Quantum Computing

A technology of the future already present

pwc

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Quantum computing: the 5th revolution

You have probably heard of the fourth industrial revolution: it is about the impact of exponential technologies such as (inter alia) artificial intelligence, blockchain, and data analytics, on the way we live, interact, work, do business and organize our government.

We are now on the verge of the fifth industrial revolution, and this is brought to you by Quantum Computing.

We have seen strong innovations in computing in recent years. However, the architecture behind them has not changed as they still rely on binary calculation (1's and 0's). With this new generation of computing, we can think of amazing possibilities in terms of power, speed but even more than that: a new way of solving problems and potential solutions to topics that were not handled so far by classical computers.

Furthermore, in the same way that steam engines and microprocessors once redefined entire industries, quantum computing could create new businesses and sectors, while also shape the future of current sectors, such as artificial intelligence, resources exploration, chemical and pharmaceutical development, financial management and so on.

Forget Moore's law, it's Neven's law now

Hartmut Neven, the director of the Quantum Artificial Intelligence Lab at Google, was the first to notice the phenomenon: the law dictates how quickly quantum processors are improving, or getting faster at processing calculations, relative to regular computers. And it's expanding way faster that Moore's law.

With double exponential growth, "it looks like nothing is happening, nothing is happening, and then whoops, suddenly you're in a different world," Neven said. "That's what we're experiencing here."

This is one of the reasons why Google announced on the 23th of October 2019 that they had just achieved Quantum Supremacy. **Google's quantum computer was reportedly able to solve a calculation in 3 minutes and 20 seconds that would take the world's fastest traditional supercomputer around 10,000 years.**

This is what we want to empathize here: this is happening right now.

Marc HADDAD
Partner, FS Consulting
Technology & Innovation

01

Understand Quantum computing

In order to have an understanding of the potential of this particular technology, we need to have some basic knowledge on quantum physics.

Quantum physics

Quantum is the study of the atomic level of things.

If I ask you “Where are you?” Your response might be “I am in Paris”, which is more accurately described with a latitude and longitude. The position are example of what physicists refer to as observables: things that can be measured directly.

For hundreds of years, we have constructed predictive models of interactions in physics on the assumption that observables were simply numbers that can be determined absolutely at any instant by a sufficiently accurate measurement. This worked very well for most systems of interest.

However, as we started studying smaller and smaller systems, we found some peculiar behavior. Quantum systems seemed to be randomized. It’s measured with probabilistic functions that change with physical states of the quantum element.

Quantum computers & Qubit

Now you must be wondering what the relationship between IT and quantum physics is.

The quantum computer uses quantum mechanics to perform operations more efficiently than a regular computer. A classical computer uses bit, which is the smallest unit of data, a series of 0 and 1 that manages information and makes operations. Computers usually provide instructions that can manipulate bits to store data and execute instructions.

Today, we produce a large amount of information and calculations are becoming more complex. The increase of data will be faced with the limits of standard processors and of the combinations of 0 and 1 that they manage. Quantum computing introduces a new data unit, the qubit. This paradigm shift transforms the way data is designed and processed.

A qubit is a “quantum bit”. Unlike the classical bit, each qubit has a more complex structure than the classical bit, and the multistate feature allows the qubit to hold more information and to process it at the same time, thus greatly increasing its speed. Qubit is subject to new properties called superposition and entanglement.

The increase of data will face the limit of standard processors and the combination of 0 and 1 that they can manage. The quantum computing introduce a concept of new data unit, the qubit.

Imagine that you had to process a 2-bit operation. With a conventional computer, there are 4 possibilities: 00, 01, 10 or 11. These four states are managed one by one by a classic processor. If we use qubit, these four operations will be processed at the same time. The qubit can be 0 or 1, and can use an intermediary state where it can be both.

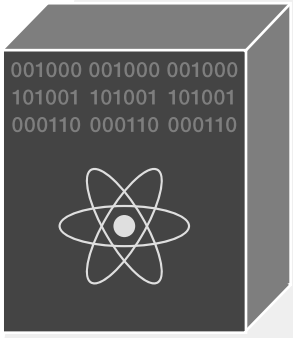
Classical Computers

Number of possible states determined 0 or 1

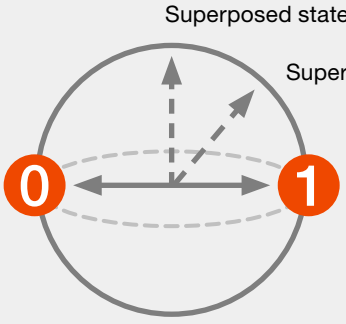
0 ← OR → 1

The value is deterministic, repeated computation on the same input will lead the same result

Quantum Computers



Infinite possible of states



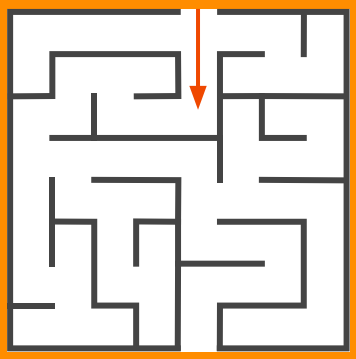
The value is measured probabilistically, considering several possibilities at the same time, sorting sets of probable results that converge to the correct result

Superposition & Entanglement

Quantum mechanics is complex to introduce. Let's use some examples to describe the two main components of quantum mechanics:

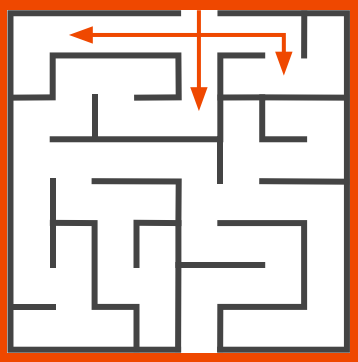
Superposition is essentially the ability of a quantum system to be in multiple states at the same time. Imagine that you have to solve a labyrinth:

Classical Computers



A classical computer will, at each junction, try a direction, turn back when it reaches the end, then start again until it finds the exit.

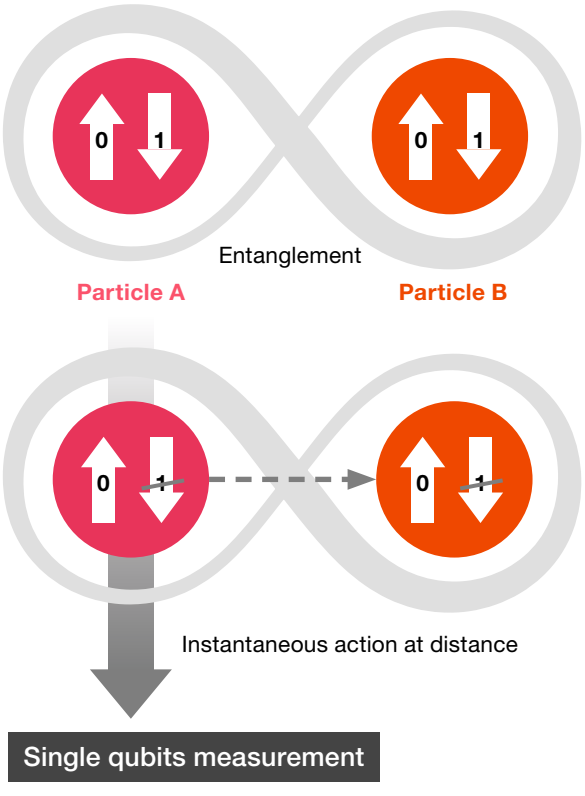
Quantum Computers



A quantum computer will "superpose": at each branch, one state will explore every single direction. So the quantum computer is trying all paths in parallel. It builds a state that superposes all states that are performing all the possible routes, including the one that gets through to the end.

Entanglement is a phenomenon, based on what Einstein called "spooky action at a distance", in which two qubits form a linked system. They have quantum states depending on each other regardless of the distance that separates them. In terms of classic computing, this is a bit like having a logic gate connecting every bit in memory to every other bit.

These two properties confer a sort of intrinsic parallelism to the quantum computer and bring freedom to program designers, to do better than classical equivalents.



Overcoming technological hurdles

There are a number of obstacles to the development of quantum computers and we tried to list the major ones in the following sections.

Qubit stability

Quantum objects that are used to create qubits can only maintain a certain quantum state for a short time. Calculations not only require that qubits maintain their state, but also that they interact with one another.

The challenge is to extend the lifespan of qubits and increase the number of qubits interacting to achieve more complex and reliable quantum information protocols.

QuDits & QuTrits

Rather than trying to maintain the stability of a large qubit system, researchers have tried to increase the dimensions of the systems required for calculations. Qudits are quantum objects where the number of possible states is greater than two. These multiple levels make the processes involved in the manipulation of quantum operation more efficient. The use of these would also simplify certain calculation tasks, and thus the circuits required to realize a quantum computer. A system with 3 states, producing qutrits (3N), would be less fragile and it would take less time to perform consistent quantum calculations. It is therefore a way not only for the miniaturization of quantum computers but especially to solve problems related to Qubit instability.

Quantum computing Standard

As for all new disruptive technologies, there is a need for definitions and a nomenclature of quantum computing that all speak the same language. The IEEE association launched the IEEE P7130™—Standard for Quantum Computing Definitions project in June 2019. The new standards project aims to make Quantum Computing more accessible.

These physical and technological advances open up a wide range of possibilities. This will have an impact on the latest digital technologies such as artificial intelligence and will serve as a catalyst for the future of the digital revolution.

Quantum supremacy

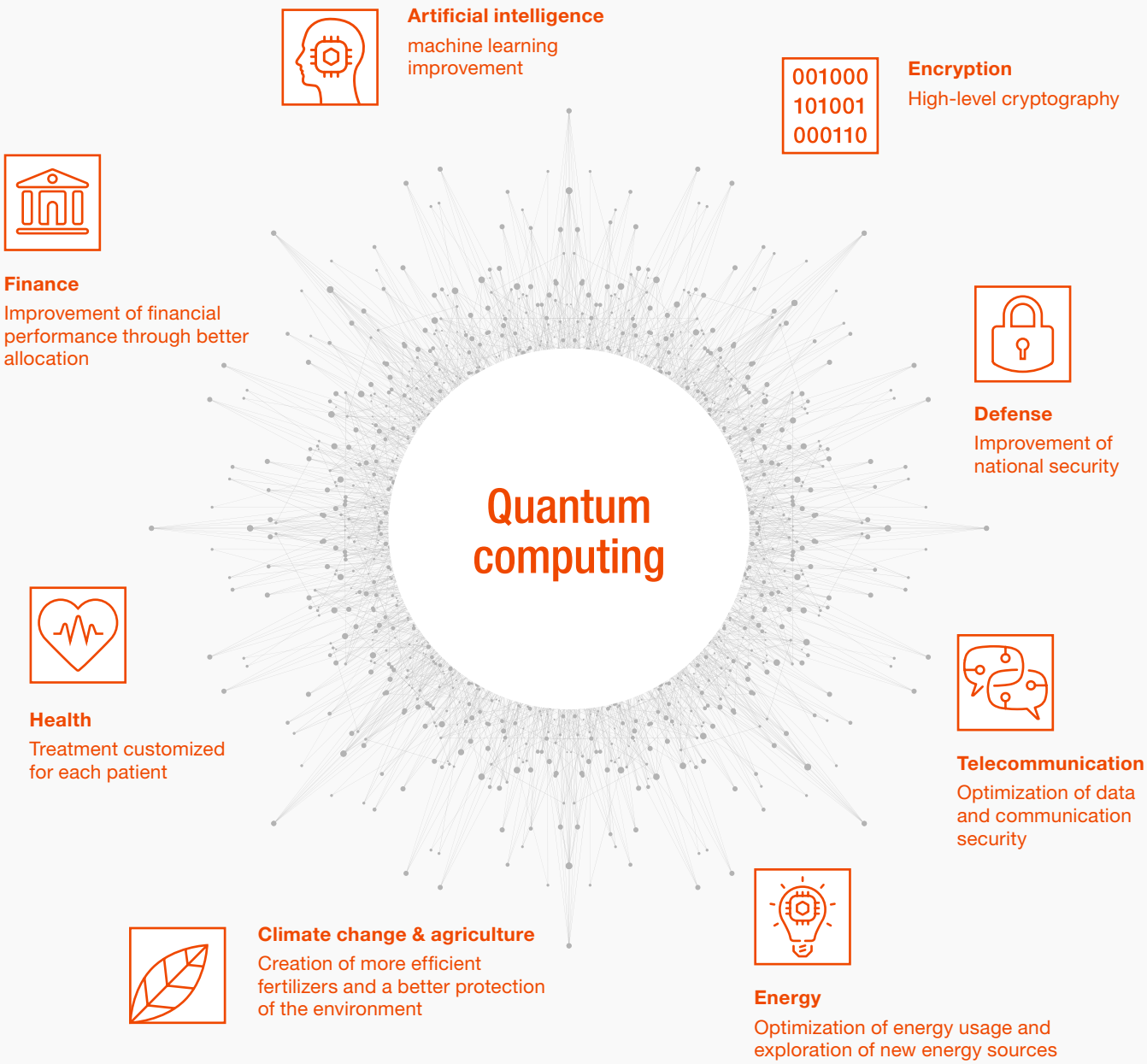
A quantum computer can run simulations on all variables at the same time compared to the classical one that needs to run them one after the other. This technology can optimize every decision to make, in a very short time. However, classical computers will never be fully replaced by Quantum computing as their roles are complementary. The latter will be used for highly complex calculations when classic computers will be used for common operations such as communication via video chat applications or sharing and distribution of information whether in a commercial context or not.

Quantum supremacy represents the day Quantum computers will efficiently solve problems out of the reach of classical computers. Engineers and analysts are currently working in synergy in order to make this happen as soon as possible. As we said in the introduction, Google announced at the end of October 2019 that it had achieved this goal, meaning the competitors will soon follow.

02

Applications

Quantum computing will have an impact in various sectors: many players have already chosen to invest in this technology to improve their businesses and place themselves in a leadership position for the coming years. Below are some examples of benefits that industries could reach with Quantum Computing:



Artificial Intelligence

The artificial intelligence sector has been driven by an innovative concept: machine learning. Machine learning consists of creating algorithms in order to model mathematically neuronal networks.

These networks, like biological neurons, are able to create logical links, and rules of generalization. Thus, once exposed to previously processed data samples (network's training phase), the computer is able to analyze, interpret or generate predictions on new data (prediction phase).

A special case of machine learning consists of using a very large number of intricate mathematical functions (deep network) in order to gain autonomy; deep learning. In the latter model, human intervention during the training phase of the network is greatly reduced, no prior processing of the basic data is necessary.

In this context, the emergence of Quantum computing would significantly boost the artificial intelligence known to date. Indeed, at the age of Big Data, the considerable number of data exchanged and available data cannot be processed by conventional computers. In addition, the mathematical power of quantum computing will allow an efficient learning phase, especially for deep learning machines where the number of underlying mathematical functions is very important.

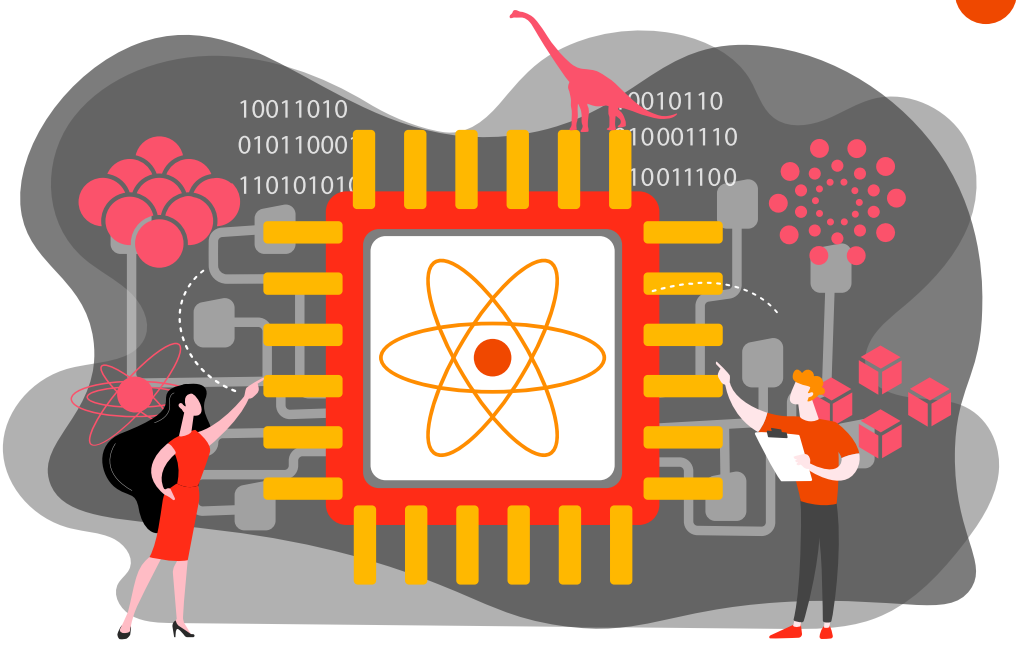
Quantum computing is seen as one of the main solutions to enable Artificial Intelligence to search and analyze enormous datasets. Some players have already identified the potential and are in the process of developing new possibilities. IBM and MIT-IBM Watson AI Lab are currently developing and testing a quantum algorithm to improve machine learning in the upcoming years. They have already improved feature maps and classification of data, and with the IBM Q technology, they have already found a solution against classification errors.

Encryption

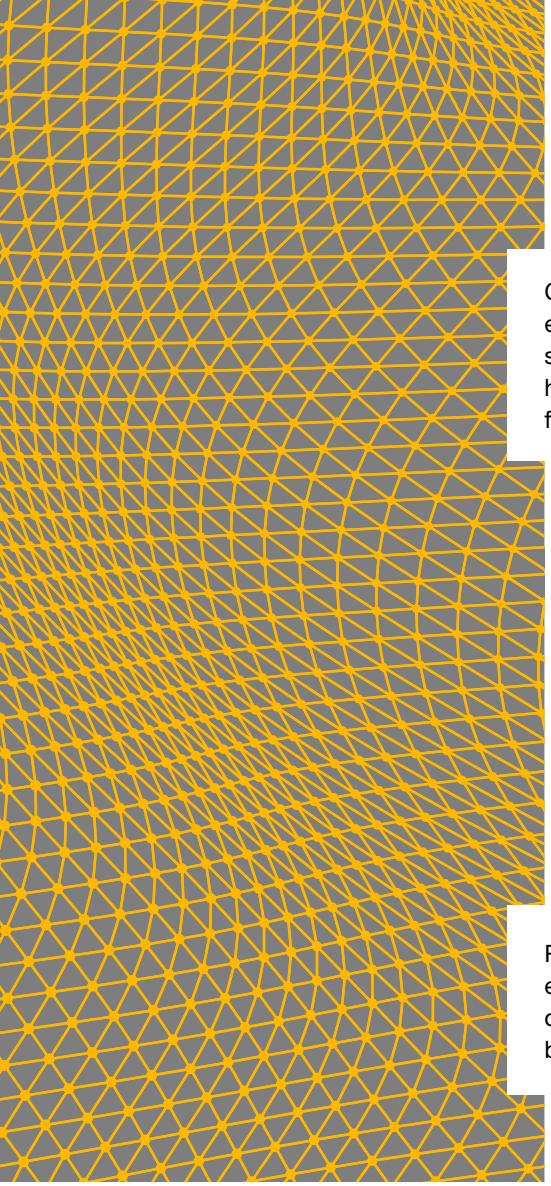
Cryptography is the process of encrypting data, or converting plain text into scrambled text so that only a "key" code allows the message to be deciphered.

In this context, quantum computing is seen as a significant threat. Indeed, the mathematical power of quantum computers will eventually allow the deciphering of the most complex codes in existence today. In an economy based on the virtualization of cash flows, the deciphering of banking encryption, in particular, constitutes a major risk posed by this technology. Paradoxically, it is precisely here that lies the opportunity to secure flows.

If it is confirmed that quantum computing will decipher all existing codes to date, a code generated through this technology will be extremely reliable.



Experts believe that in the long run, to decipher such code would take an amount of time equivalent to the age of our universe, no matter how much standard computer power you use.



Cryptographic algorithms which secure against quantum computer attacks already exist, and are called “post-quantum cryptography.” However they are not yet in a sufficiently efficient format. Lattice-based cryptography, multivariate cryptography or hash-based cryptography are quantum algorithms and are already identified as favorites to secure public-key.

A Lattice is a regular collection of points in a Euclidian space with the same distance between each point.

To solve a lattice-based computational problem, you need to reach a fixed central point in the grid called the “origins”, only using the shortest path.

Regarding post-quantum cryptography, Google declared in early July 2019 that it was experimenting in Chrome. In addition to its existing key, Google added a post-quantum key-exchange algorithm. For now the conclusion is that the key is still breakable even with normal computers.

Defense

In the continuity of last paragraph, encryption can also be applied in the Defense industry. The field of quantum information science is giving rise to multiple new defense-related applications that are often grouped together under the single moniker ‘quantum’, but which merit independent consideration. Quantum key distribution (QKD), quantum cryptanalysis and quantum sensing will permit to make evolve strategic security in differing ways. For instance, QKD provides a near-term advantage for defenders to secure their communications, while quantum cryptanalysis is an inherently offensive capability, though one that is maturing at a slower pace. It should be remembered that this technology is promising but still at early stage.

In September 2018, the United States published its National Strategic Overview for Quantum Information Science, which defined quantum sensing as ‘leveraging quantum mechanics to enhance the fundamental accuracy of measurements and/or enabling new regimes or modalities for sensors and measurement’. Such new capabilities could afford clear military advantages. Also, the United Kingdom’s Defense Science Expert Committee has highlighted the potential importance of improved gravity sensors (quantum gravimeters), which could detect moving masses under water, such as submarines.

Telecommunication

Today, telecommunications have become instantaneous and use multiple channels. By using quantum technology, the four most important impact areas would be:

- Quantum encryption: reshape the current cryptography protocols
- Quantum networks: increase the bandwidth of telecommunications networks
- Quantum infrastructure: optimize routing and network infrastructure
- Quantum internet: allow transmission of quantum bits (qubits) between any two points on earth

The European Union has launched a major 10-year program called Quantum Technology Flagship. The aim is to accelerate technological development and the transfer of research towards technological innovation.

The project CiViQ integrates for the first time into a quantum communications project several telecommunication operators: Orange, Deustche Telekom and Telefonica. The objective is to develop quantum-enhanced physical layers that can be combined with modern cryptographic techniques, to enable secured applications and services.

On September 2nd 2019 the pilot project, OPENQKD, was launched. That will install a test quantum communication infrastructure in several European countries. Its aim is to enhance the security of critical applications in the fields of telecommunications, health care, electricity supply and government services.

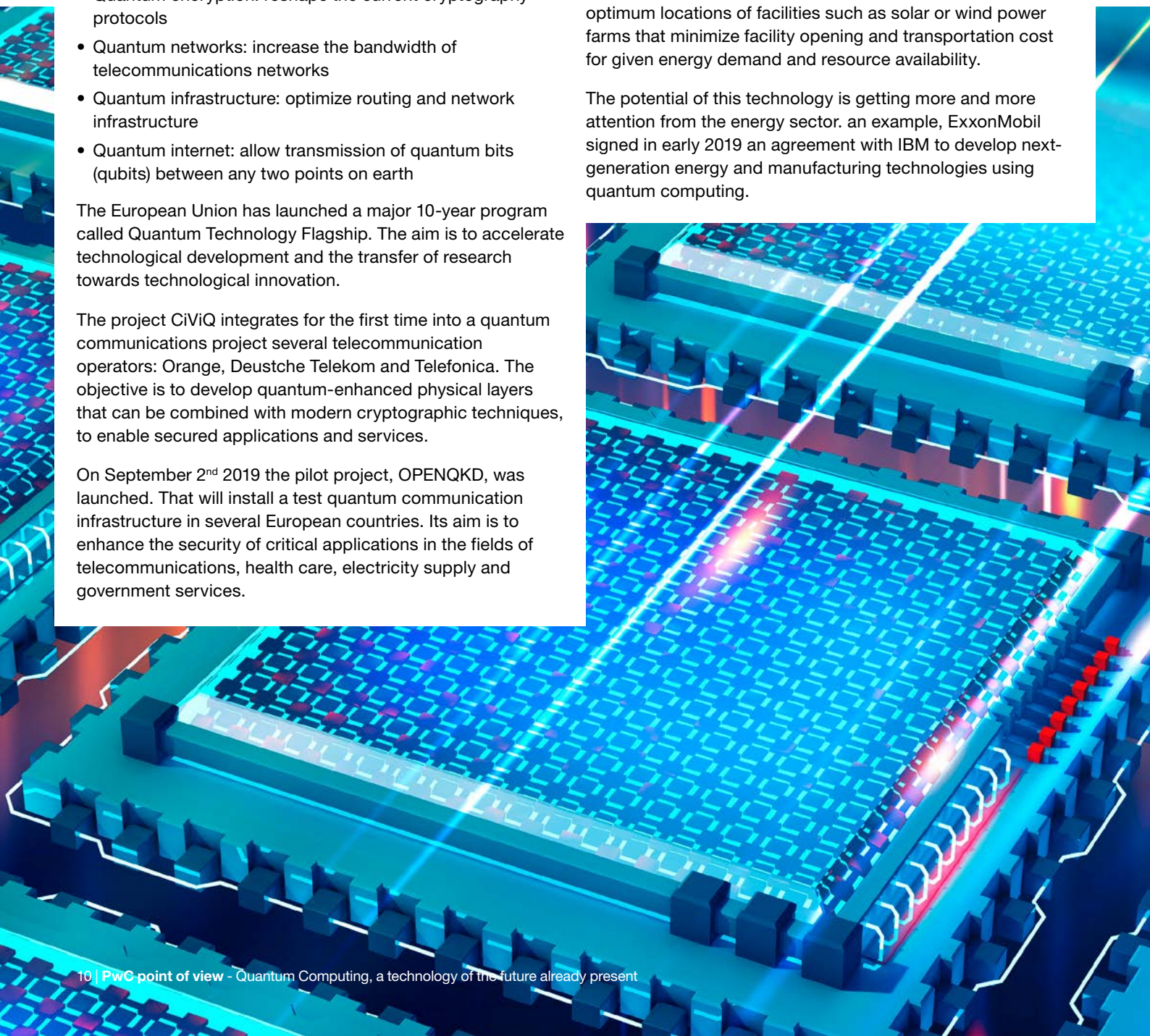
Energy

The rising demand for renewable energy calls for highly-optimized energy management systems. Although renewable energy resources are ‘free’, they are hard to predict because of various factors such as fluctuation of solar irradiation, weather and wind speed.

Recently, hybrid power systems utilizing the combination of solar, wind and hydro have been deployed to improve their reliability. Optimization methods are then used to find the cheapest combination of all power generators: that’s when quantum computing plays a role.

A concrete application of quantum computing would be for the facility-location allocation problem: the goal is to find optimum locations of facilities such as solar or wind power farms that minimize facility opening and transportation cost for given energy demand and resource availability.

The potential of this technology is getting more and more attention from the energy sector. an example, ExxonMobil signed in early 2019 an agreement with IBM to develop next-generation energy and manufacturing technologies using quantum computing.



Climate change & agriculture

Quantum computing technology is so powerful that you can imagine everything about solving climate and global warming issues.

Indeed, regarding the substantial increase in global food consumption, Quantum computing can be used to significantly improve agricultural methods. These prospects will be much more likely as research and experiments in quantum computing are pursued by a group of educational institutions, businesses and governments.

Similarly, this technology can quickly process the decline in carbon footprint by developing a catalyst.

In addition to solving some of the world's most complex problems, quantum computers consume significantly less energy, which could lead to reduced costs and decreased reliance on fossil fuels as adoption increases.

For example, Volkswagen uses quantum computers to create legacy applications that will optimize the routing of public transport in cities around the world.

Companies are already starting to feel the pressure to get into the game of quantum computing, but the impetus goes beyond innovation and technological competition for a single company. It is a common goal: to ensure that the computing power of our world does not exceed the capacity of our planet to take charge of it.

Health

Our society is a great consumer of medicines. Unfortunately, solutions are too often not adapted to the patients. Quantum Computing technology could allow in the near future solutions specific to each patient, taking into account the particularities of each one. Indeed, human DNA is composed of an astronomical amount of information to process. The analysis of data is only possible with technology as powerful as Quantum Computing. Through the processing of this data, optimal genomic sequencing could be performed and would allow a better understanding of each case.

Another solution that this technology would bring is the determination of the most effective drugs. Indeed, an efficient and quick comparison between the effects of drugs according to each type of disease would allow the identification of the best drugs.

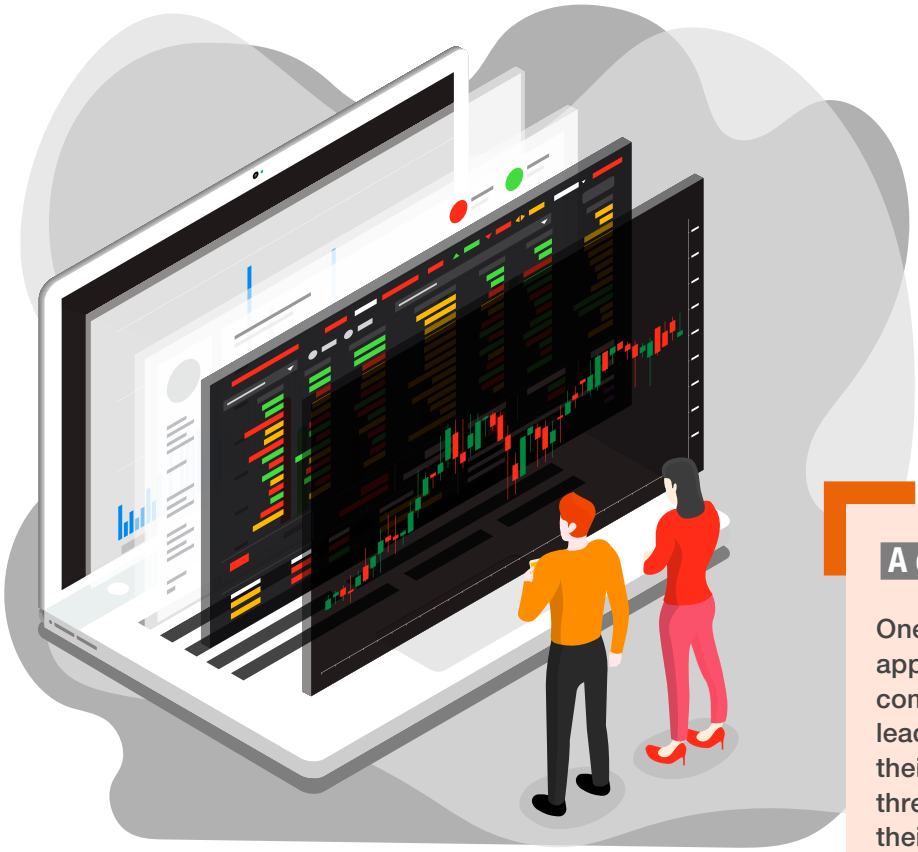
This technology could also be a way to treat the diseases which are getting more and more present in our society, such as Alzheimer's or Parkinson's. Researchers see artificial intelligence as one of the main ways to predict if a patient will have Alzheimer's or not. Improving the predictive capabilities of this technology would help identify future patients. As mentioned in this document, Quantum Computing can improve Artificial Intelligence and at the same time all the possibilities of this technology.

Finance

The financial industry is already in the process of developing new solutions with quantum computing. Indeed, according to BCC Research's Quantum Computing, the predicted profitability of Quantum computing technology is very high.

Financial modelling can be very complex, specifically due to the impossibility of carrying out experiments in real life. The ability for Quantum computing to explore all possible ways at the same time would ensure efficient results. As an illustration, the technology could drastically reduce the margin of error and time wasted, immediately identifying the best path. This aspect is perceived as very promising, notably in terms of arbitrage. Indeed, a digital computer would be overwhelmed by the high number of possibilities on financial operations when a Quantum Computer would solve the problem immediately.

Moreover, one of the great advantages consists in the randomness inherent within the nature of quantum computers. Indeed, this is congruent with the stochastic nature of financial markets. With this technology, a significant number of scenarios generated randomly can be used to evaluate the distribution of investments outcomes.



A concrete financial POC

One good example of finance application is the use of Quantum computing by Stefan Woerner (IBM leader) and his colleagues: they ran their Monte Carlo calculations using three of the 20 qubits available on their machine. Although this experiment was performed on a reduced sample, it is a promising proof of concept: once quantum computers capabilities are growing, we will be able to industrialize financial calculations and predictions.

03

Main players

Financial companies & tech giants

One of the most famous initiatives on Quantum Computing technology has been launched by IBM. The tech firm has developed a partnership with industries known collectively as Q Network, which consists in making IBM's most advanced quantum systems available through the IBM cloud, a 20-qubit quantum computing system. The IBM simulators allow parties sharing the same ideas or businesses to test and develop them within an approximate Quantique computing environment. Regarding financial industries, major banking actors are already involved in this initiative. Players include JP Morgan Chase and Barclays. The two banks plan to start to integrate this technology into their commercial strategy for the 2020s] commercial strategy.

Both financial entities identified business features that will, in the next years, be significantly impacted by Quantum computing such as financial risk and fraud detection.

BBVA are also part of IBM Q hub, although this entity chose not to rely entirely on it. Indeed, BBVA also set up a bilateral partnership with CSIC aiming to achieve further development in optimization of portfolio management and services provided to clients.

Other important financial actors chose bilateral partnerships to develop quantum computing based solutions such as ABN Amro and QuTech with the aim to develop a new form of quantum key distribution. That technology would allow a unique and complex code exchange between various actors.

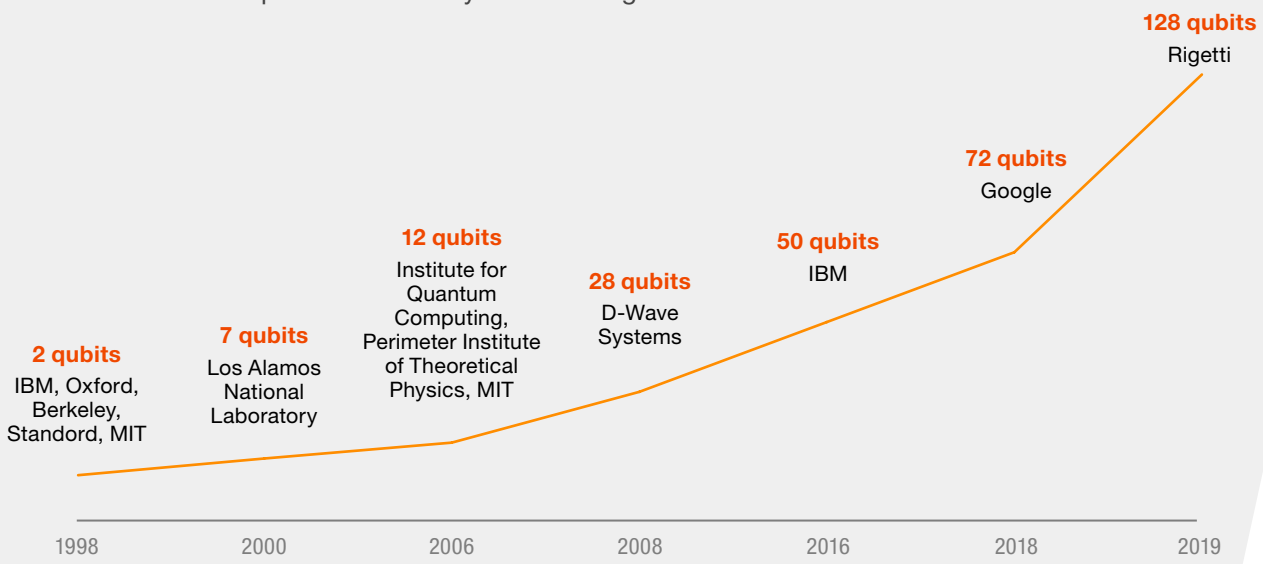
Last but not least, it is to be noted that major financial entities such as Goldman Sachs are currently investing in quantum computing leader D-Wave Company.

In January 2019, IBM unveiled its first commercial quantum computer at the Consumer Electronics Show (CES). IBM's Q System One uses 50 qubits maintaining a quantic state of 90 microseconds and has both classical and quantum components. The company's announcement made it clear that it will take time before commercial quantum computers can beat today's classical machines:

"IBM Q systems are designed to one day tackle problems that are currently seen as too complex and exponential in nature for classical systems to handle."

Quantum Computers are getting more powerful

Number of qubits achieved by date and organization 1998 – 2020*



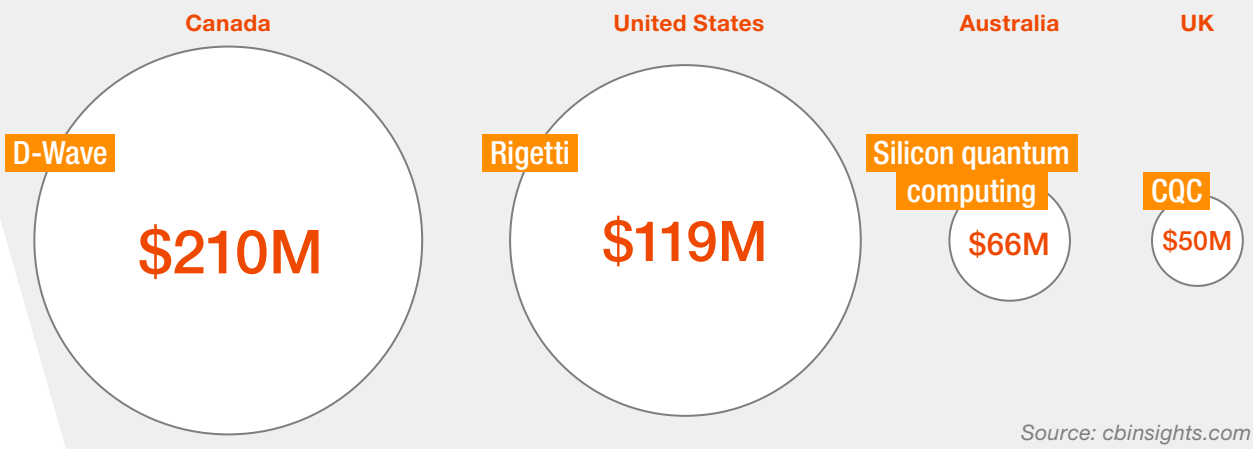
Source: MIT, Qubit Counter

There is only a small number of private companies in the industry that have been able to raise at least $50M (and fewer with over $100M), which suggests that commercial application of quantum computers — for both hardware and software — is nascent at this point, despite the hype.

D-Wave is the most well-funded private quantum computing company with $210M raised to date, followed by Rigetti Computing ($119M), Silicon Quantum Computing ($66M), and Cambridge Quantum Computing (CQC) ($50M).

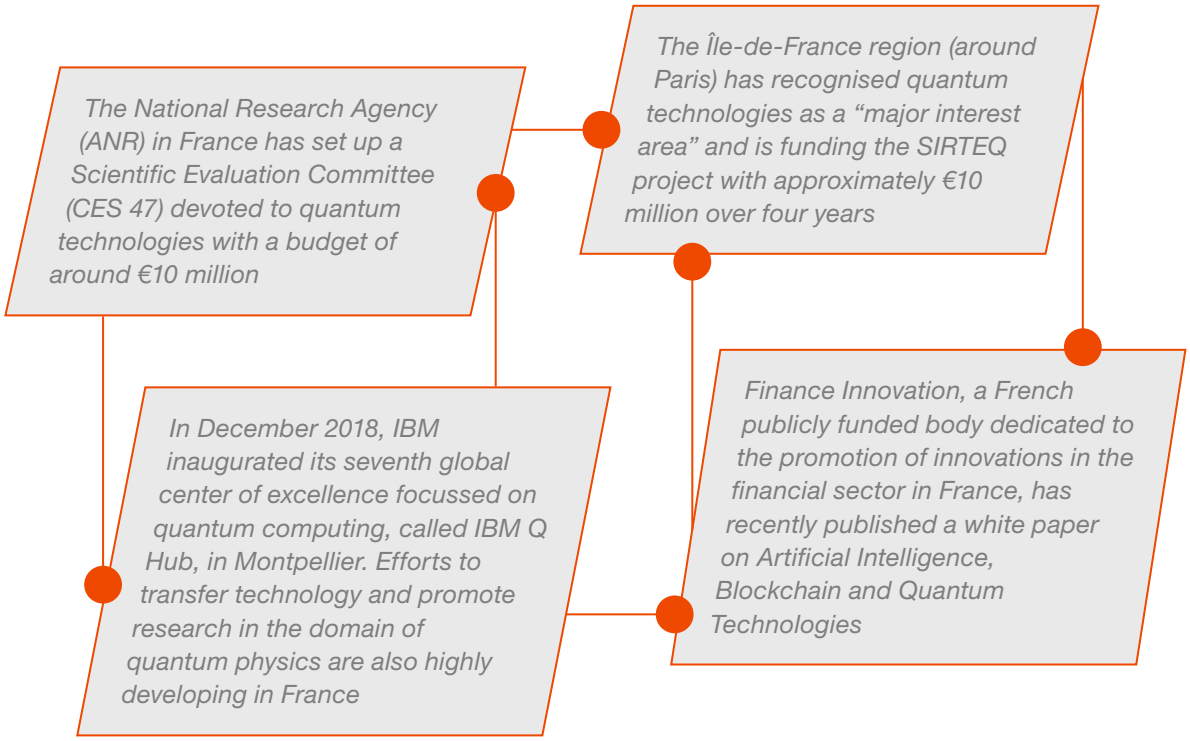
Notably, deals to these four companies accounted for ~70% of the industry's total funding since 2013. Additionally, deals to private quantum computing companies overall reached an all-time high in 2018.

Quantum computing startups with more than $50M raised (as of 01/07/2019)



Source: cbinsights.com

Focus on investment and development in quantum technologies in France



Top Organizations Innovating in Quantum Computing

Out of the players working on and innovating in quantum computing, the majority are SMEs and startups (40%) and universities (33%). When looking at the top ten leaders in Quantum Computing, most are prestigious universities such as Oxford, Harvard, or MIT, and big tech corporations like IBM, Microsoft, and Google.

D Wave Systems (Canada) has recently announced that it has received 50M in funding to deploy its next-generation quantum computing system with more densely-connected qubits, as well as platforms and products for machine learning applications.

IBM announced in April 2019 the expansion of the IBM Q Network to include a number of global universities with the intent to partner with IBM to accelerate joint research in quantum computing, and develop curricula to help prepare students for careers that will be influenced by this next era of computing, across science and business.

The University of Waterloo (Canada) is the one with the highest activity in publications and conference proceedings (229 and 61 respectively). One of their lines of research focuses on the precision measurement of photons, one of the main constraints to the development of quantum applications. And recently, they have published a study that shows that a well-designed optomechanical device can non-destructively detect phonon signals of a wide range of frequencies and in single-quantum level.

The University of Oxford (UK) is the entity that has gained the most public funding: $117.59 M for 62 grants. The majority of them come from the national UK agency GTR. Since 2016, they focus on lattice systems and high-performance sensors for the development of quantum computing.

Sources:

https://www.dwavesys.com/press-releases/d-wave-closes-50m-facility-fund-next-generation-quantum-computers

https://newsroom.ibm.com/2019-04-25-Leading-universities-partner-with-IBM-to-accelerate-joint-research-and-drive-educational-opportunities-in-quantum-computing

https://blog.linknovate.com/quantum-computing-leaders-must-know/

Table presenting the main players

QxBranch/Rigetti

What it does

QxBranch works hardly on a quantum computing software that is mostly focused on data analytics. One of the aim of QxBranch is to help the prediction of particular events. For instance, they actually work on a sophisticated election forecasting models.

Latest news: Jul 11, 2019 Rigetti Computing acquires QxBranch to expand full-stack capabilities

Rigetti Computing is building the world's most powerful computers to help solve humanity's greatest problems.

QC WARE

What it does

QC Ware permits to companies to realize diverse Quantum Computing projects. They offer a multitude of services as process optimization, Monte Carlo methods and Machine learning using the power of Quantum computing.

Latest news: QC Ware announced that the company been awarded a U.S. Department of Energy grant to use quantum computing to better understand complex material and chemical systems. Collaborating with SLAC, QC Ware will apply its expertise to develop hybrid classical-quantum algorithms.

D-wave

What it does

D-wave was created in 1999 and is one of the main actor that was believing in the potential of Quantum Computing. Since, they are dedicated to show that this technology can help to solve some of the most complex technical, scientific, national defense, and commercial problems that organizations can face.

Indeed, D-wave focused on Quantum Computing real-world applications that bring value to enterprises, governments, laboratories, and academic institutions.

Latest news: D-wave announced that its next-generation quantum system will be named Advantage™. Advantage will be available in the Leap™ quantum cloud service in mid-2020. Designed to speed the development of commercial quantum applications, the Advantage quantum system will power a new hardware and software platform that will accelerate and ease the delivery of quantum computing applications.

Microsoft

What it does

According to Microsoft, Quantum Computing is one of the most innovative technology and as such they are focusing its R&D efforts on. Microsoft dedicates its efforts on developing software platforms and architecture for Quantum computers.

Also, Microsoft is developing, for quantum computers, its own programming language.

Latest news: The company announced on May 6th 2019 that it is open-sourcing its Quantum Development Kit, including its Q# compilers and simulators, this summer on GitHub.

IBM

What it does

Contrary to Microsoft, IBM is focusing on the hardware part of Quantum Computing and has recently established itself as a dominant player with a 50 qubit computer.

IBM already offers a prototype to quantum developers to play around with a 20 qubit computer via its cloud services and the objective of this initiative is to develop real-world applications.

Latest news: IBM Expects Commercialization of Quantum Computers in 3 to 5 Years.

Google

What it does

Google works for developing quantum processors and algorithms for the quantum computing sector aiming to solve near-term problems in practice but also in theory.

Google is convinced that quantum computing will play an important in the future in the innovation sector, including AI. That's why they're committed to building dedicated quantum hardware and software today.

Latest news: 23th of October 2019 Google says that it has achieved quantum supremacy, a major milestone towards the development of quantum computers.

04

How can PwC help you moving forward?

Exploration

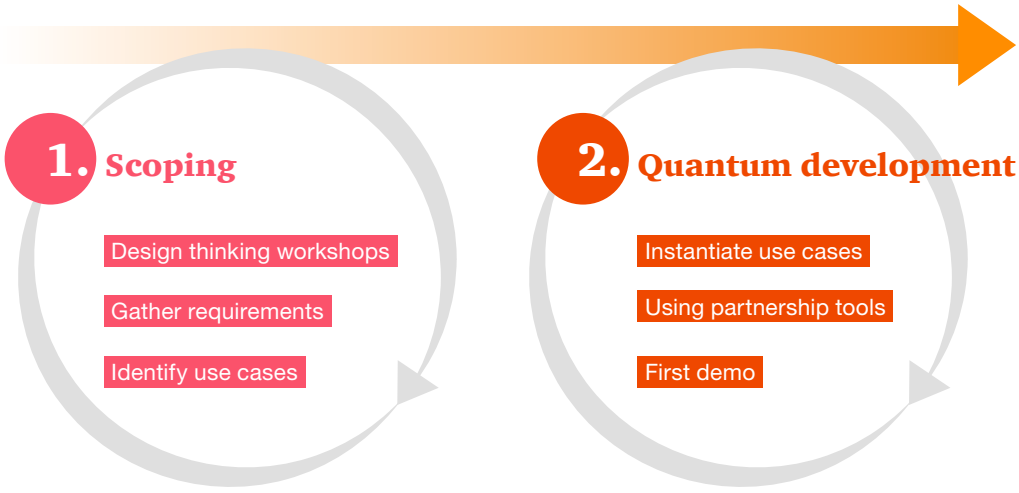
As this technology is not fully mature yet, we believe that the first step is to explore together its potential. We assess your current processes and technologies in place and see how Quantum Computing fits into your ecosystem.

We base ourselves on our expertise on the subject, but this is a co-creation approach in which after an initial scoping phase we identify together the areas of improvement.

Use cases identification

The identification of use-cases can be approached from two different angles:

- Either we present to you the use-cases already identified on our end and apply them to your own environment
  - Financial sector: Risk & fraud detection, portfolio management optimization…
  - Encryption
  - Acceleration of calculation coupled with AI
  - Other applications
- Or we conduct a study in a co-creation approach with your teams in order to identify the potential use-cases that will emerge directly from your processes. This study will follow the process described below:



Dedicated PwC team

We have experts within PwC Consulting on this topic that can help you for the following tasks:

- Help you understand better the technology and its implications
- Describe the benefits and risks
- Identify use cases linked to your business
- Put in place a POC in order to run a simulation

A dedicated team within PwC

As part of the consulting technology practice, we are a growing team that focuses on this technology

A chance to test the technology on concrete examples

With all the industries present within PwC, we have the opportunity to work on real uses cases, in finance, drugs, encryption and so on

Partnerships with IT experts

We partner with the best technological experts on this field to provide concrete applications

Be at the technological forefront

From defining concrete use cases to the delivery of a functional prototype, we can offer clients a first glimpse of tomorrow's technology

Partnerships with world tech leaders

Quantum computing is not just a brand new technology. It is a part of the global ecosystem that regroups cutting-edge technologies, from Robotics to Blockchain.

We are already working with IT development leaders such as Microsoft on various technologies (RPA, AI…) and we are building partnerships on this specific technology to offer you a concrete approach.

As you most certainly understood throughout this document, there are vast investments that are being made today by the worldwide tech giants, but also by big companies such as investment banks.

At PwC, new technologies are a part of our daily jobs and we try to partner with the best team for each job.

Google, Microsoft and IBM are currently confident that this technology has the potential to revolutionize the way we work and we will partner up with the IT leaders to apply this brand new technology to your day-to-day processes.

Experience on RPA, AI & Blockchain

At PwC, we have various experiences and POCs with the implementation of new technologies such as RPA, Artificial Intelligence, or Blockchain. We strongly believe that Quantum computing represents an emulator for all these technologies and is a part of a larger ecosystem that gathers the technologies of tomorrow.

You can find here our publication on Smart automation:

And our platform dedicated to blockchain:

>> the documents are available by clicking on the images above

Conclusion

Throughout this document, we have discussed the concept, benefits, difficulties, potential applications and major players of quantum physics applied to computers.

Quantum computers will perform certain tasks much more efficiently than classical computers, providing us with a new tool for specific applications. But quantum computers will not replace their classical counterparts. In fact, quantum computers require classical computers to support their specialized abilities, such as systems optimization.

This new type of computers will be useful in advancing solutions to challenges in diverse fields such as energy, finance, healthcare and aerospace, among others.

> Its capabilities will help us combat climate change, discover new drugs and help cure diseases, reduce traffic, decrease machine learning time and more. Such a powerful new technology should be used to benefit humanity.

Combined with AI, we can drastically speed up the machine learning and open a whole new world of possibilities. Various companies have already understand the potential of this technology:

- Tech giants are investing huge amount of resources in this technology
- Major industries (investment banking, pharmaceuticals…) have already started to build partnerships with those tech giants and simply have create in-house teams to monitor the progress of this technology
- Many universities have invested in research as well

The recent announcement in October 2019 by Google stating they have already achieved Quantum supremacy will create a momentum and encourage the other players to intensify their efforts. As Quantum supremacy is getting real, the possibilities are endless.

Whether it's for improvements in your calculations, cybersecurity or just to stay on the cutting edge of technology, we believe that this technology is within our reach and will be available in the next coming years.

Quantum computing is the next big thing.

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