

Developing Cutting-Edge Technologies to Achieve Digital Co-creation

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As a technology company, Fujitsu always tries to be a powerful leader of innovation with the aim of providing a prosperous and dream-inspiring future to the people in the world through ICT. As a member of Fujitsu Group, Fujitsu Laboratories has a mission to put Fujitsu's corporate philosophy into practice and continuously drive its growth through cutting-edge technologies. Today, digital technologies are becoming indispensable not just for social innovation but for corporate development, and a new growth model for digital transformation is required. Therefore, we have to develop cutting-edge technologies and associated business models as well as to fuse high-level expertise for dealing with digital technologies with a wide range of skills for utilizing expertise in business activities of Fujitsu customers. By providing technologies and business models by top-level experts, Fujitsu Laboratories is promoting Digital Co-creation to create new values in collaboration with customers. This paper describes Fujitsu Laboratories' R&D strategies for Digital Co-creation, medium- and long-term approaches in cutting-edge technology development, and recent research achievements.

1. Introduction

With the dramatic changes in business environments in recent years, it has become more difficult to maintain competitiveness in business over the long-term. The role of ICT has also changed greatly under these situations. It has improved efficiencies in management, but it is also increasingly being relied upon to increase enterprise value. With these changes, the role required for ICT is shifting to creating innovative solutions to issues in management and society. As a leading company in ICT, Fujitsu needs to continue striving to create new value to meet the needs of society and of the times. This is accomplished through advanced technologies, and our mission is to use such technologies to lead this digital age.

Fujitsu Laboratories is Fujitsu's main R&D organization, undertaking various initiatives to accelerate digital transformation. This encompasses research themes in various fields, from ICT related R&D on advanced materials, next-generation devices, computing, communication, cloud systems, and security, to the creation of next-generation solutions and services. The mission of Fujitsu Laboratories is to drive growth within the

Fujitsu Group through advanced technologies, toward Fujitsu's goal of providing a rich and hopeful future for the people of the world.

To promote digital transformation for our customers' business expansion, we need to connect their core business and competitive core competencies with Fujitsu Laboratories' cutting-edge technologies and create new value. This requires fostering people who can integrate the specialized skills of both sides. In this way, Fujitsu Laboratories is developing technologies and methods to achieve Digital Co-creation and also enhancing skills of personnel.

This paper gives an overview of the 50-year journey of Fujitsu Laboratories, our R&D strategy for Digital Co-creation, and our research and latest results in various advanced technology fields.

2. Fujitsu's DNA

Fujitsu Laboratories celebrates its 50th anniversary in November 2018, which was established in 1968 as an organization independent from Fujitsu Ltd. for conducting autonomous research with a long-term perspective, and building a base for business by improving

technical capabilities. Since then, it has produced successive, revolutionary R&D results and provided new value to people, society, and enterprises by bringing innovation to the world. This was made possible by a continual drive toward innovation, which is part of the DNA of Fujitsu.

A history of innovation at Fujitsu Laboratories is shown in **Figure 1**.¹⁾

In 1974, we developed the world's fastest LSI-based computer, realizing compactness, low-power consumption and high reliability, and bringing innovation to enterprise business systems. This heralded the arrival of the ICT age.²⁾

In 1979, we invented the first high electron mobility transistor (HEMT), propelling the global spread of satellite broadcasting and the world-wide flow of information.³⁾

In 1989, we developed a full-color plasma display, realizing the first full-color large screen video display in the high-definition television (HDTV) era.⁴⁾

In 1992, we developed the world's smallest, highest-performance ladder-type surface acoustic wave

(SAW) filter, enabling great contributions to the growth of mobile communications through the global spread of mobile phones and smartphones.⁵⁾

In 1996, we developed an ArF resist material using our own materials design, advancing semiconductor microfabrication techniques, and contributing to the continued progress of Moore's Law. This cleared the way for the development of current computer systems.⁶⁾

In 1999, we developed a ferroelectric random access memory (FRAM) product with the smallest cell size in the world. FRAM is used in contactless smart authentication cards, which are now widespread, and are used to realize safe, convenient payment and settlement systems.⁷⁾

In 2003, we developed the world's first palm vein authentication system and applied this immutable contactless biometric authentication technology to security services, which has currently expanded to a scale of 100 million users around the world.⁸⁾

In 2006, we used digital video encoding technology to enable transmission of ultra HDTV (UHDTV) video at high speed, making it possible to view high

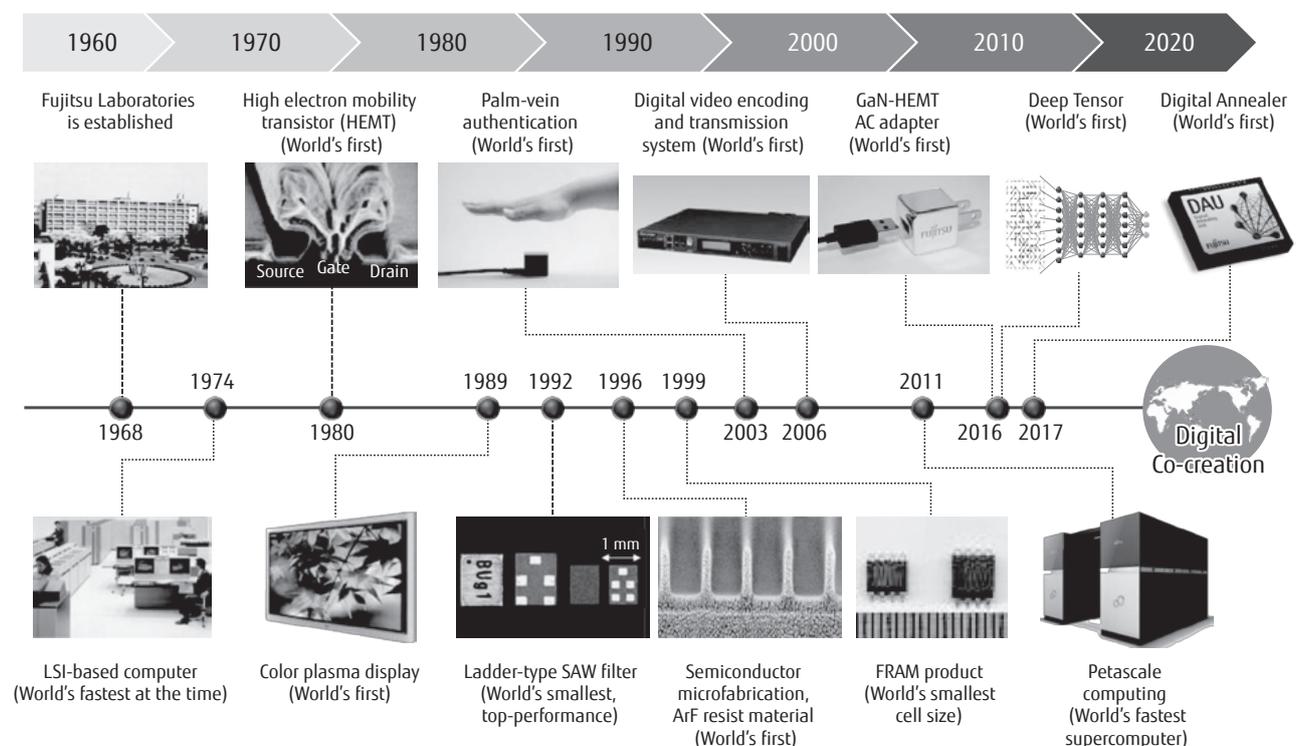


Figure 1
Innovation at Fujitsu Laboratories.

quality video all over the world through satellite broadcasting and other distribution media.⁹⁾

In 2011, we developed a peta-scale computing technology, the highest in the world, contributing to the opening of fields not-previously explored by science and technology, such as medical and natural disaster simulations.¹⁰⁾

In 2016, we developed Deep Tensor, the first learning technology implementing Explainable AI.¹¹⁾ We also developed the world's smallest, highest-efficiency GaN-HEMT AC adapter, contributing to a lower-carbon society and to reducing the load on the global environment.¹²⁾

In 2017, we devised a new computing architecture inspired by quantum phenomena and developed the Digital Annealer, which can solve complex combinatorial optimization problems at high speed. It has led to significant advances in solving social issues that were intractable for current computers.¹³⁾

These technologies have been recognized for their great contribution to the development of humanity and industry with many awards such as the Medal with Purple Ribbon.^{note)} Recently, the HEMT received the prestigious, 33rd Kyoto Prize¹⁴⁾ for its contribution to the information and communications industry over the years. It also led to the development of a GaN-HEMT AC adapter, which received the 26th Global Environment Award. They really mark our almost 40 years' efforts.

To this date, Fujitsu Laboratories has been continuing its growth by developing groundbreaking technologies with its pioneering spirits.

3. R&D strategy of Fujitsu Laboratories

Fujitsu Laboratories promotes research under the slogan "Solving societal issues through cutting-edge technologies by predicting the future and world trends." We must envision what the future should be like and consider what we have to do at present to realize an ideal world. It is our duty to always take this stance to generate technologies that will be needed in the future. From this perspective, we set up eight emerging technologies for leading the world.

On the other hand, just digging deeply into a

particular technical field will not work. We have to use our developed technologies actually in society. Thus, we are advancing R&D, considering the usage of technologies and what kind of business models we have to implement.

The environments surrounding us are also changing greatly, and it is more difficult than ever for a single enterprise to solve problems on its own. This provides a similar suggestion to the management strategy for sustainable growth of enterprises. In addition to growth scenarios extending existing business, we have to promote co-creation with new partners, and digital technologies are becoming a driving force for such co-creation among enterprises.

To take the lead in Digital Co-creation, using digital technologies, Fujitsu Laboratories is promoting open innovation globally, not only with customer enterprises, but also with universities and research institutions. Through synergies arising with excellent knowledge and ideas from around the world and Fujitsu Laboratories' technologies and experience, we are creating new value and contributing to the growth and development of all stakeholders.¹⁵⁾

3.1 Eight emerging technologies for leading the world

To promote global Digital Co-creation with our customers, Fujitsu Laboratories has R&D initiatives to become a world leader in the following eight emerging technologies (**Figure 2**).

1) Innovative Computing for Solving Social Issues

Using our unique computer architecture inspired by quantum phenomena, we have developed a technology that can instantly solve complex combinatorial optimization problems, which were difficult to be solved by conventional computers.

2) Reliable AI that Develops the Society

A basic problem with current AI is that the reasons for a result cannot be given. To resolve this, we are working to realize Explainable AI by combining a new machine learning method with a knowledge base.

3) Data Management System that Facilitates the Value Creation Cycle

To create new value through Digital Co-creation, we are consolidating infrastructure for data utilization that overcomes barriers between enterprises and types of industry, and comprehensively developing various

note) The medal is awarded by the Emperor of Japan to individuals who have made excellent achievements such as inventions and discoveries in the field of science and technology.

core technologies related to data processing.

4) Information and Communication Management in the 5G Era for Connecting Cyberspace and Physical World

We are developing technologies for dynamically connecting all kinds of systems together, whether on-premises, cloud-based, edge computing, or IoT, so that services can be used safely and as needed.

5) System Engineering Supporting Digital Co-creation

We are systematically developing technologies that can dynamically apply advanced digital technologies to existing system software resources, to promote Digital Co-creation.

6) Digital Security Systems Protecting Society from Potential Threats

We are developing technologies to protect the whole part of connected services ranging from cyber security, authentication of people and things, privacy and data security, and utilization of block-chain technology.

7) Sensecomputing for Human-Machine Collaboration through Human Emotion Understanding

We are working to realize the next generation of computing technology in which ICT will cooperate more closely with people, understanding their psychological states including the five senses, intuition, illusion, desire, and empathy.

8) New Materials/Devices that Revolutionize the Existing Paradigm

We aim to create innovative new materials and devices by collecting data and knowledge on materials and devices accumulated over many years and using applications of advanced computing and AI technologies.

This issue includes several papers on the above themes.

We are working to develop advanced technologies that will dazzle the world in these eight domains. Rather than developing these advanced technologies in separate organizations, we are promoting co-creation through mutual cooperation, and managing R&D for the creation of new value.

3.2 Digital Co-creation initiatives

To promote Digital Co-creation, we are trying to build customer relationships as early as possible, using advanced technologies as a first step in gaining interest. By directly supporting our customers' core business, we will newly develop or enhance products and services that can become fuel for our customers' ongoing growth. In medium-term research, we are collaborating closely with excellent external researchers, facilitating global open innovation, and strategically acquiring excellent knowledge. We describe some examples of recent Digital Co-creation below.

To accelerate the implementation of Digital Annealer in society, Fujitsu Laboratories established a quantum computing research laboratory at the University of Toronto, Canada in March 2018. By uniting Fujitsu Laboratories' technologies for solving combinatorial optimization problems, including Digital Annealer as the core, with the wide knowledge at the University of Toronto in areas such as medicine and finance, we are striving to bring innovation to various fields, such as radiation treatment of cancer, and financial asset management.

Using AI, we have worked with Shimadzu

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|---|--|---|---|
| 1 | Innovative Computing for Solving Social Issues | 2 | Reliable AI that Develops the Society |
| 3 | Data Management System that Facilitates the Value Creation Cycle | 4 | Information and Communication Management in the 5G Era for Connecting Cyberspace and Physical World |
| 5 | System Engineering Supporting Digital Co-creation | 6 | Digital Security Systems Protecting Society from Potential Threats |
| 7 | Sensecomputing for Human-Machine Collaboration through Human Emotion Understanding | 8 | New Materials/Devices that Revolutionize the Existing Paradigm |

Figure 2
Eight emerging technologies.

Corporation to develop technology that can automatically analyze results from liquid chromatography equipment. This dramatically increases the speed and efficiency of identifying the composition of substances. At the San Carlos hospital in Spain, we have also developed a new healthcare system that supports doctors in performing examinations more quickly. We are also conducting R&D with the RIKEN Center for Advanced Intelligence Project (AIP), combining their accumulated knowledge of AI technologies with our wide range of ICT and experience in system development.

In data utilization, we conducted a field trial in collaboration with Shimane Prefecture and Payke Co. Ltd. to connect government and enterprise data and create new services that contribute to regional revitalization.

Through this type of Digital Co-creation, we are able to generate innovative solutions by enabling those with specialized knowledge to inspire each other's knowledge and awareness of issues. We also hope that these types of initiatives will open up new business opportunities.

4. Conclusion

This paper introduced Fujitsu Laboratories' history of producing innovations through advanced technologies, with sensitivity to changes in society in the 50 years since it was established. It also gave an overview of R&D strategies for eight emerging technologies that we will continue developing in the future, and open innovation initiatives that promote them.

With the increasing significance of digital technologies in society and industry, Fujitsu Laboratories will continue to support our customers' core business activities through Digital Co-creation. We will provide the necessary advanced digital technologies and innovative business models for the development of our customers' business and society.

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Mr. Kono is currently engaged in designing and executing R&D strategies and overall management of research resources.