

### QUANTUM COMPUTING TREND RESEARCH FROM SCIENCE TO BUSINESS

# THE FUTURE OF QUANTUM COMPUTING

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With **SONAR Trend Platform Reply** is able to create an overview and mapping of relevant trending industries related to **Quantum Computing**, based on their occurrence within expert media articles, mass media, patents and scientific publications.

## SONAR

SONAR is an innovative, **DATA-AS-A-SERVICE TOOL** for quantified foresight. It recognises, compares and analyses existing trends, and identifies new developments in real-time.

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## WHAT IS QUANTUM COMPUTING?

Quantum Computing is an evolving technology that will provide faster computational solutions to problems currently being handled only by supercomputers – or considered unsolvable with the present state of computer technology.



### **Quantum Mechanics**

Quantum mechanics is the basis of Quantum Computing and refers to the scientific laws that affect the smallest dimension of nature: molecules, atoms and subatomic particles. At this level new physical phenomena arise (superposition, entanglement) and they can be used for computing – if carefully engineered into machines.

### **Quantum Computing**

Today standard computers process information in bits, with each bit represented by a **zero or one**. Quantum computers, however, use quantum bits, or qubits, which can be **zero, one or a mixture of zero and one (a so-called superposition).** This can lead to extremely quick processing – meaning that calculations that are not possible using conventional computers are becoming a reality.

### **Quantum Algorithms**

Quantum computers can explore problems which are exponential in nature and are best suited to solving problems using three types of algorithms:

### 1. Optimisation Algorithms

Finding the best solution with the least error from a multitude of possible solutions.

### 2. Sampling Algorithms

Finding values from data sets that allow generalisations about the distribution of the population.

### **3. Machine Learning Algorithms**

Executing machine learning algorithms on a Quantum Computer leads to better algorithm processing and faster results.

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## MILESTONES TOWARDS QUANTUM COMPUTING



High recent growth rates within patent filings show that Quantum Computing is in the midst of moving towards commercialisation and the fifth generation of Computing has started. But what have been the milestones in Computer Science that have paved the way for this new age of Computing?



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## WHO ARE THE CURRENT TRENDSETTERS ACCORDING TO QUANTUM COMPUTING NEWS?

#### **IMPLEMENTERS**

Industries with an above average number of articles over the last 12 months, but declining or low growth compared to the previous 12 months.

Industries already engaging in the new ecosystem, often leading their own efforts for several years.

#### GROWTH

#### PROSPECTS

Industries with a low number of articles over the last 12 months, and declining or low growth compared to the previous 12 months.

Industries observing the space, carefully analyzing business potential or creating early networks. - Chemicals & Pharma

Military –

- Telecommunications

Media & Marketing

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Here is an overview and illustration of relevant trending industries related to Quantum Computing, based on their occurrence in trade media, mass media, patents and scientific publications.

The arrow in the illustration implies a typical trend development and a **life cycle from a small and growing trend** – which is discussed in relatively few scientific articles and publications – **to a larger**,

**established trend** with stagnating growth, which has long been discussed in various media and has shifted from niche circles into the mainstream.



## A CLOSER LOOK INTO THE "EARLY ADOPTER" INDUSTRIES

With Sonar it is possible for Reply to gain insight into how individual industries are currently dealing with the topic of Quantum Computing. Where do they see the possibilities for the use of quantum computers and how far are the real application scenarios already?



## COMPUTER SCIENCE

Quantum computing in the Computer Science industry has grown continuously since 2013.

Morgan Stanley analysts predict that the highend quantum computing market (currently estimated by IBM at \$5-6 billion per year) will nearly double and reach \$10 billion per year by 2025. The development of quantum computers has experienced a serious boost since the tech giants entered the race. IBM's numerous announcements and launches have created quite a stir among media circles and has driven significant volume, among the announcements that generated the highest media interest have been in 2017: IBM makes its Quantum Computer API available to the public and IBM's launch of a Quantum Computing Platform with many Fortune 500 clients and in 2019 the unveiling by IBM of the IBM Q System One, its first standalone 20-qubit quantum computer. High media interest also arose in 2018 when Microsoft launched a Quantum Computing Toolkit and Intel's start of testing its tiny "Spin Qubit", said to have huge impact on Quantum Computing.

D-Wave Systems, the **only company producing and selling commercial quantum computers** until **January 2019** raised **\$204.7M** in 14 funding rounds.







Xanadu, a company with a mission to create the **world's first practical quantum computer** has raised a total of **\$9M**.

Cambridge Quantum Computing develops **tools for the commercialisation of quantum computers** and has raised a total of **\$18.8M** in funding.



With its quantum-first cloud platform Rigetti brings together the best of classical and quantum computing on a single cloud platform that helps to build and run programs that harness the power of real quantum hardware with the ease of a virtual development environment.

With this, Rigetti wants to address fundamental challenges in medicine, energy, business, and science.



These are booming or upcoming trends, meaning the number of articles in various media dealing with these phenomena has drastically increased over the past 12 months.

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## CYBER SECURITY

As Quantum computing poses a threat to today's security mechanisms because it challenges the most common encryption methods, it is essential that governments and enterprises develop quantum secure solutions.

In this race, China is at the forefront with initiatives such as the Micius satellite or the establishment of a national network infrastructure. Although not yet available at commercial level, advances in quantum computing also have the potential to improve security and encryption. The trending players in the field of Quantum Computing are led by ISARA, followed by ID Quantique, Quintessence Labs, Qubitekk and Post Quantum. They all have one thing in common: they are all leading start-up companies in the field of quantum security and encryption.



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In July 2015, Alibaba´s Cloud Unit and the Chinese Academy of Sciences founded the Alibaba Quantum Computing Laboratory, a research facility based in Shanghai.

Alibaba wants to use quantum computers to develop increased security for e-commerce and its underlying data centers.



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## FINANCIAL SERVICES

Quantum Computing is attracting increasing interest from financial services companies with applications ranging from portfolio optimisation, fraud detection, payment systems to high frequency trading.

In recent years, there has been a steady increase in investment activity, with financial companies such as Goldman Sachs, RBS, Citigroup investing money in Quantum Computing technology or hiring their own talent to stay ahead of the competition. Some financial firms are already beginning to experiment with use cases that apply the technology in the Fintech field. In 2018, Goldman Sachs (one of D-Wave's major investors), along with Citigroup, invested as a second major investor in QC Ware, a software company that introduces quantum computers into the company. J.P. Morgan and Barclays received extensive media coverage when they joined the IBM quantum computer system.

1QBit receives **\$45M** in Series B funding from Fujitsu, Accenture, Allianz, RBS, CME Ventures to drive Quantum Computing industry applications.







QC Ware raises **\$6.5M** in a Series A financing – Lead investors: Goldman Sachs and Citigroup.

J.P. Morgan Chase & Co is working with IBM to understand how the emerging technology will impact the company and its customers and explore possible use cases.

They are experimenting with quantum computing's potential for solving computationally-intensive problems such as those related to risk analysis and trading strategies.



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## LOGISTICS & TRANSPORTATION

Logistics and transportation trends showed the highest growth rates from the end of 2017 as many companies in this industry began to take advantage of the opportunities that Quantum Computing has to offer.

The announcement that the major automotive companies Daimler and Honda are buying IBM quantum computers led to a large increase in interest in early 2018. This growth continued as many aerospace companies increased their investments and research into the role of Quantum Computing in their industry. In January 2019, however, there was the highest increase in interest to date: Volkswagen announced the use of Quantum Computing for traffic management.

A **partnership** between Ford and NASA looks into possibilities to apply Quantum Computing to **autonomous vehicle** research with **\$100,000** funding from Ford.





Airbus part of second funding round for quantum software company QC Ware to drive aircraft research. QC Ware raised \$6.5M in total in this round.



Volkswagen laid the foundation for simulating and optimising the chemical structure of high-performance electric vehicle batteries on a Quantum Computer.

Such a quantum algorithm could simulate the chemical composition of a battery on the basis of different criteria and provide a design which could be used directly for production.

This would significantly accelerate the battery development process, which has been time-consuming and resource-intensive to date.



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## **QUANTUM COMPUTING FOR BUSINESS**

## QUANTUM COMPUTING WILL REVOLUTIONISE AI

Quantum computers are able to reduce computing processes from years to hours or even minutes by parallel processing – which is exponentially scaled by the addition of qubits. Particularly in the areas of ML, AI and Big Data, this promises to address complex problems that could not be solved due to the computational limitations of classical computer architecture.

## 2 CURRENT DATA ENCRYPTION TACTICS BECOME OBSOLETE

The power of quantum computers will dwarf current processing possibilities and lead us into a new era of knowledge and discovery. However, this power poses such a huge threat to cyber security that the protection of commercial transactions and other data transfers must be completely redesigned. Fortunately, quantum cyber security is already meeting this challenge with advances such as quantum key distribution, quantum secure algorithms, and true random numbers.



#### EXAMPLES:

- Al on a Quantum Computer has the potential to hold a real conversation with humans and actually understand what is being said in real-time.
- Quantum computing could sequence and analyse a person's genes much faster than the methods we use today. This would pave the way for personalised drug development.



### EXAMPLES:

 According to Gartner, within five years more than 20% of all companies will be investing in quantum computing products including quantum secure encryption, to ensure their safety from cyber-attacks.

## QUANTUM COMPUTING APPLICATIONS BY INDUSTRY

## **1** EARLY ADOPTERS

### COMPUTER SCIENCE

- Detecting statistical anomalies
- Recognising images and patterns
- Training neural networks
- Verifying and validating software
- Classifying unstructured data

### CYBER SECURITY

- Cryptography
- Quantum secure communications
- Optimising network operations
- Fraud detection

### FINANCIAL SERVICES

- Detecting market instabilities
- Developing trading strategies
- Optimising portfolios
- Financial forecasting
- Market simulation
- Asset pricing

### LOGISTICS & TRANSPORTATION

- Intelligent traffic management
- Autonomous vehicles
- E-Charging Network Optimisation
- Material Science: e.g. battery technology
- R&D and Manufacturing

## 2 PROSPECTS

#### DEFENSE

- Mission planning and logistics
- System validations and verification
- Optimising battery technology

#### MEDIA & MARKETING

- Advertising scheduling
- Revenue maximisation
- Campaign optimisation

#### TELECOMUNICATIONS

- Quantum secure communications
- Optimising network operations

## 3 LAGGARDS

### **ENERGY & UTILITIES**

- Network design
- Energy exploitation
- Climate modeling and weather predictions
- Energy distribution
- Seismic survey optimisation

### **4** IMPLEMENTERS

#### CHEMICALS & PHARMA

- Faster drug discovery
- Optimising radiotherapy treatments
- Personalised drugs
- Improved Patient diagnostics

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