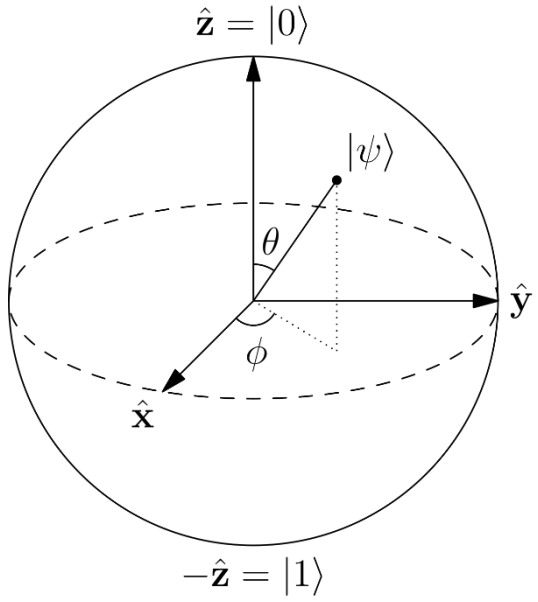
FIA JAPAN

26th November, 2019



Quantum Computing in Finance

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Quantum Computing in Finance

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A seminar organized by FIA Japan Technology Committee

With the support of:

QuantFi
Quantum Computing For Finance

GT GreenbergTraurig

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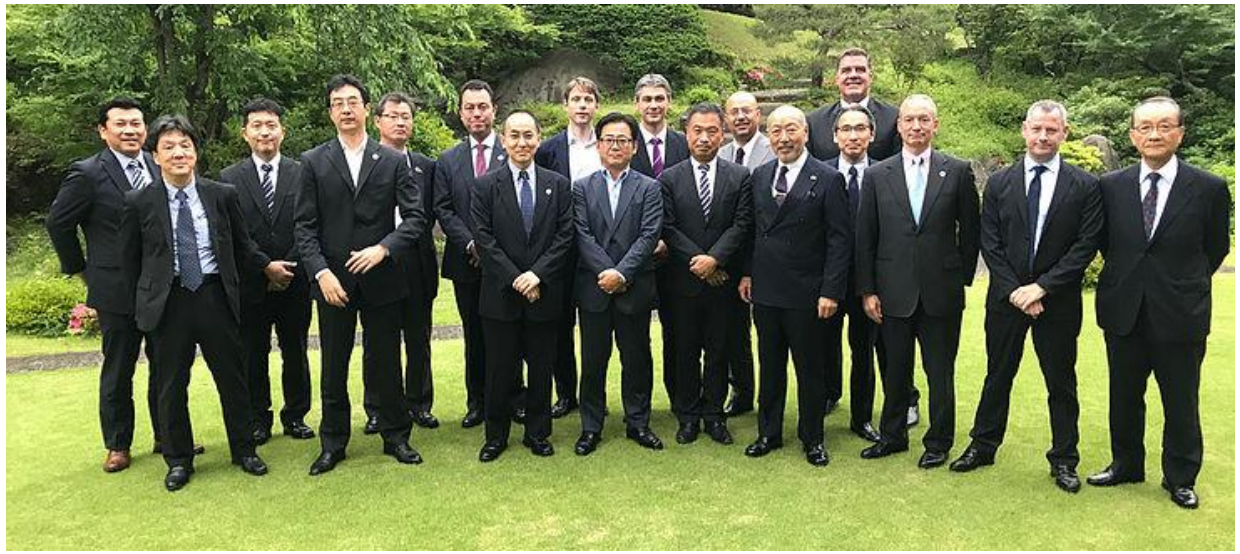

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The Futures Industry Association Japan (FIA Japan) is the only organization in Japan with a membership drawn from the entire cross section of the futures industry. Members include futures and securities exchanges, FCMs, security firms, banks and other users of the markets, as well as legal, technology and other professionals that provide services to the industry.

FIA Japan focuses on both financial and commodity markets and we stay abreast of both domestic and international development in this global industry.

Its members have a common interest in the growth and success of the Japan financial marketplace. FIA Japan is actively involved as a forum for discussion of industry issues as well as an education and promotion place for the Japanese derivatives markets.

The Wall Street Journal
Nov. 8, 2019

Quantum Computing Holds Promise for Banks, Executives Say

…

When quantum computing hits the market, the financial-services industry could be the first to benefit, a Goldman Sachs Group Inc. executive said at a quantum-computing panel event.
…

Since late 2017, JPMorgan has been collaborating with researchers at IBM to experiment with quantum computing. A working group from the bank has been running tests via the cloud on IBM's early-stage quantum-computing machine, suitable for small-scale experiments.
The team has found that quantum computing could be used to speed up computationally intensive option-pricing and risk-assessment calculations.
…

Nikkei Asian Review
Nov. 23, 2019

Japan plots 20-year race to quantum computers, chasing US and China

…

China, the U.S. and some European countries are investing strategically in quantum technology at the national and corporate levels.
Google recently claimed a breakthrough in quantum computing, in which a processor using quantum bits, or qubits, solved a problem that existing computers cannot complete in a practical amount of time. Both Google and IBM have produced prototype quantum computers with processors in the range of 50 qubits.
Under the government road map, Japan will aim to produce a 100-qubit machine in about 10 years, followed by a more powerful, full-fledged quantum computer by around 2039.
…

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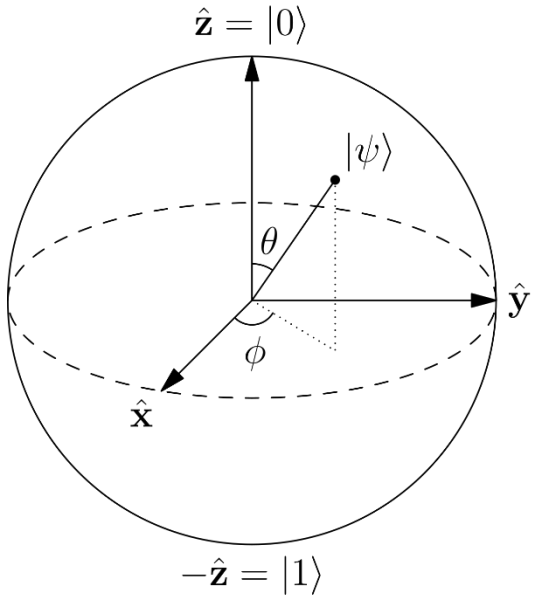

- PART I: Quantum Computing Concepts
- PART II: Quantum Computing Market
- PART III: Financial actors activities in Quantum Computing
- PART IV: When will my Quantum Computing application go live?
- Q&A / Open Discussion

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PART I

Quantum Computing Concepts

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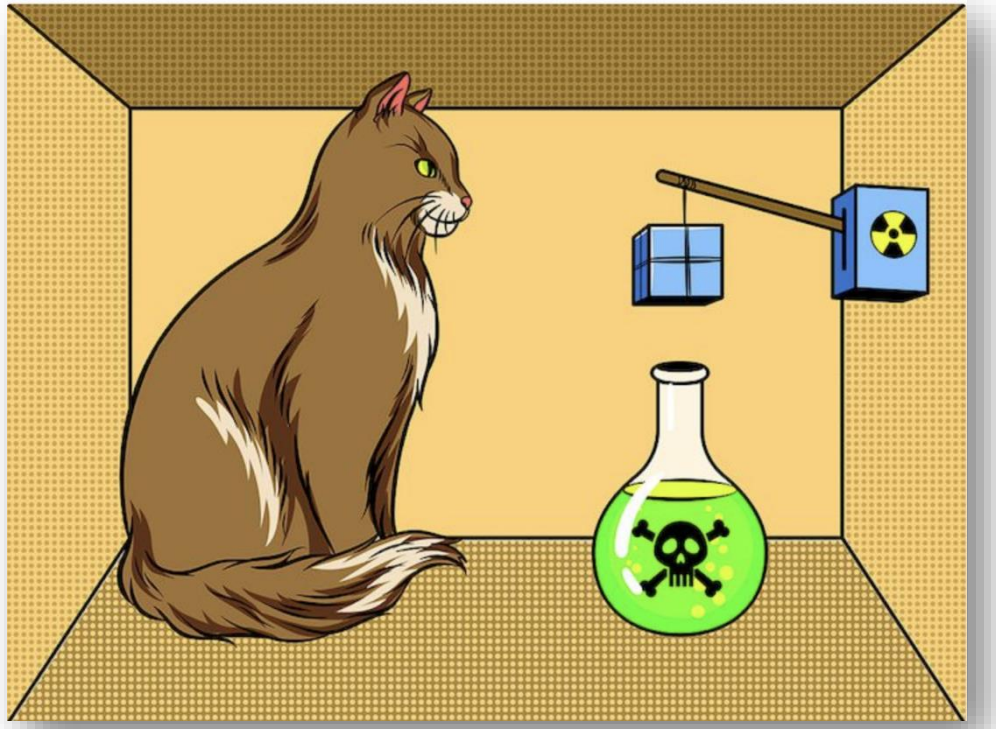
PART I, The Schrödinger Cat



The radioactive material has equal possibility to release or not the cube that would release the deadly substance.

All this happens in a box that is closed.

For the human observer it is impossible to say before opening the box if the cat is dead or alive.

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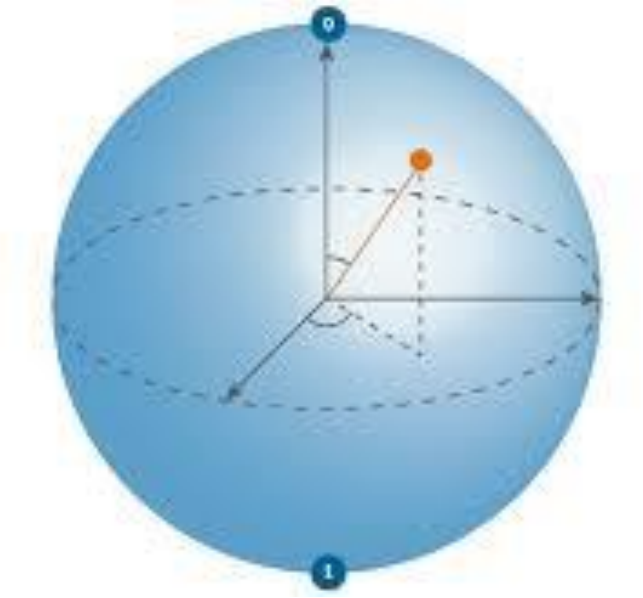
PART I, The Qubit



Like the Schrödinger cat the qubit can be in superposition state, being at the same time partly 0 and partly 1. But when observed it is either 0 or 1.

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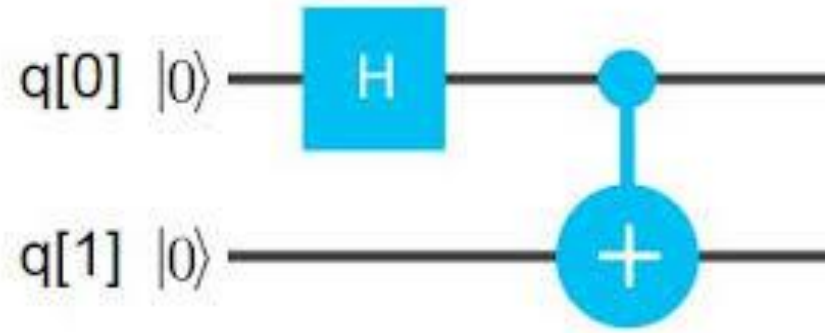
PART I, The gates



The gates are changing the states of the qubits like classical computer gates (NOT, AND…) are changing the states of the classical bits

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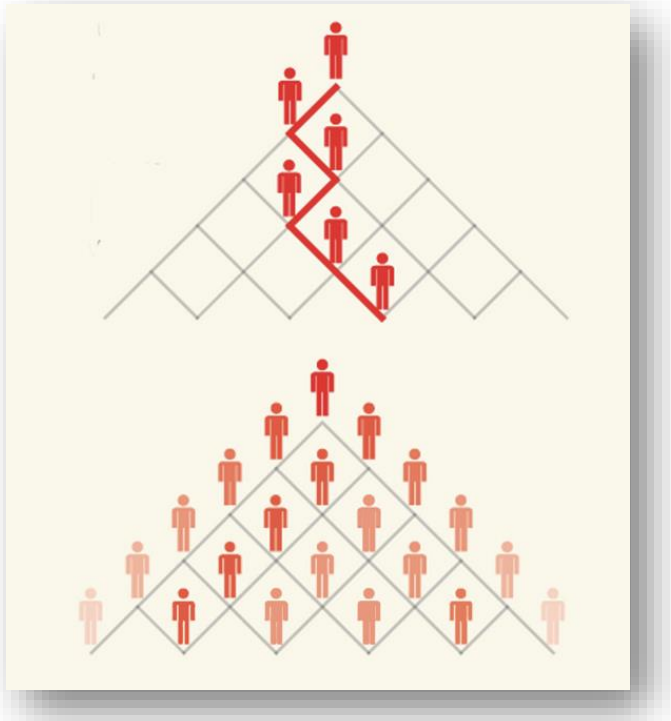
PART I, Parallelism



A classical simulation would repeat a number of time the simulation of each path while the quantum version would check all possible path in one simulation

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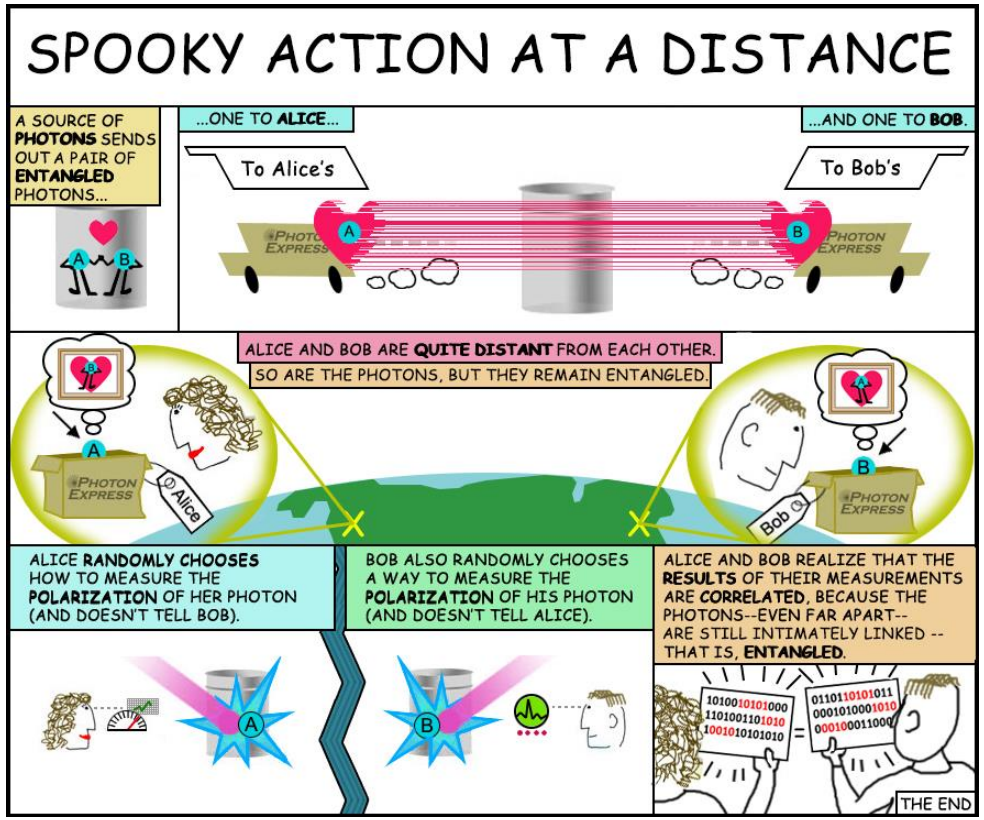
PART I, Entanglement



Once qubits are linked together they share some information

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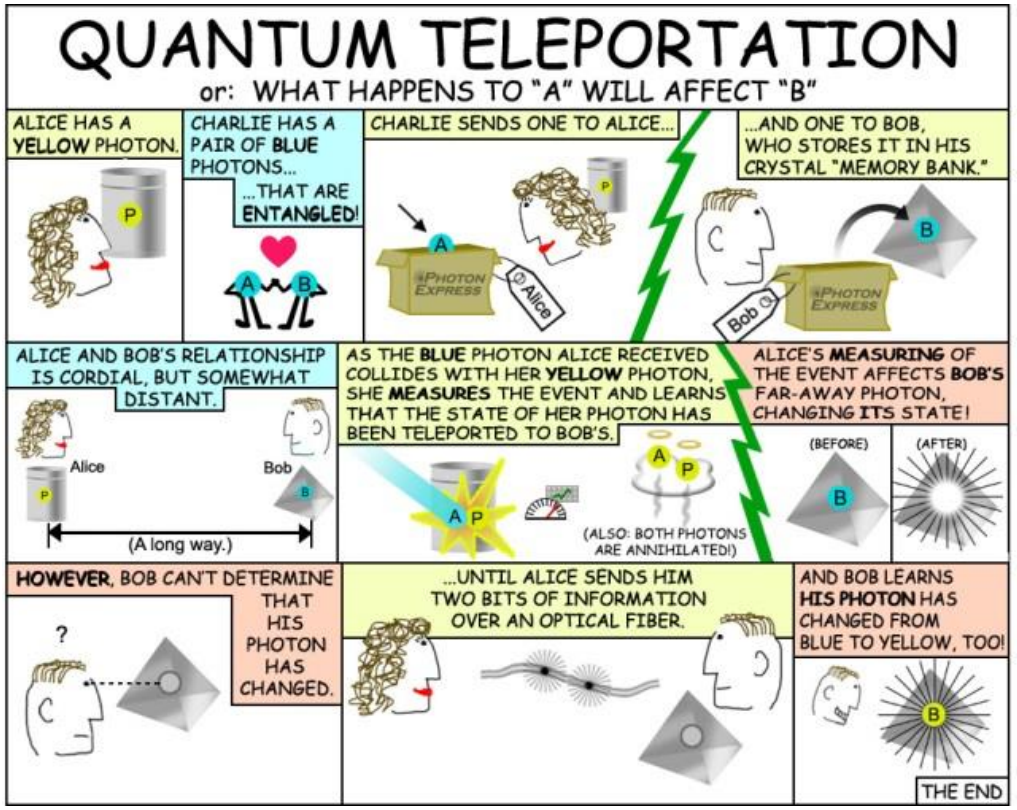
PART I, Teleportation



Qubit cannot be copied (no cloning)
but can be moved.

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PART II

Quantum Computing Market

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PART II, BUSINESS ASSUMPTIONS

3y, 4y, 5y, 6y, 7y, 8y… ?

WE ESTIMATE THAT ACTORS SHOULD BE READY FOR THE FIRST COMMERCIAL USAGE OF THE GATE MODEL BASED **QUANTUM COMPUTERS IN 3 YEARS EVEN IF IT COULD TAKE A FEW MORE YEARS**

DURING THE FIRST FEW YEARS WE WILL BE IN A VERY **COLLABORATIVE** ENVIRONMENT EVEN WITH FUTURE COMPETITORS

According to BCG many experts believe that progress toward maturity in quantum computing will not follow a smooth, continuous curve. Instead, quantum computing is a candidate for a precipitous breakthrough that may come at any time.

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PART II, Market & clients' value

BCG expects productivity gains by end users of quantum computing, in the form of both cost savings and revenue opportunities, to surpass $450 billion annually in the coming decades. Gains will accrue first to firms in industries with complex simulation and optimization requirements. It will be a slow build for the next few years: we anticipate value for end users in these sectors to reach a relatively modest $2 billion to $5 billion by 2024.

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PART II, Market & clients' value

TABLE 8 QUANTUM COMPUTING MARKET FOR CONSULTING SOLUTION, BY END-USER INDUSTRY, 2016–2024 (USD MILLION)

End-user Industry	2016	2017	2018	2019	2021	2023	2024	CAGR (2019–2024)
Space & Defense	7.36	9.40	12.03	15.43	25.45	42.06	54.11	28.5%
Automotive	6.76	9.02	12.01	16.07	28.68	50.95	67.81	33.4%
Healthcare	1.70	2.23	2.92	3.85	6.71	11.73	15.53	32.1%
Energy & Power	0.54	0.70	0.92	1.22	2.12	3.72	4.92	32.3%
Chemicals	1.87	2.45	3.21	4.22	7.32	12.69	16.70	31.6%
Banking & Finance	3.48	4.42	5.61	7.16	11.62	18.74	23.73	27.1%
Total	**21.70**	**28.22**	**36.70**	**47.96**	**81.91**	**139.88**	**182.80**	**30.7%**

Source: Press Releases, Annual Report, Investor Presentations, Expert Interviews, and MarketsandMarkets Analysis

Source: M&M

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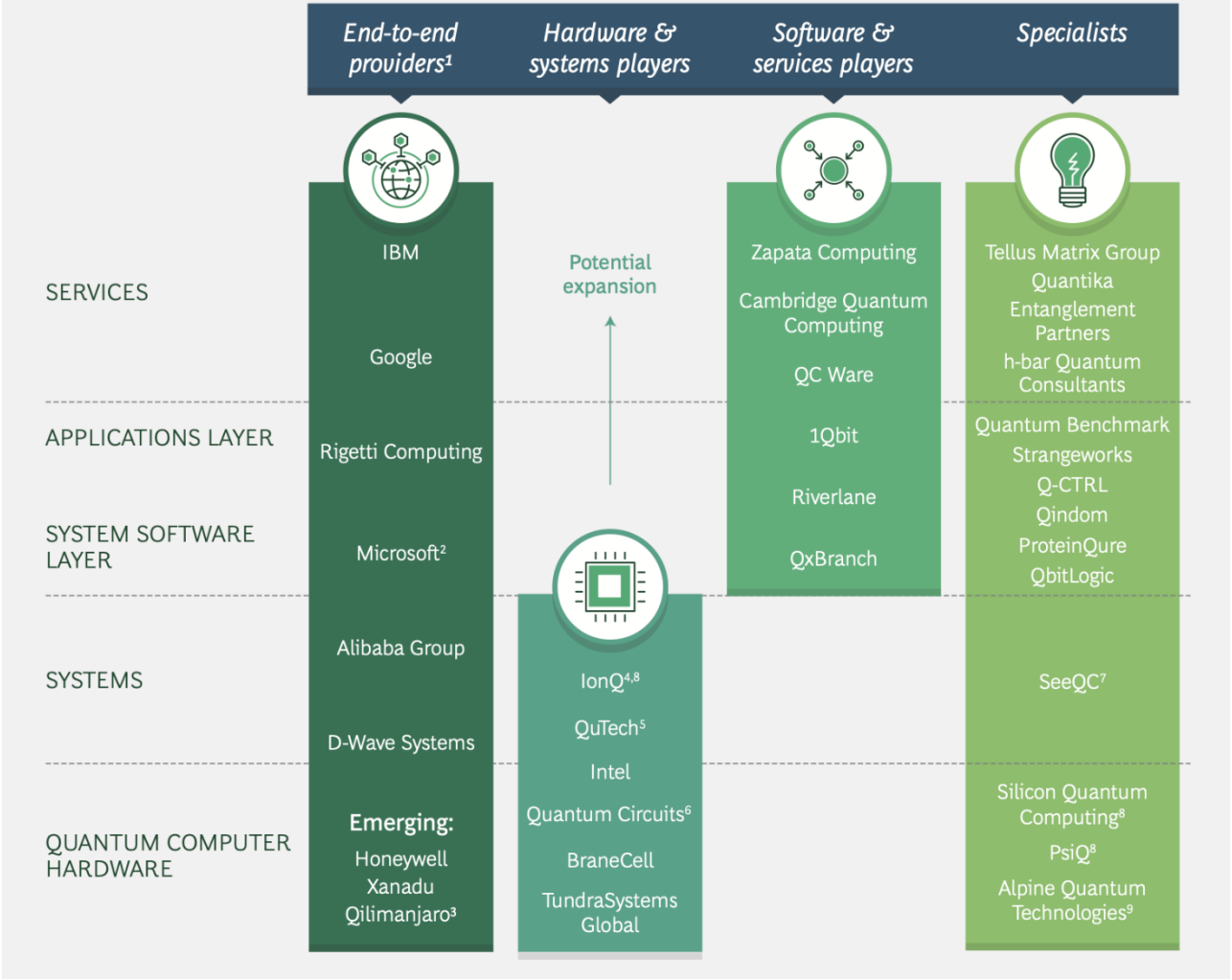
PART II, Competitive landscape

EXHIBIT 1 | Companies Assume Four Roles Across Layers of the Stack in the Quantum Computing Ecosystem



Source: BCG

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PART III

Financial Actors activities in Quantum Computing

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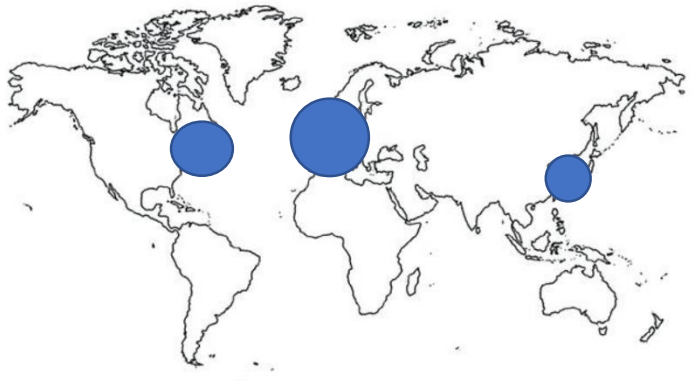

Part III, Collected Use Cases

This map represents the number of financial institutions met by QuantFi this month.

Trends:
- Crashes
- Market
- …

Portolio management:
- Goals
- Optimization
- Arbitrages
- ALM
- …

Risk management:
- Pricing
- VaR
- Fraud detection
- …

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PART IV

When will my Quantum Computing application go live?

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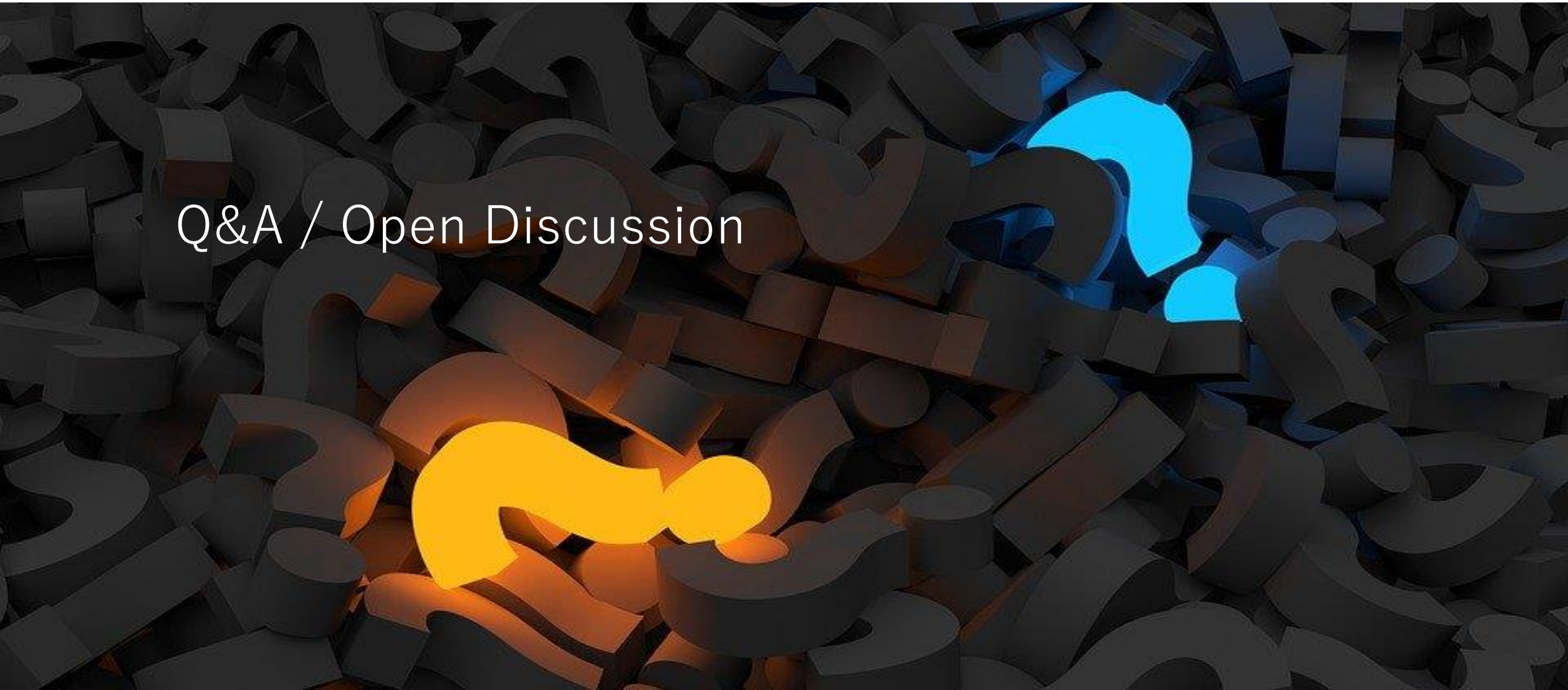
EXHIBIT 6 | Assessment Criteria for Gate-Based Quantum Computers

CRITERIA	CURRENT RANGE	WHAT DOES IT MEAN?	WHY IS IT IMPORTANT?
Number of physical qubits	2–20	Number of physical quantum bits on a chip	Relevant for scaling and achievable operation complexity
Number of logical qubits	0	Number of error-corrected qubits used for fault-tolerant quantum computing	Determines scaling of sophisticated algorithms
Qubit lifetime	50 µs–50 s	Period of time information can be stored in a qubit	Determines how long qubits can store and process information
Gate fidelity	90–99.9 %	Accuracy for a two-qubit operation	Critical determinant for quality and overhead of quantum error correction
Gate operation time	1 ns–50 µs	Time for a two-qubit operation	Determines the clock speed for manipulating physical qubits
Connectivity	1:1–n:n	Connections between qubits	Determines how much information can be encoded in qubit group states
Scalability	low–high	Potential of the system to scale	Determines the ability to build a large-scale quantum computer
Maturity	TRL 1–5	Technology readiness level	Determines technological maturity on a scale from 1–9

Part IV, Go-Live Extrapolation

Source: BCG



Q&A / Open Discussion