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# Cutting-edge technologies to realize "Digital Trust"

Dr. Hirotaka HARA
CEO, Fujitsu Laboratories LTD.

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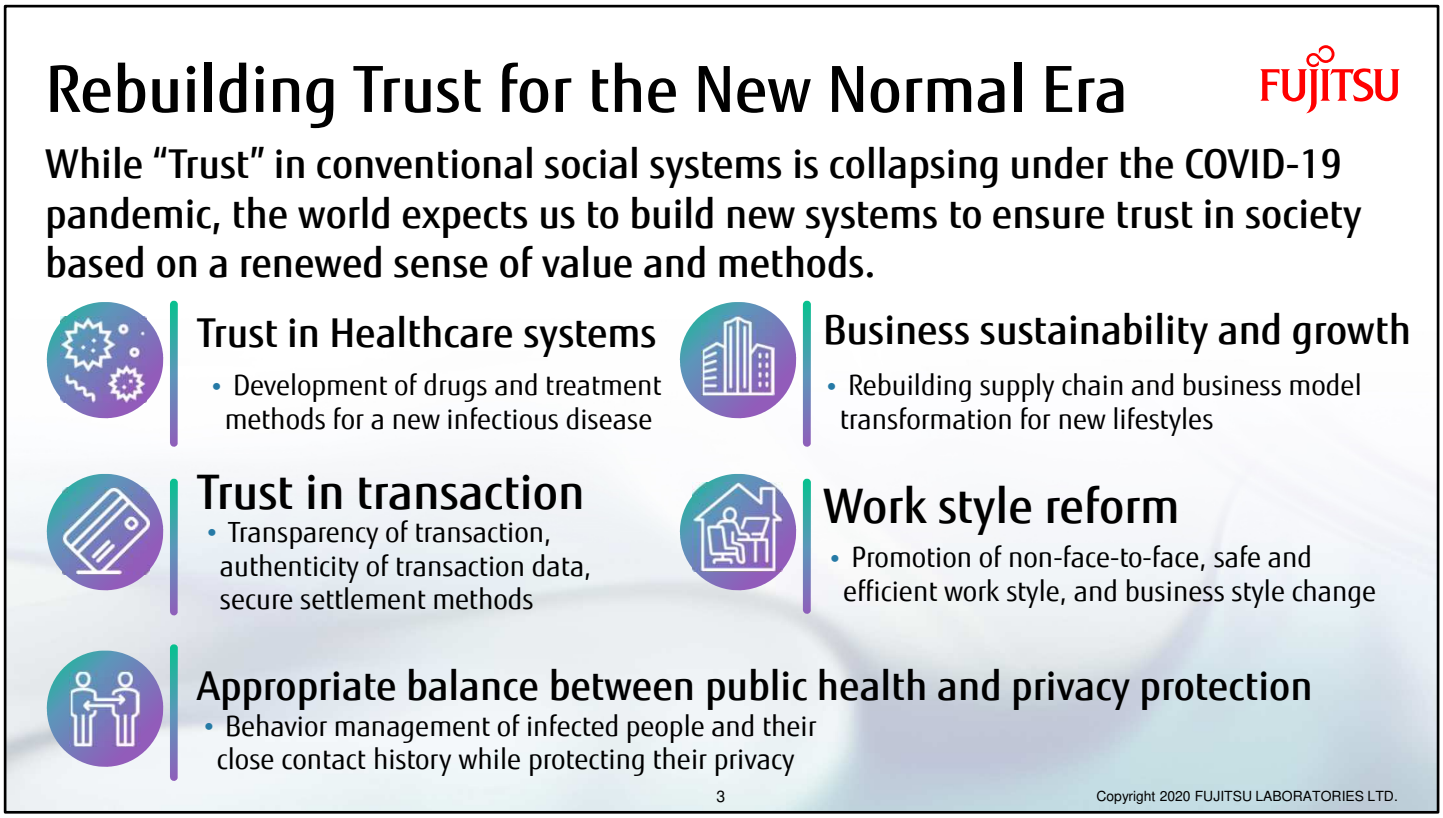
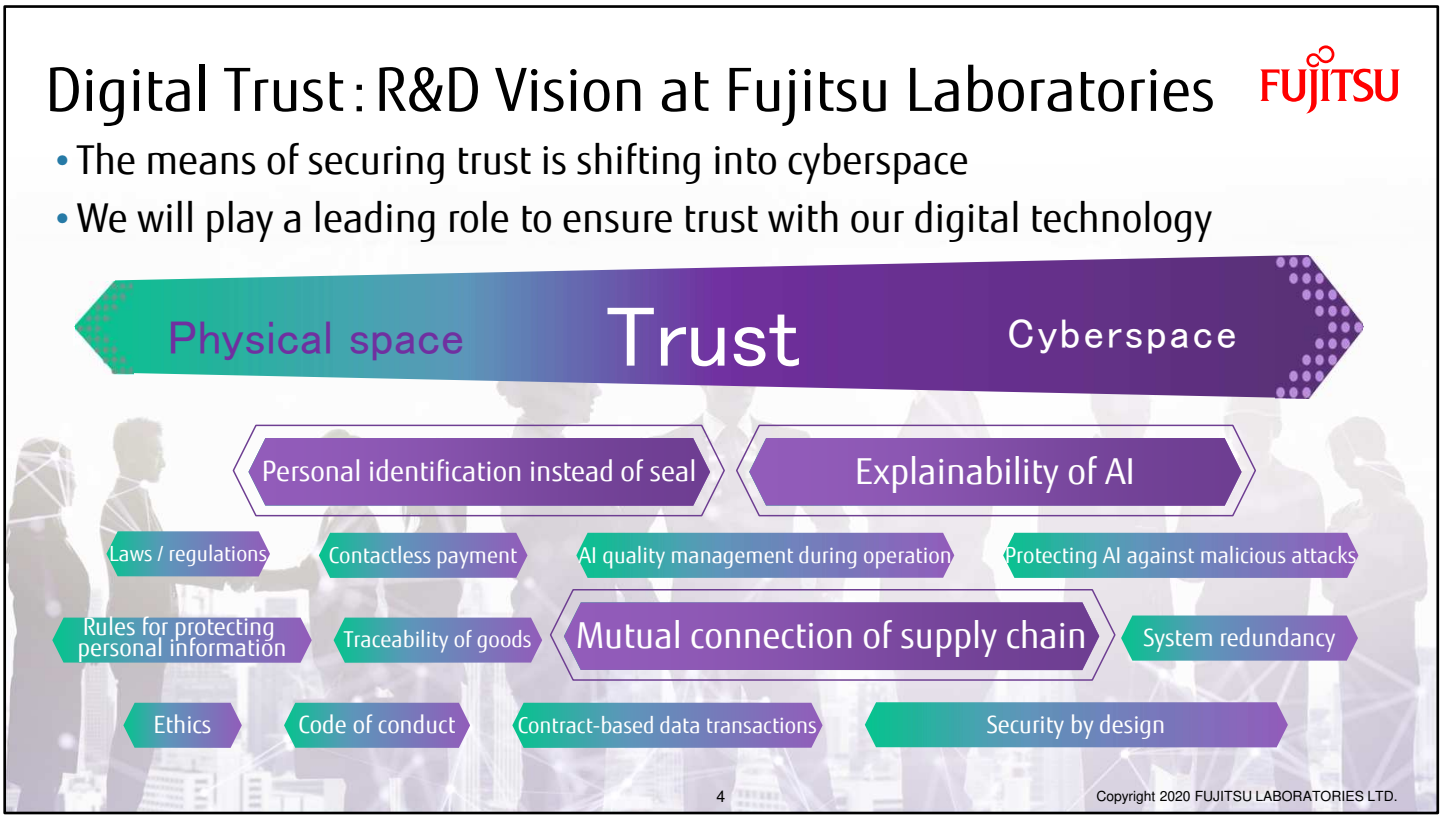
- Hello, everyone. I'm Hirotaka Hara, CEO of Fujitsu Laboratories.
- I would like to talk about the activities of Fujitsu Laboratories based on Fujitsu's R&D strategy as explained by Mr. Furuta.


- At the last year's strategic briefing, I talked about "Digital Trust" as the R&D vision of Fujitsu Laboratories.




- The word "trust" is a key element to Fujitsu's purpose that Mr. Furuta introduced earlier, and the concept of "trust" is becoming even more important in an era of increasing uncertainty.
- The dramatic change in society due to this COVID-19 crisis is also a manifestation of uncertainty. The COVID-19 crisis has shaken everything that we previously trusted in, and we need to rebuild trust. Let me give you some examples.
- The risk of infection will continue and the health care system will always be at risk. In order to secure trust in medical care, it is necessary to develop a quick treatment method and realize safe and smooth medical care.
- Business and work styles have been changing significantly. A major challenge is how to solve new problems arising from the shift from analog to digital.
- In addition, technology has become essential in the quest to achieve a balance between social needs such as public health and the protection of individual rights and privacy in order to gain and maintain trust.

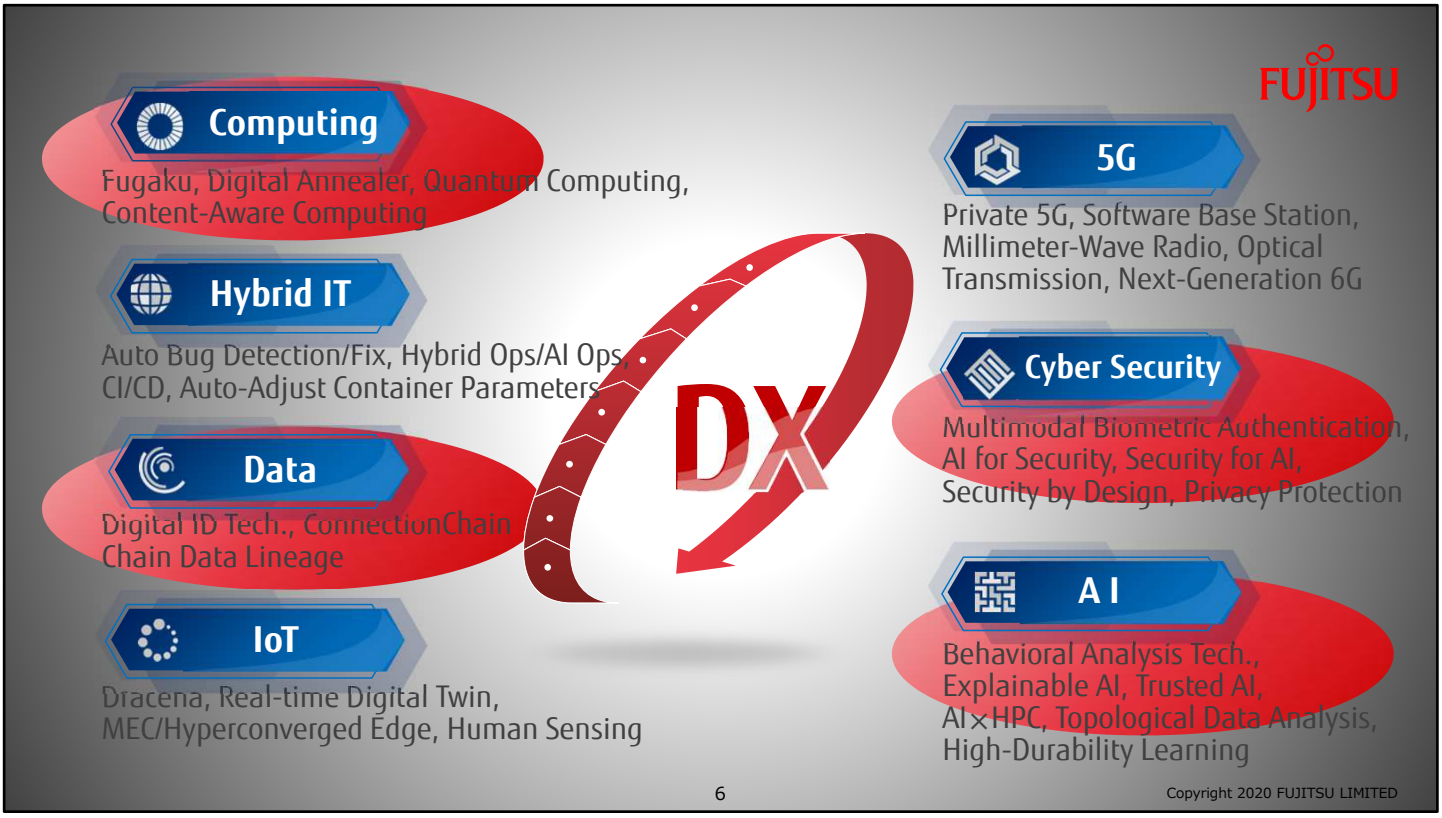



- In today's world, everything is interconnected, and as a result there are many factors of trust that must be considered to ensure safe and smooth social and economic activities.

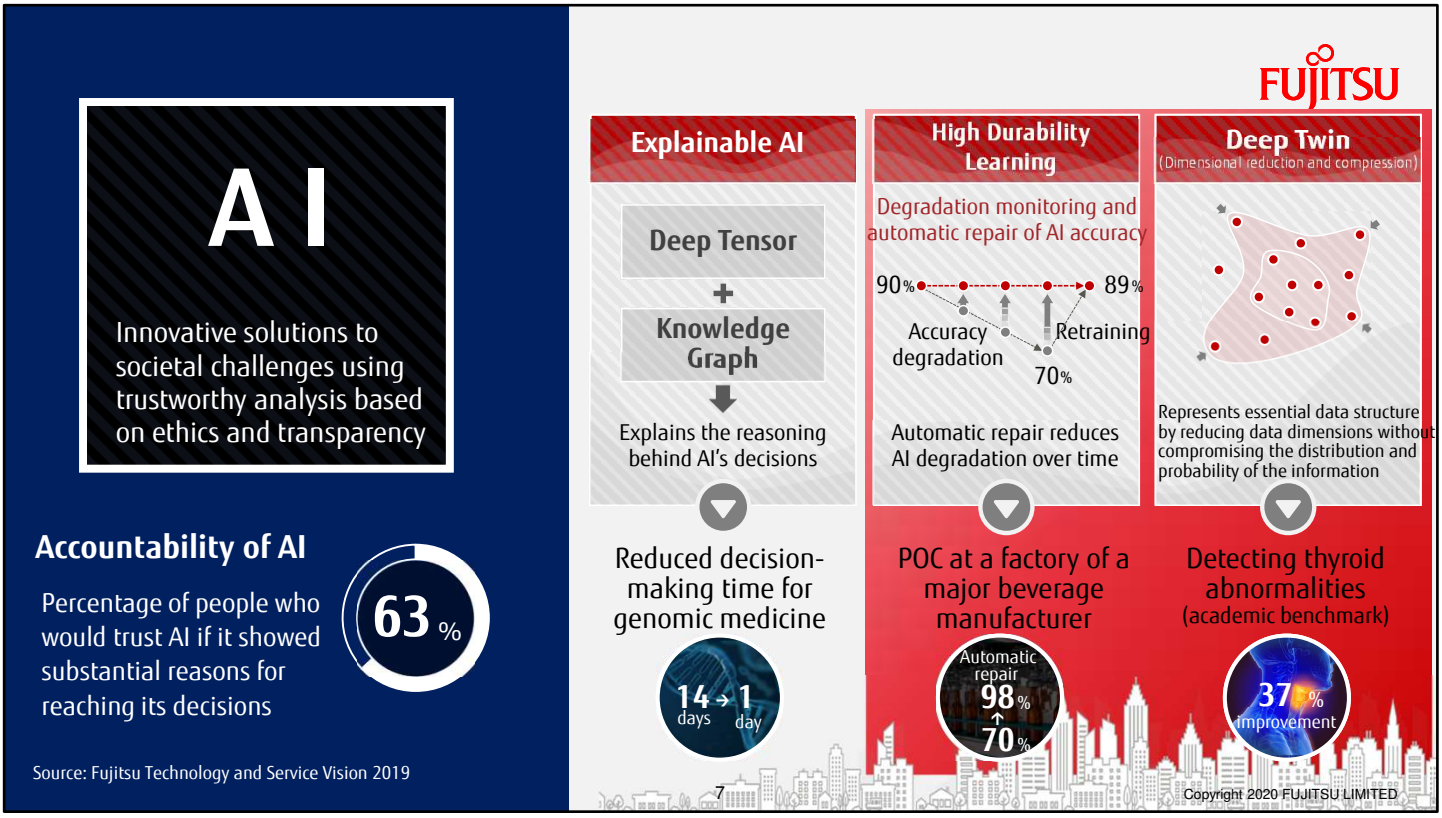
- The means of securing trust is shifting into cyberspace and away from the physical space we live in.
- You may well already be familiar with the idea of personal authentication methods being replaced by electronic signature or biometric authentication via digital seals. In addition, new technical challenges have emerged, such as interconnecting supply chain systems and the explainability of AI.

- Fujitsu Laboratories is committed to playing a key role in providing trust through our digital technologies, engaging in R&D with our R&D vision "Digital Trust".


- Now, please let me explain our technology strategy.




- Mr. Furuta talked about Fujitsu's seven core technologies, and I would like to talk about four of these.



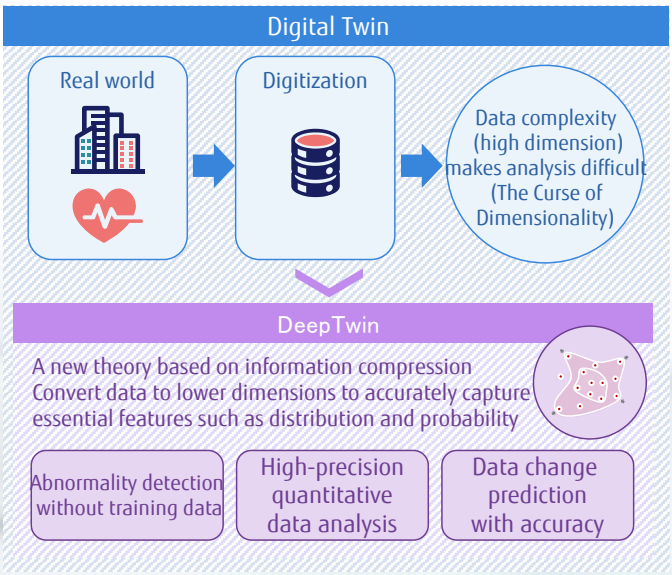

- With regard to AI, as I said earlier, we aim to conduct trustworthy analysis and solve social challenges in an innovative manner through AI underpinned by a sense of ethics and transparency.

- Today, I would like to briefly introduce two of them, DeepTwin and High Durability Learning.

# DeepTwin : Addressing the long-standing problem in AI

- More dimensions of data make learning difficult in practical time (The Curse of Dimensionality)
- We developed the new AI theory to solve this long-standing problem

2020/7/13 Press Release





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- This is a technology we call DeepTwin.
- In the AI world, the “curse of dimensionality” is recognized as a long-standing problem. It means that a higher dimension of data becomes exponentially more complex, and more difficult to analyze in a practical timescale.
- We constructed a new theory based on information compression to solve this problem, and succeeded in converting complex high-dimensional data into low-dimensional data. We also accurately acquired features such as distribution and probability. We verified its accuracy in several application cases and confirmed the world's best accuracy.
- This achievement was accepted by ICML, one of the most authoritative academic conferences in the field of AI, and was widely covered by the media. As a result, we received a request for an invited session at GTC, an international conference that has been attracting increasing attention in recent years and received a great response not only from Japan but also worldwide.
- In this way, Fujitsu Laboratories will continue to promote world-class research.

# Maintaining quality of AI: High Durability Learning

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2019/10/25 Press Release

- It is inevitable that the accuracy of the learning model deteriorates in the actual operation of the AI system
- To solve the deterioration of accuracy, it is necessary to prepare learning data and retrain, but it's very costly

**Finance: Credit risk evaluation**

Accuracy deteriorates due to changes in economic structure, exchange rate, product price, interest rate, and regulations

Deterioration of accuracy (After a year) 91% → 69%

**Retail: Classification of merchandise images**

Accuracy deteriorates due to changes in packaging after product design changes, campaigns, etc.

Deterioration of accuracy (After a year) 95% → 66%

**Transportation: Delivery slip character recognition**

Accuracy deteriorates due to character shape change after slip form change, and character image change after device change, etc.

Deterioration of accuracy (After a year) 98% → 82%

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- The next area I would like to focus on is HDL or High Durability Learning, which we presented at the Strategy Briefing last year.

- This is a technology that solves the challenges of AI quality. Although it is not widely recognized yet, there is a serious problem that the accuracy of AI decisions gradually deteriorates due to changes in the environment and data while operating the AI system. And, this is unavoidable. A practical solution is to reorganize a large amount of training data and retrain the system, however this is very costly.

- Here are some examples from the finance, retail, and transportation industries, all of which show a significant decline in accuracy over a short period of time.

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- Last year, we presented that HDL can automatically restore accuracy in such cases.

## Application example:
## Anomaly detection manufacturing lines

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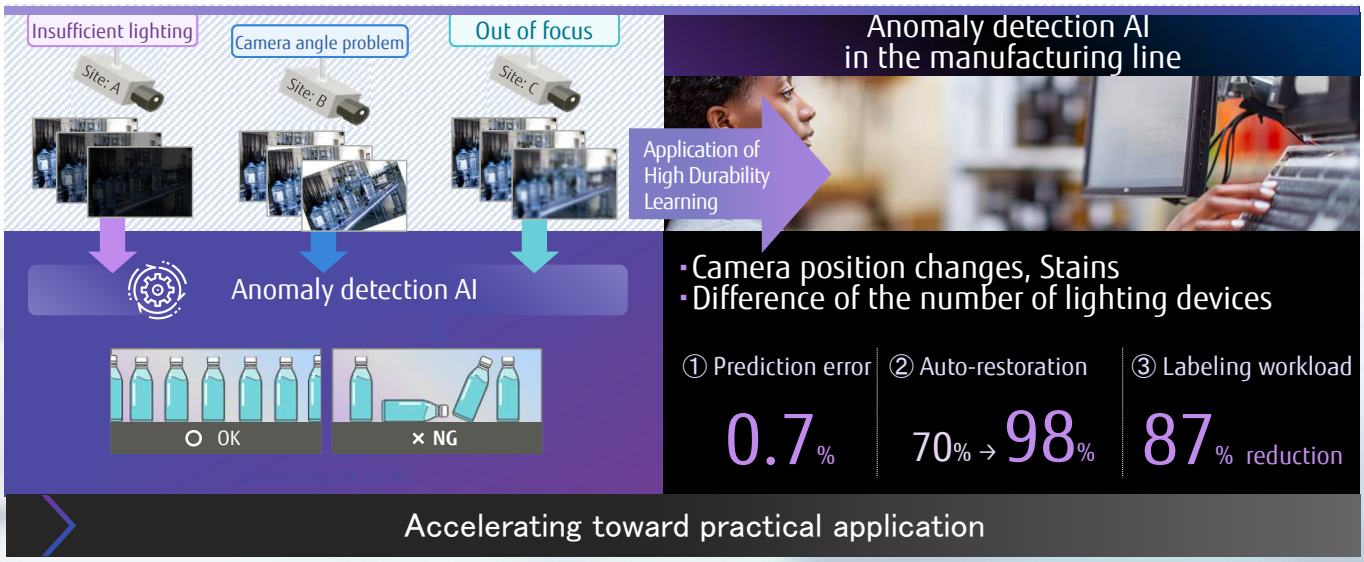
- Applied to anomaly detection AI in the manufacturing line of a beverage production plant
- Realized the high-durability AI operation to cope with various kinds of data changes in work sites

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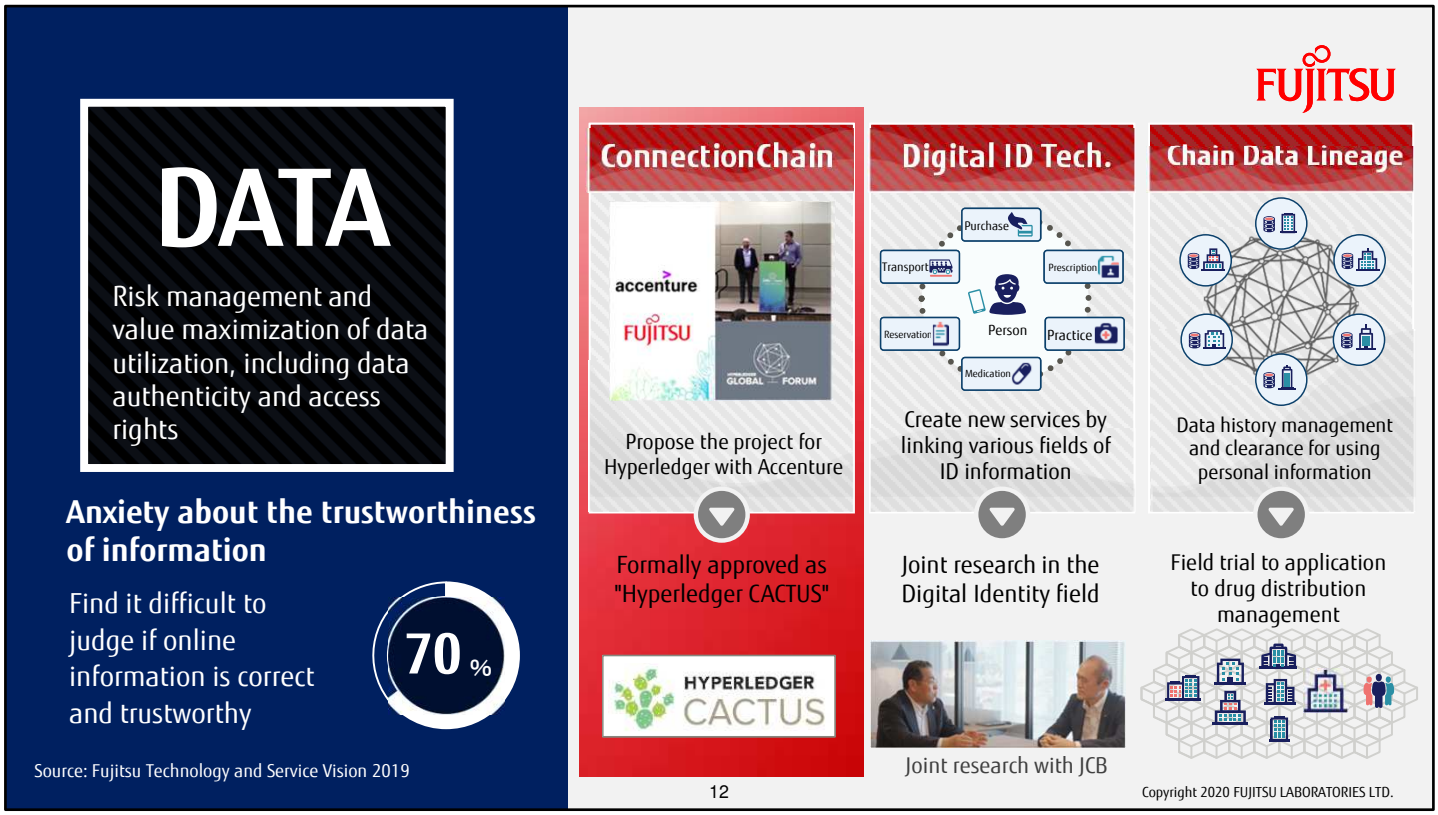
- We are proud to say that this is a unique and innovative technology. And in less than a year we have seen some important tangible applications for this technology.
- This example was applied to an anomaly detection AI system at a factory of a major beverage manufacturer in Japan.
- This customer operates an AI system that detects anomalies such as whether the bottle has fallen or is out of position on the factory line.
- The recognition rate had deteriorated to nearly 70% due to lighting, camera angles, being out of focus, and other factors.
- So we applied HDL here.
- HDL automatically raised the recognition rate from 70% to 98%.
- Automatic recovery also reduced the number of workloads required to reorganize learning data and retraining by 87%.
- We will further promote the practical application of this technology to ensure the quality and trustworthiness of AI.




- Now, I would like to move on to the field of data.
- In data processing, there are fundamental issues related to trust, such as ensuring the authenticity of data itself and managing the right to use ID information. We are researching technologies to manage all risks associated with the use of such data and to maximize the value of the data.
- In 2018, we introduced a technology called Chain Data Lineage to ensure the authenticity of data. In addition, last year we introduced a digital identity technology as a basis for the secure use of ID information. As for this technology, we will introduce the latest example in Fujitsu ActivateNow starting tomorrow, so please check it out.
- Blockchain is also attracting attention as a secure data processing infrastructure technology. It is expected that blockchain is increasingly used in various fields, and we have developed ConnectionChain technology that overcomes technical problems associated with the connection between blockchains. Today, I would like to explain about this ConnectionChain.

# ConnectionChain

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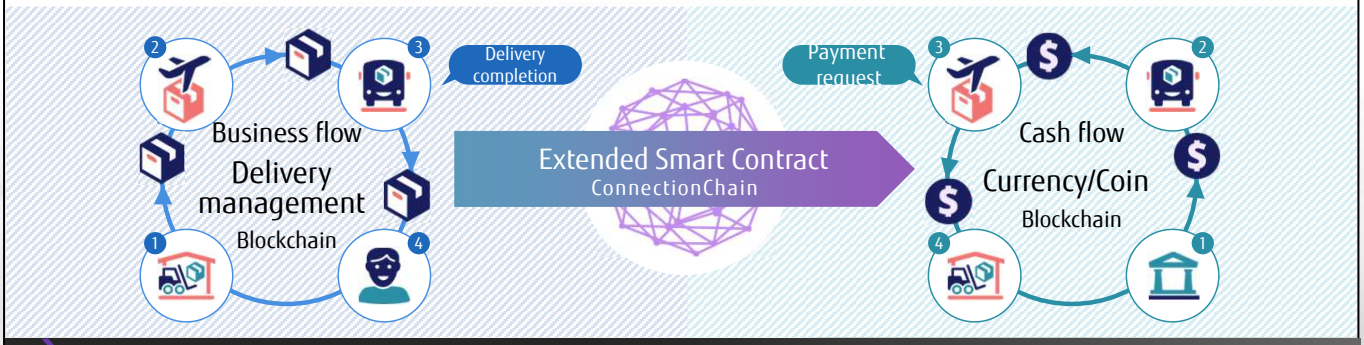
## Blockchain connection technology essential for building distributed trust

- Abstraction technology to transparently and securely connect multiple blockchains which have different specifications
- Rollback technology to address failures that occur in new transactions across multiple blockchains




Field Trial of Decentralized Finance (DeFi) with BOOSTRY Co., Ltd. (May 2020)

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- Although the use of blockchain technology is rapidly increasing, it is not sufficient to ensure the trust of a single supply chain when the blockchain is used in accordance with the actual conditions of the economy and industry. It is also necessary that various blockchains will interconnect across industries securely.
- However, since there are various specifications of blockchain all over the world, it is not easy to bridge all the gaps, and special technology is required to connect them securely.
- Fujitsu Laboratories has recently developed “ConnectionChain”, a proprietary technology that mediates between blockchains, involving a lengthy research process to tackle this problem.
- Since the distribution of goods and the payment are inseparable, each blockchain that controls both transactions must be connected to complete the entire transaction safely. And ConnectionChain can connect these through its enhanced smart contract function.
- In May this year, we succeeded in a demonstration experiment involving decentralized finance with BOOSTRY, which was established jointly by Nomura Holdings and Nomura Research Institute. Digital assets such as securities managed in different blockchains are connected by ConnectionChain to ensure the safe and smooth transfer of rights and settlement.

# Dissemination of results by utilizing OSS

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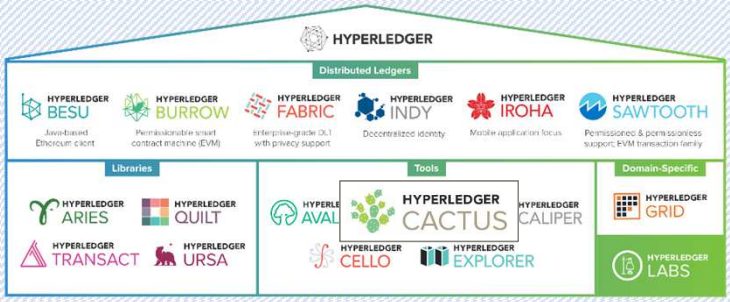
We lead the OSS community and aim for early realization of global standards

2020/5/15 Press Release

In the Hyperledger community, which is the largest consortium in enterprise blockchain, a project to interconnect blockchains named "Hyperledger Cactus" was started





We hope to standardize the plug-in function as OSS that facilitates the connection between various blockchains and contribute to the improvement of blockchain interoperability.



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- At Fujitsu Laboratories, we are leading the OSS community and aiming for the early realization of global standards.
- We are also actively involved in the OSS community to promote the spread of this ConnectionChain.
- Hyperledger, a global OSS community for blockchain technologies, has approved a project to connect different blockchains suggested by Fujistu and Accenture as a "Hyperledger Cactus".
- Through this project, we hope to standardize the plug-in function as OSS that facilitates the connection between various blockchains and contribute to the improvement of blockchain interoperability.


- Next is security.

- In this field, we aim to protect society from digital risks and ensure safety and security by using “zero-trust technology”. This is based on the assumption that there is constant exposure to various attacks and the policy of “boundary defense”, which has been the mainstream until now, no longer sufficient.

- In order to improve the realization of greater security, we are promoting research on multi-biometric authentication, which provides a hygienic and privacy-friendly means of payment, Trust as a Service or TaaS, which is a digital trust intermediation technology that ensures the authenticity of business data across organizations, and technologies that address the security risks particular to AI systems.

- Today, I would like to introduce multi-biometric authentication.

# Safe and convenient society realized by multi-biometric authentication without identity data at hand

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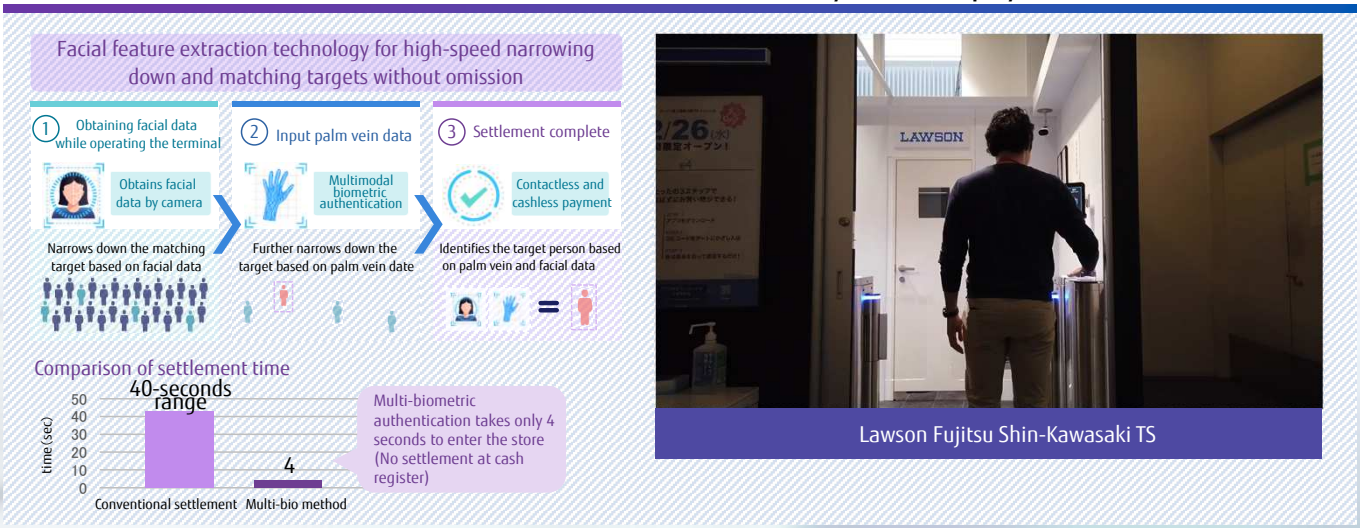
- Combination of the authentication of palm vein and face can address up to 1 million people (actual store operation level)
- Interface controlled with the wave of a hand dramatically reduces payment time




- Fujitsu Labs is researching a secure and convenient payment method to realize a safe and convenient society where we do not have to carry our identity data. Our multi-biometric authentication system which has high accuracy and convenience, plays a key role.
- By combining our palm vein authentication and face recognition technologies with the world's top level accuracy, we realized a contactless authentication method to identify one million people.
- This is a scale that can be used in a real store operation.
- A major feature is that both the palm and face are can easily be adjusted during sensing without causing stress to users at all. And because the face is captured naturally in a series of motions, the user is actually only aware of it by holding his or her hand over the sensor. The accuracy of personal authentication is extremely high, and it can be used safely even in a cloud environment.
- This video shows the deployment of multiple biometrics authentication at the entrance gate of a LAWSON store, involving a joint test at one of their register free stores. We received high marks for an overwhelmingly superior user experience.

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chapter 3

# R&D Strategy on quantum computing



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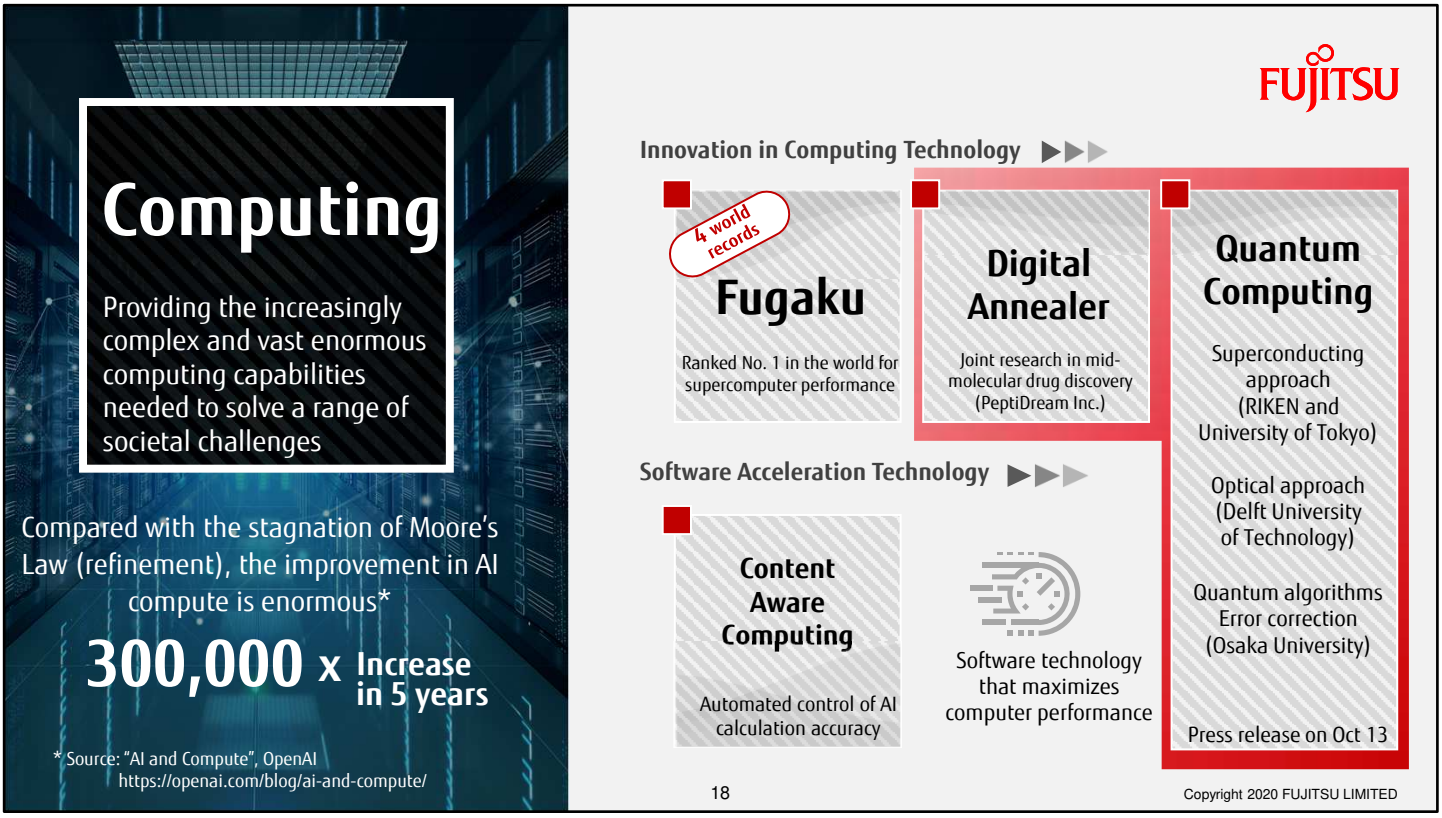
- Next, I would like to talk about the research and development strategy of quantum computing.




- As Mr. Furuta said earlier, the advancement of computing technology is an important theme for solving increasingly complex social problems.

- Today, I'm going to talk about quantum computers and Fujitsu's Digital Annealer.

# Quantum computer

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- A quantum computer is a computer that uses the principles of quantum mechanisms
- Based on the difference in operating principle, it is classified into the quantum gate-type and the ising machine-type

| Quantum gate-type | Ising machine-type |
| --- | --- |
| • Computation using "quantum gate" which is an arithmetic circuit combining quantum bits in which both zero and one exist simultaneously<br>• To perform general-purpose processing like a conventional computer<br>• There are many issues to be solved before practical application, such as error reduction, large scale, and high temperature operation | • Method for searching solution by mapping problem to ferromagnetic model in statistical mechanics<br>• Specialize in combinatorial optimization problems<br>• Quantum annealing has a limitation on the problem that can be solved due to its difficulty on scale-up<br>• Quantum inspired method has an advantage in terms of practical application |


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- As you can see on this slide, there are two major processing methods for the quantum computer: the quantum gate type and the ising machine type.

- It is assumed that the quantum gate type can be used for general purpose processing. However there are still a lot of problems to be overcome such as error reduction, large scale, high temperature operation, and so on.

- Ising machine-type is a mechanism for solving combinatorial optimization problems.
- The Quantum annealing method also has problems such as expansion of the scale in the same way as the quantum gate-type.
- In terms of practical application, we believe that quantum inspired method including Digital Annealer which based on existing semiconductor technology has an advantage.

# R&D strategy on quantum computing

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## Quantum gate-type

- Started research and development as a general-purpose next-generation computing technology
- Work on everything from devices to application algorithms
- Open innovation with the world's leading research institutions

## Ising machine-type

- Digital Annealer commercial service launched in 2018
- Based on Digital Annealer 's world-class practicality, expanding business globally
- Expanding application areas through strategic partnerships

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- Here is our R&D strategy for each method.
- First, with respect to the quantum gate-type, we will strategically address everything comprehensively from the device level to application algorithms. To this end, we will work together some of the world's leading research institutions and accelerate our research in this open innovation style.
- On the other hand, with regards to the ising machine-type, we launched commercial services for the Digital Annealer in 2018, and we are proud to lead the world in terms of its practical application and global business expansion.

## Example : Toyota Systems

2020/9/10 Press Release FUJITSU

Optimization of parts distribution network required for automobile manufacturing

- ✓ Explore more than 3 million routes through hundreds of suppliers, several transit warehouses, dozens of factories
- ✓ Optimization of distribution costs, including the number of trucks, total mileage, sorting, etc.
- ✓ Demonstrated the possibility of reducing total distribution costs by approx. 2 ~ 5% by discovering effective distribution routes, improving loading efficiency, and increasing the number of trucks and the total distance traveled


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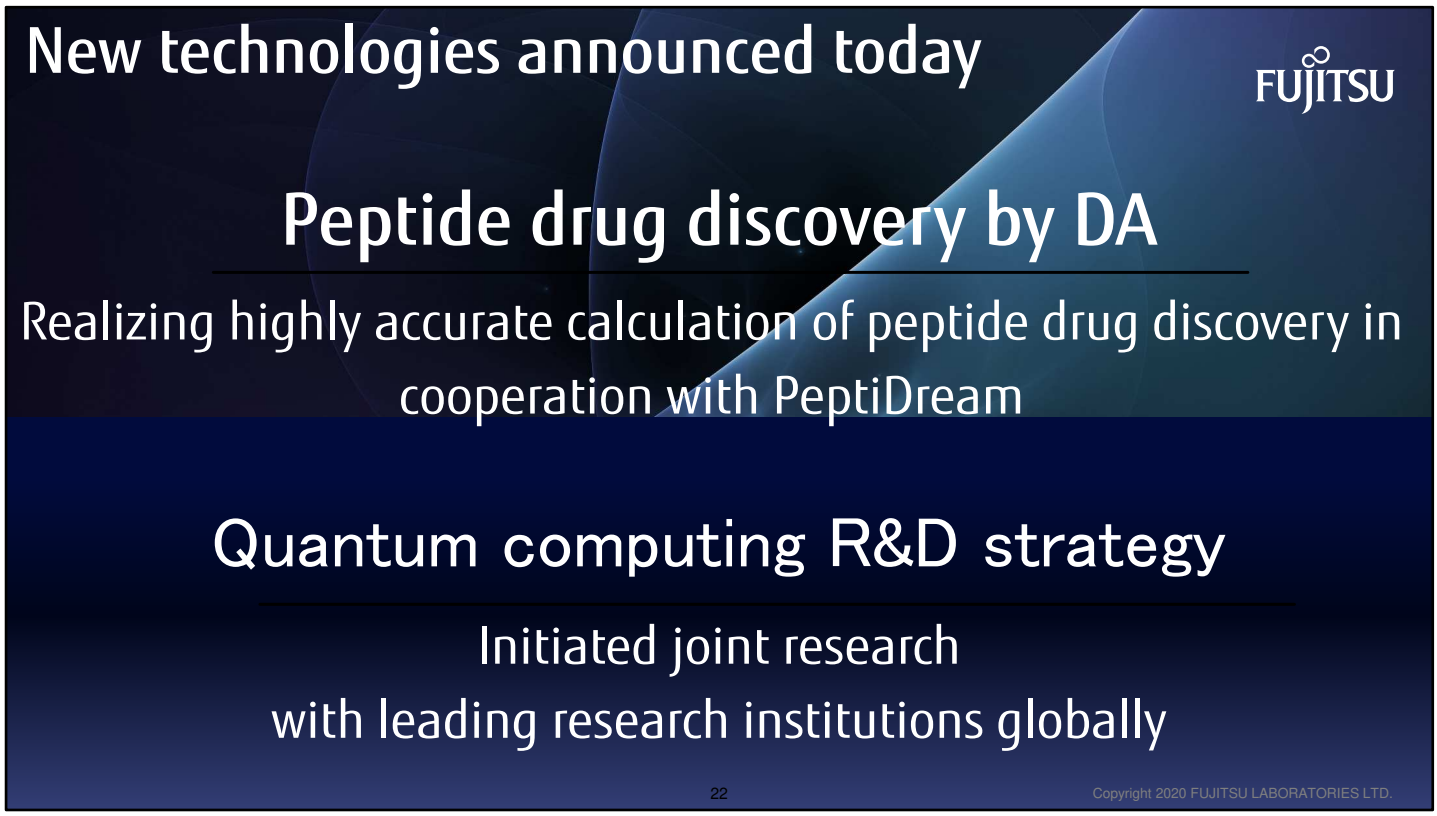
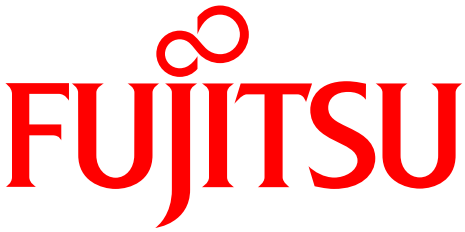
- As a recent example of Digital Annealer, I would like to introduce briefly a use case involving optimizing the transportation schedule jointly conducted with Toyota Systems.
- In this case, we calculated the route with the lowest distribution cost out of more than 3 million routes in which automobile parts are purchased from hundreds of suppliers, passed through several transit warehouses, and delivered to dozens of plants.
- We succeeded in discovering a new route within 30 minutes that could reduce overall distribution costs to deliver an anticipated cost reduction effect of approximately 2 ~ 5%.
- According to a survey, logistics costs account for about 5% of net sales, so this reduction is expected to have a significant impact on profits.




- Thank you very much for your attention.
- After this, we would like to explain the Digital Annealer 's latest breakthrough in drug discovery and the details of our quantum computing strategy.

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