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Quantum Technology and Japanese Law

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In recent years, quantum computers and other "quantum technologies" have rapidly been attracting attention. Specifically, quantum technology is expected to bring about high computing power and innovations in encryption technology that surpass conventional information technology, and various parties both in Japan and overseas are working on its practical application.

On the other hand, new issues are emerging, such as the risk of existing encryption being broken, and it is expected that there will be an increasing number of situations in which quantum technology will be required in national security, cybersecurity, and contract practice. This article focuses on quantum computers as a representative example of quantum technology, providing an overview of quantum computers and summarizing the main points of contention under current Japanese law.

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I. Summary of Relevant Legal Frameworks

1. National Security Legislation

・Foreign Exchange and Foreign Trade Act:

With the revision of Cabinet Orders and Ministerial Ordinances in 2024 and 2025, quantum computers and related items will be subject to export and technology transfer permission. The restrictions are currently expanding, and manufacturers and others need to continue to pay attention to the restrictions.

・Economic Security Promotion Act:

"Quantum information science" has been designated as a specific important technology and will be subject to research and development support through public-private councils and large-scale subsidies. In addition, quantum technology is not currently subject to the "patent non-disclosure system," but there is a possibility that this will change in the future.

・Act on the Protection and Utilization of Critical Economic Security Information

To be enacted in May 2025. It will establish a mechanism for protecting and utilizing information related to important infrastructure and important material supply chains. In relation to these, quantum technology-related information may also be subject to strict management as "important economic security information" (however, this will only be limited to government-held information).

2. Cybersecurity Legislation:

Although the current law does not directly mention quantum technology or Post-Quantum Cryptography, if the threat of the spread of quantum computers increases, measures based on existing laws may be required.

Movements have already begun at the guideline level, with the Financial Services Agency's guidelines to specify attention to quantum computers in October 2024, and a request to major and regional banks to quickly switch to Post-Quantum Cryptography in May 2025.

3. Contractual issues regarding the use of quantum computers

It may become necessary to stipulate in contracts the scope of liability and disclaimer clauses (probabilistic results, potential errors, etc.) that differ from those for classical computers in terms of the challenges and characteristics unique to quantum computing.

Given the large scale and high cost of actual machines, cloud-based quantum computing is the general method of use, but there is no established standard for quality assurance (error rate, uptime, etc.). Companies are publishing various

indicators of quality.

II. Overview of Quantum Computers

1. Basic Principle

Quantum computers use quantum properties such as "superposition", "entanglement", and "quantum tunneling" to perform calculations, which are expected to enable calculations that are significantly faster than conventional computers (known as classical computers) for certain problems.

[Terminology] ・Quantum Superposition: Classical computer bits can only be in the "0" or "1" state, but quantum bits can be in the "0 and 1" state at the same time. For example, while a coin is spinning, it is not yet clear whether it will land on heads or tails. This superposition allows a quantum computer to process multiple calculation patterns in parallel with one quantum bit, achieving significantly faster calculations than classical computers in certain tasks. ・Quantum Entanglement: A phenomenon in which multiple quantum bits remain in linked states. For example, when two quantum bits are entangled, measuring one of them instantly determines the state of the other, regardless of distance. It is expected that this property can be used to link bits together to perform complex parallel calculations and realize highly secure quantum cryptography. ・Quantum Tunneling: A phenomenon in which quantum mechanical properties allow the "slip-through" of energy barriers that cannot be overcome in classical physics. In optimization problems, slipping through the "mountains" between the valleys rather than overcoming them makes it easier to reach the optimal solution, enabling efficient search.

There are two main types of quantum computers: Gate-Based Quantum Computers and Quantum Annealers.

Method	Basic principles/properties	Main applications	Representative companies

Gate-Based Quantum Computer	Using quantum "superposition" and "entanglement," complex problems can be calculated in parallel for high-speed processing	Versatile quantum algorithms support a wide range of applications (e.g., chemical simulation and machine learning)	Google (superconductivity), Intel (semiconductors), IonQ (ion traps), PsiQuantum (light), QuEra Computing (neutral atoms)
Quantum Annealer	Using quantum "quantum tunneling" to explore the lowest energy state	Specializing in optimization problems (logistics route optimization, portfolio optimization, etc.)	D-Wave Systems

The Gate-Based Quantum Computers are "general-purpose quantum computers" that can execute general-purpose quantum algorithms. Various methods are being researched, including superconductivity, semiconductors, ion traps, light, and neutral atoms. However, mainstream technology has not yet been established, and there are issues such as error correction before it can be put into practical use. In contrast, the Quantum Annealers are specialized for combinatorial optimization problems, and D-Wave Quantum Inc. provides commercial machines. In general, when people say "quantum computer," they are often referring to the Gate-Based Quantum Computers, but the terms are used differently depending on the application and implementation technology.

Method	How qubits work	Advantage	Issue	Representative companies, research institutes and universities
Superconducting	By passing microwaves	High-speed gate operation *	- Noise and errors are	[Internet] Google, IBM,

approach	through a superconductin g circuit, two states of electric current or magnetic flux are converted into quantum bits.	- Existing semiconductor manufacturing technology can be applied	likely to occur - Extremely low temperature (close to absolute zero) environment required	Rigetti [Japan] Fujitsu, NEC, RIKEN, National Institute of Advanced Industrial Science and Technology
Semiconduct or approach	Utilizing the state of electrons and spin in semiconductors such as silicon	- High compatibility with CMOS technology, making it easy to achieve large-scale integration in the future	- Quantum bits have a short coherence time, making them difficult to control	[Overseas] Intel, Equal1, Diraq, UNSW University of Sydney [Japan] Hitachi, RIKEN, National Institute of Advanced Industrial Science and Technology, blueqat
Ion trap approach	Ions suspended in a vacuum are manipulated with a laser to turn their internal states into quantum bits	- Long coherence time and high gate accuracy	- The equipment tends to become large, making it difficult to arrange many quantum bits.	[Overseas] IonQ, Quantinuum, AQT, Oxford Ionics, Universal Quantum [Japan] RIKEN, National Institute of

				Advanced Industrial Science and Technology, Qubitcore
Photonic approach	Converting the state of a photon, such as its polarization or path, into a quantum bit	- Operates at room temperature - High compatibility with quantum communication and networks	- Large-scale integration and error correction technologies are still in development - Photon source and detector are issues	[Overseas] PsiQuantum, Xanadu [Japan] NTT, RIKEN, University of Tokyo, OptQC
Neutral Atom approach	Utilizing the internal state and configuration of neutral atoms cooled and aligned by laser	- It is relatively easy to arrange a large number of quantum bits, making it highly scalable.	- Gate operation is slow - High precision laser control is required	[Overseas] Computing, Pasqal, Infleqtion, Atom Computing [Japan] National Institute of Advanced Industrial Science and Technology, Institute for Molecular Science, Kyoto University, Yaqumo

*Gate operation: A basic operation in which a quantum bit is given a certain stimulus (such as a microwave pulse or laser pulse) to change its state, and corresponds to the logical gates

(AND/OR/NOT, etc.) of a classical computer. Examples include the X gate (which swaps the quantum bit's 0 and 1) and the H (Hadamard) gate (which puts the quantum bit into a superposition state). The key to developing quantum hardware is to perform these gate operations quickly and with high precision.

On the other hand, Quantum Annealers are specialized for "combinatorial optimization" and cannot perform general-purpose calculations, but it is more advanced in practical use than Gate-Based Quantum Computers. In addition to the commercial machine provided by D-Wave, a Canadian company, "Quantum-Inspired Annealing" (Fixstars Amplify AE, Fujitsu Digital Annealer, etc.), which reproduces the behavior of classical computers in a pseudo-manner, has also been developed.

2. Current Status of Quantum Computers

In January 2025, NVIDIA CEO Jensen Huang said that it would take about 20 years to realize a practical quantum computer, causing a sharp drop in quantum-related stocks in the United States. This is thought to be a forecast referring mainly to Gate-Based Quantum Computers, and at the time of writing this article (end of May 2025), many experts believe that it will take a considerable amount of time before they can be put to practical use. The main reason is that errors (decoherence due to external noise) that occur in the process of maintaining "superposition" and "entanglement" in Gate-Based Quantum Computers are serious, and advanced "error correction" technology is essential to resolve this. However, it is still thought that a considerable amount of time will be required to establish error correction technology, which is the background to the view that it will take 10 to 20 years.

However, research and development of various Gate-Based Quantum Computer approaches are accelerating around the world, and in Japan, large companies, startups, research institutes, and universities are competing to develop actual machines. In addition, commercial machines for the Quantum Annealers are already in widespread use, and an environment for online use has been established. In this way, quantum technology is not a "Matter of the distant future”, but technology that is currently being implemented in society.

3. Applications of quantum computers and risks to existing technologies

Quantum computers are expected to be used in the following areas:

Field	Examples of usage scenarios
Finance and Economics	- Portfolio optimization (instantly calculate optimal allocations from a huge number of combinations) - Accelerating risk evaluation and price simulation
Logistics and Supply Chains	- Optimization of vehicle routes and warehouse layouts - Planning optimal transportation and movement routes during disasters and peak demand
Energy Smart Grid	- Optimization of power grid supply and demand - Real-time control taking into account fluctuations in renewable energy
Material Design and Drug Discovery	- Predict the properties of battery materials and candidate drug molecules with high accuracy using quantum chemical calculations
Healthcare Genomics	- Accelerating gene sequence analysis - High-precision prediction of protein structure
Weather and Climate Simulation	- High-resolution calculations of atmosphere-ocean models - Scenario evaluation of greenhouse gas reduction measures
Machine Learning and AI	- Quantum reinforcement learning to achieve high accuracy even with small data sets and to accelerate generative AI learning

In the fields mentioned above, there are hopes for the realization of "quantum supremacy," which would enable calculations that would take years on classical computers to be completed in a short time. However, quantum supremacy does not necessarily come with benefits; it also comes with risks to existing technologies. A typical example is the weakening of encryption technology, and there are concerns that quantum computers may be able to crack conventional public key cryptography.

Cryptanalysis	If practical-scale quantum computers were to become available, currently widely used public key cryptography such as RSA and elliptic curve cryptography would be decrypted in a short time, threatening to instantly undermine the security of all aspects of society, including Internet communications and electronic payments.

Current encryption technology is based on mathematical problems that are difficult to decrypt using classical computers, but when quantum computers become practical, they may be decrypted in a short time using techniques such as "Shor's algorithm." This puts public key cryptography, which is used in every aspect of business and daily life, at risk, and is also thought to affect blockchain, which is based on tamper resistance. Furthermore, a method known as the "Harvest Now, Decrypt Later attack" has been pointed out as a risk of intercepting and storing data at present, and then decrypting it all at once in the future when quantum computers become practical.

For this reason, there is an urgent need to transition to "Post-Quantum Cryptography (PQC)," which is difficult to decrypt even with a quantum computer. In the United States, the National Institute of Standards and Technology (NIST) selected several PQCs as candidates for standardization in August 2024, and has continued to consider them since then. In Japan, CRYPTREC (Cryptographic Technology Evaluation Committee), which evaluates and monitors cryptographic technologies, will publish the "CRYPTREC Cryptographic Technology Guidelines (Post-Quantum Cryptography) 2024 Edition" at the end of March 2025[1], which provides technical explanations, evaluations, and implementation guidance for various PQCs. Since encryption technology is the foundation of all services, each business operator needs to pay close attention to the standardization trends of these PQCs and begin preparations early.

4. Trends of foreign governments regarding quantum technology

Overseas, major countries are making large-scale investments in quantum technology, and some countries are also focusing on developing legal infrastructure. Japan must also keep a close eye on these trends and strive to balance its international competitiveness with issues such as cybersecurity and national security.

Country	Trends
US	In 2018, the federal government passed the National Quantum Initiative Act, which allows the federal government to work to promote quantum R&D and build a system for developing human resources.
EU	The EU has launched a large-scale project worth 1 billion euros called the "Quantum Flagship" and is leading research and development into

[1] https://www.cryptrec.go.jp/report/cryptrec-gl-2007-2024.pdf

	quantum computers and quantum communications.
China	The nation is investing heavily in research and development of quantum communications and quantum computers, with a particular emphasis on applications in the military and security fields.

III. Quantum Technology and Japanese Law

In Japan, at the time of writing this article (end of May 2025), there is no specific law targeting quantum technology. Looking at other cutting-edge technology fields, various regulations have already been imposed on blockchain (crypto assets, etc.), and in May 2025, the Act on Promotion of Research, Development and Utilization of AI-Related Technologies was passed with the aim of promoting utilization and reducing risks[2][3] It is possible that a dedicated law for quantum technology will be enacted in the future, but for now, it is necessary to consider the applicability of existing laws for each use case. Specifically, we will review (1) how national security-related laws relate to export control and development support for quantum equipment and technology, and (2) how cybersecurity legislation will handle the impact of quantum technology on existing cryptography. Furthermore, (3) when providing and using quantum services, new issues will arise that need to be considered, such as contractual allocation of responsibility and exemptions, and quality assurance. We will provide an overview of the legal framework regarding these issues.

1. Quantum Technology and National Security

(1) Risks of quantum technology to national security

The United States and China are investing heavily in quantum technology on a national scale, as it is directly linked to national security in terms of invalidating existing encryption technology and making communications difficult to intercept. In the United States, the National Quantum Initiative Act was enacted in 2018 with the aim of maintaining and strengthening both economic competitiveness and national security. A quantum R&D system was established through collaboration between universities,

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[2] https://www.nikkei.com/article/DGXZQOUA270UW0X20C25A5000000/

[3] https://www.cao.go.jp/houan/pdf/217/217gaiyou_2.pdf

companies, and research institutes and large-scale budget investment. Japan does not have a law specifically related to quantum, but the advanced quantum field may be subject to existing security-related laws (Foreign Exchange and Foreign Trade Act, Economic Security Promotion Act, and Important Economic Security Information Protection and Utilization Act). We will consider how research and development of quantum computing and quantum sensors can be regulated and supported from a security perspective within the framework of these existing laws.

(2) Foreign Exchange and Foreign Trade Act

(i) Overview of the Foreign Exchange and Foreign Trade Act

The Foreign Exchange and Foreign Trade Act is a law that controls the overseas provision of goods and technology and investment from abroad from the perspective of national security. Specifically, it stipulates 1) export restrictions (to prevent overseas outflow), 2) restrictions on service transactions (including the provision of intangible technology), and 3) restrictions on inward direct investment (prior notification for investment and acquisition by foreign capital).

(ii) Restrictions under the Foreign Exchange and Foreign Trade Act that apply to quantum technology

Quantum technology is one of the areas in which there is concern about the risk of goods and technology being leaked overseas. For this reason, a revision to the Cabinet Order and Ministerial Ordinance in September 2024 will make quantum computers subject to export controls, and permission will be required for exports to all regions.[4] Furthermore, the amendments coming into force on May 28, 2025 will similarly add key technologies and materials essential to practical-scale quantum computers as targets for regulation.[5][6] In addition, the transfer of technology regarding

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[4] Article 48 of the Foreign Exchange Law , Article 1, Schedule 1-8 of the Export Trade Control Order, Schedule 1 of the Export Trade Control Order, and Schedule 6 of Article 7 of the Ministerial Ordinance Prescribing Goods or Technology Pursuant to the Provisions of the Foreign Exchange Law

[5] https://www.nikkei.com/nkd/industry/article/?DisplayType=1&n_m_code=036&ng=DGXZQOUA316FJ0R30C25A1000000

[6] Article 48 of the Foreign Exchange Act , Article 1, Schedule 1-7 of the Export Trade Control Order, and Article 6 of the Ministerial Ordinance on Goods and Technology Pursuant to the Provisions of Schedule 1 of the Export Trade Control Order and the

quantum computers and related items that are subject to export controls is also subject to regulations.[7]

Regulated (as of the end of May 2025)	Official Location
Quantum computing	All regions
Quantum computer-related items: Cryogenic refrigerators Cryogenic amplifiers Cryogenic wafer probers Isotope separation Silicon/germanium substrates and raw materials	All regions

Given that export and technology transfer restrictions under the Foreign Exchange and Foreign Trade Act are currently expanding, quantum-related companies will need to establish a system that allows them to constantly check whether their products and technologies are subject to restrictions.

(3) Economic Security Promotion Act

(i) Outline of the Economic Security Promotion Act

The Economic Security Promotion Act ("Act on Promoting Security through Integrated Economic Measures") enacted in 2022 aims to support the technology and materials of domestic companies and research institutions and strengthen national security from an economic perspective. The specific mechanism is based on the following four pillars. These measures.[8] hope to reduce risks through public support and information

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Schedule of the Foreign Exchange Order (https://www.meti.go.jp/policy/anpo/law_document/shourei/20250403_gaiyo.pdf, https://www.meti.go.jp/policy/anpo/law_document/20250328_ristshiryou.pdf)

[7] Article 25 of the Foreign Exchange Law, Article 17, Appended Tables 7 and 8 of the Foreign Exchange Order, Appended Tables 1-7 and 8 of the Export Trade Control Order, Appended Table 1 of the Export Trade Control Order , Article 6 and Article 7, Item 6 of the Ministerial Ordinance Prescribing Goods or Technology Pursuant to the Provisions of the Appended Table of the Foreign Exchange Order

[8] However, with regard to ② ensuring the stable provision of core infrastructure services, prior screening of suppliers and parts is required when introducing and maintaining "specific important facilities" such as electricity, communications, and logistics, and these facilities are directly subject to regulation.

sharing.

1. Ensuring a stable supply of essential materials
2. Ensuring stable provision of core infrastructure services
3. Supporting the development of cutting-edge technologies
4. Non-disclosure system for patent applications

(ii) Relationship with quantum technology

In the third pillar- advanced technology support, "quantum information science" has been designated as a specific important technology.[9] Research and development will be promoted and utilized through the provision of financial support, the establishment of a council to provide support through public-private partnerships, and the outsourcing of research and study work.

In addition, the fourth pillar, the patent non-disclosure system, allows for measures such as withholding the disclosure of inventions that pose security risks and prohibiting foreign applications. At the time of writing this article (end of May 2025), quantum computers and quantum cryptography communication have not been designated as "specific technology fields" that are subject to this system. However, given the intent of the law, the assumption can be made that they may be designated in the future, so it is a system that developers should be aware of.

(4) Act on Protection and Utilization of Important Economic and Security Information

(i) Overview of the Act on Protection and Utilization of Important Economic and Security Information

On May 16, 2025, the Act on Protection and Utilization of Important Economic and Security Information came into force. Previously, the Act on the Protection of Specially Designated Secrets was a security clearance system for defense, diplomacy, terrorism, and espionage-related information[10], but this Act aims to expand into economic

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[9] https://www.cao.go.jp/keizai_anzen_hosho/suishinhou/doc/kihonshishin3.pdf

[10] According to the Cabinet Office, the security clearance system is described as "a system that, as part of the nation's information protection measures, grants access to information held by the government that is designated as important for national

security, establishing a system for protecting and utilizing information related to important economic infrastructure.

The Act first defines the systems for providing critical infrastructure and the supply chains of important materials as "critical economic infrastructure" (Article 2, Paragraph 3). It then defines four types of information as "critical economic infrastructure protection information," including measures to protect the critical economic infrastructure, and information on the vulnerabilities of the critical economic infrastructure and innovative technologies related to security (Article 2, Paragraph 4). Furthermore, among the information that falls under the category of critical economic infrastructure protection information, there is a mechanism by which the government may designate information that is not publicly known and meets the requirement of confidentiality as "important economic security information" (Article 3, Paragraph 1).

Important Economic Infrastructure	Provision of critical infrastructure and supply chain of critical material

Important Economic Infrastructure Protection Information	Four types of information related to the protection of critical economic infrastructure ① Measures to protect important economic infrastructure from external actions + related planning and research Important economic infrastructure protection information ② Information on the vulnerability of important economic bases, innovative technologies, and other important information related to national security ③ Information collected from foreign governments and international organizations regarding the measures in ① ④Collection and organization of information listed in ②③ or the ability to do so

security to those who need to access it, and who have been confirmed to be trustworthy with no risk of leaking the information"
(https://www.cao.go.jp/keizai_anzen_hosho/hogokatsuyou/doc/sankou_clearance.pdf).

Important Economic Security Information	① Applicability of the information to protect important economic infrastructure, ② Non-public knowledge, ③ Necessity of confidentiality

The purpose of this law is to both "protect" and "utilize" designated important economic and security information. Specifically, to properly handle economic information held by the government that is important for national security, the law stipulates the requirements for businesses that are permitted to provide information designated as important economic and security information, as well as the methods of evaluating the suitability of individuals who handle the information. Note that the designation is strictly limited to government-held information, and technical information independently developed by private companies is not unilaterally designated and its handling is not restricted.

(ii) Relationship with quantum technology

As mentioned in (i), the Act on the Protection and Utilization of Important Economic and Security Information covers four types of information related to the protection of important economic bases (critical infrastructure and supply chains of important materials). Specifically, it includes information directly related to national security, such as measures, plans, and research to protect infrastructure from external threats, infrastructure vulnerabilities, and innovative technologies. The infrastructure and materials covered are to be determined by reference to those stipulated in the Economic Security Promotion Act and the "Action Plan for Cybersecurity of Critical Infrastructure."[11] This includes infrastructure such as electricity, gas, water, communications, transportation, logistics, finance, chemicals, and medicine, as well as important supplies such as semiconductors and advanced electronic components.

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[11] Article 18 of the Act on Protection and Utilization of Important Economic and Security Information , " Standards for uniform operation regarding the designation and de-designation of important economic and security information, the implementation of suitability evaluations, and the certification of compliant businesses " (pp. 4-5).

Quantum technology, such as quantum computers that pose a risk of breaking existing encryption, and quantum cryptography communication that increases security, is highly likely to fall under the category of information relating to the protection of critical economic infrastructure mentioned above, and it is quite possible that it will be designated as important economic and security information in the future. However, to repeat what was stated in (i), only government-held information can actually be designated as important economic and security information, and technologies developed in-house by private companies are not unilaterally designated as such.

2. Cryptography and Cybersecurity Legislation

In addition to national security, quantum technology is also an issue in Japanese law in relation to cybersecurity. As mentioned in II 3., the development of quantum computers poses the risk that conventional encryption technologies may be decrypted.

(1) Legal level

In Japan, the Basic Act on Cybersecurity imposes the responsibility to ensure security on the state and businesses, and the Personal Information Protection Act requires the appropriate management of personal data. At the time of writing this article (end of May 2025), these laws do not specifically mention quantum technology or Post-Quantum Cryptography (PQC). However, if the spread of quantum computers compromises existing cryptography and increases security risks, it is possible that necessary measures will be required to be taken based on these laws even if they are not explicitly stated in the articles.

(2) Guideline level

In response to this, quantum technology has already been mentioned at the guideline level. The Financial Services Agency has published the "Guidelines on Cybersecurity in the Financial Sector" for financial institutions.[12] " (published on October 4, 2024). It clearly states that when collecting and analyzing threat and vulnerability information, "collect information while paying attention to the circumstances surrounding the organization, such as new technologies (AI, quantum computers , etc.), geopolitical trends, disinformation, and industry trends" as "matters that it is desirable to address."

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[12] https://www.fsa.go.jp/news/r6/sonota/20241004/18.pdf

Furthermore, according to the Nihon Keizai Shimbun (dated May 14, 2025)[13], the Financial Services Agency is calling on major and regional banks to immediately begin preparations to transition to PQC. It appears that the agency is calling for an immediate response, as PQC compliance will require years of system modifications and other costs.

3. Contractual Issues Regarding the Use of Quantum Computers

When users use quantum computers, the question of how to deal with possible errors and fluctuations in the quantum computing results in a contract may arise. Such questions may arise due to the challenges and characteristics unique to quantum computing.

(1) Issues and characteristics specific to quantum computing (errors, algorithm-level probability, difficulty in verifying calculation results)

As mentioned above, errors that occur during calculations are a major issue with Gate-Based Quantum Computers. In addition, some quantum algorithms are run repeatedly to extract the statistically best solution, meaning that the same input does not always produce the same output. The Quantum Annealers may also produce different solutions each time it is executed due to the nature of its principle (probabilistically searching for solutions with low energy), hardware noise, thermal noise, etc. In addition, large-scale calculations that involve quantum supremacy are difficult to reproduce and verify on classical computers.[14] , meaning one cannot fully guarantee the correctness of the output.

For these reasons, there is a risk that the results of quantum computing will contain errors and fluctuations, which will affect subsequent predictions and simulations. As the number of services using quantum computers increases, it may become necessary

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[13] https://www.nikkei.com/article/DGXZQOUB044OX0U5A400C2000000/

[14] Verification methods include interactive protocols (a method in which a verifier using a classical computer asks a quantum computer various questions, thereby providing some degree of assurance that quantum calculations are being performed correctly) and statistical verification using random sampling (a method in which the distribution of measurement results for large-scale quantum calculations is partially checked using a classical computer to confirm the degree of agreement), but there are challenges in scaling up these methods.

to clarify the scope of responsibility for hardware (quantum processors), software (algorithms), user circuits and data, and to introduce clauses that differ from traditional IT contracts, such as disclaimer clauses that assume that results are probabilistic and that there are potential errors.

(2) Contractual considerations regarding cloud-based quantum computing

Because the actual equipment for both the Gate-Based Quantum Computers and the Quantum Annealers are large-scale and expensive, cloud-based quantum computing, in which equipment provided by hardware vendors is used via the cloud, is expected to become the standard method of use for the time being.

In conventional cloud computing, a certain level of uptime is guaranteed under a service level agreement (SLA), but in the case of cloud-based quantum computing, the question of what kind of quality guarantees (error rate, uptime, etc.) should be made can become an issue. For example, IBM Quantum Platform (Gate-Based Quantum Computer), D-Wave Leap (Quantum Annealer), and Amazon Braket (which handles multiple external Gate-Based Quantum Computers and Quantum Annealers via API) each publish various indicators (gate error rate, coherence time, time required to process a job, etc.), but it seems that a standard approach has not yet been established.

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