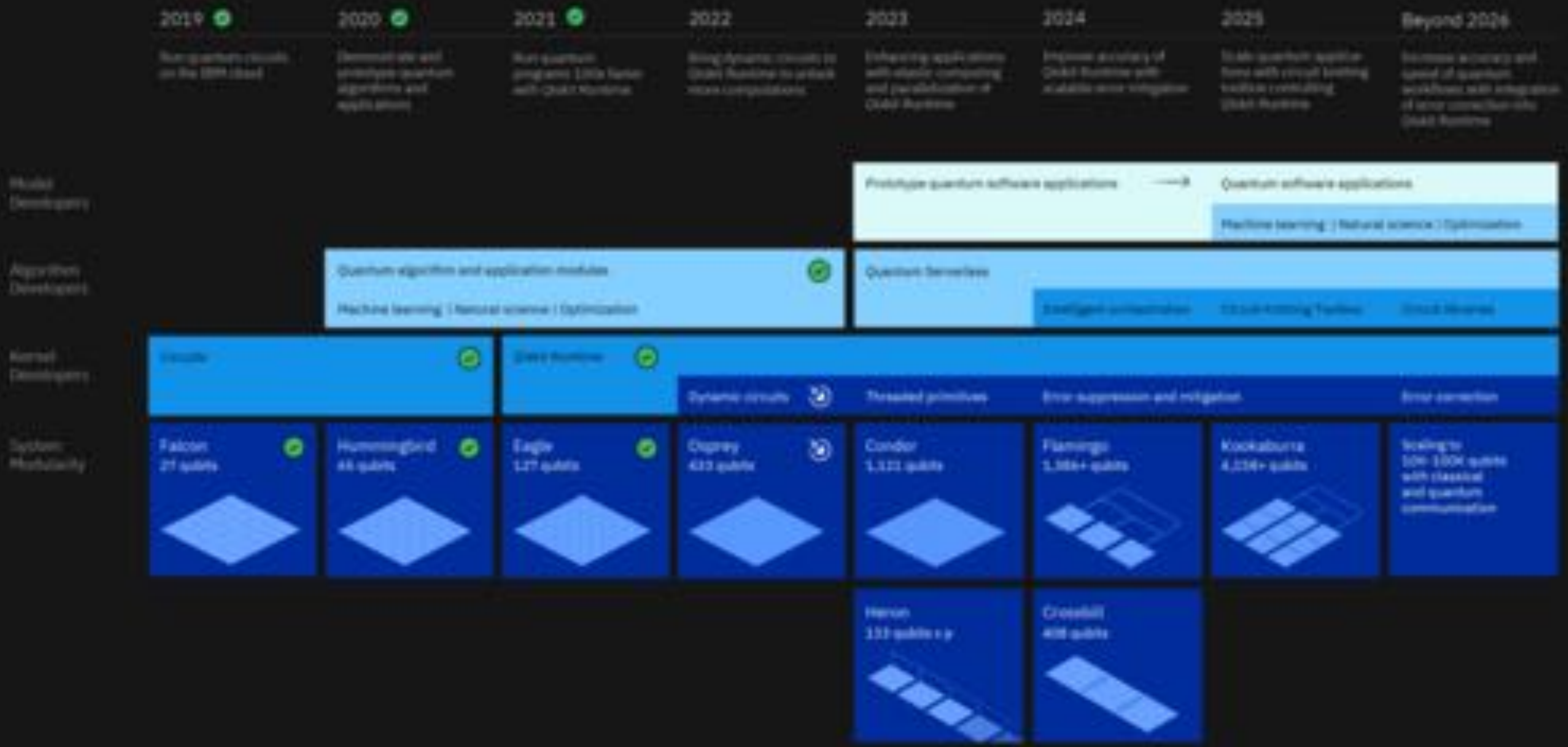
Run-times (in seconds) estimated for the different methods for the different datasets.

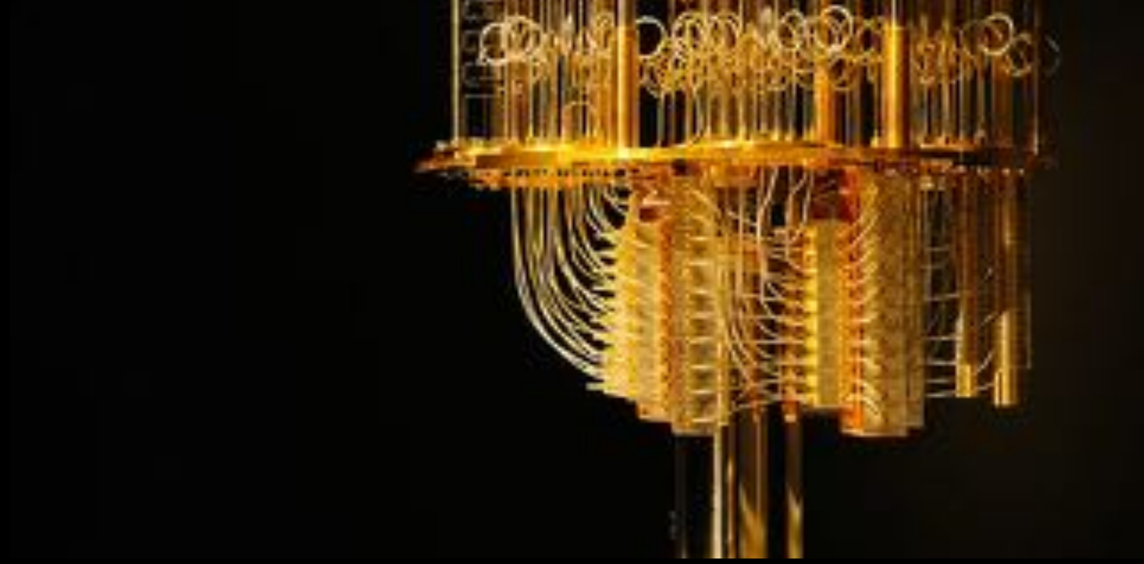
Quantum Computing | Exemplos de Casos de Uso em Finanças



Development Roadmap | Executed by IBM / On target

IBM **Quantum**





Keep in touch!

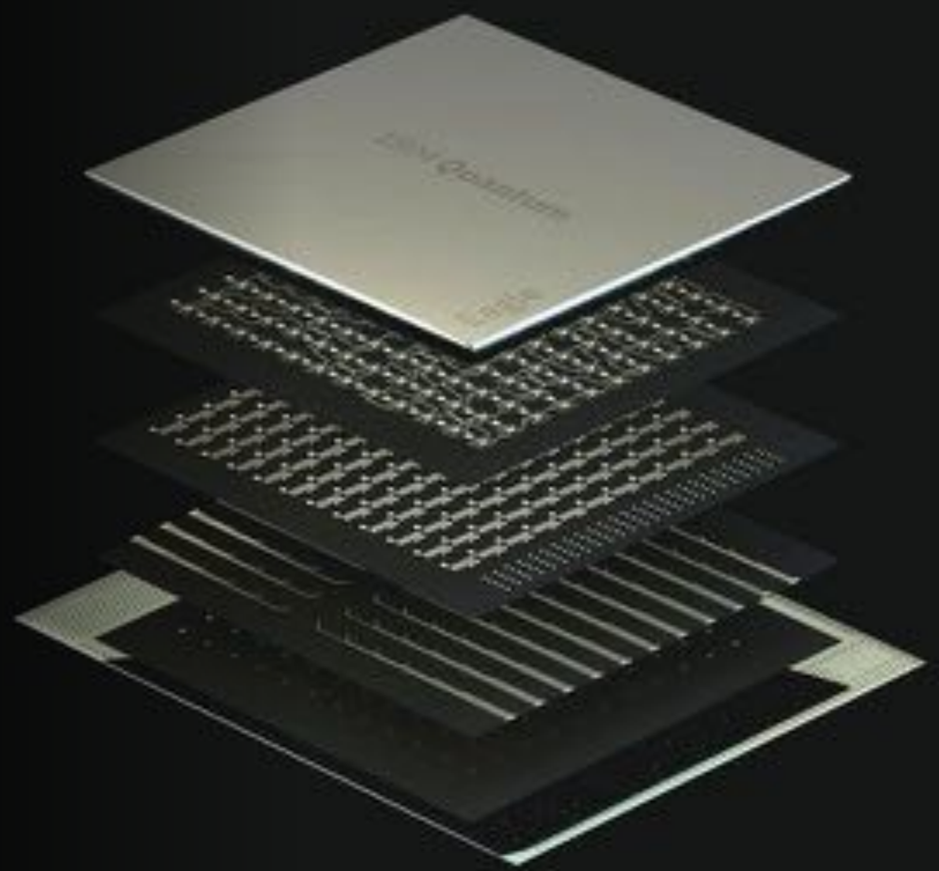
Samuraí Brito, PhD Física
Head of Quantum
Itaú Unibanco

https://www.linkedin.com/in/samurai-brito

https://samuraigab.medium.com

samurai.brito@itau-Unibanco.com.br

Itaú Quantum Technologies



PERGUNTAS