New Value-Creating Solutions Starting From IoT: Current Status and Future Outlook

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1. Introduction

The general meaning of the Internet of Things (IoT)*1 is that anything is connected to the Internet and data are shared and visualized. Its essence is to generate new customer values from the collected data and contribute to society with the values. Currently, various solutions have been disclosed as key technology not only for quality improvement and optimization but also for solutions to social issues such as work style reform, and greater usage of IoT is expected in the future.

Fuji Electric has been providing solutions for over 40 years that contribute to power stability and optimization, factory productivity improvement and energy savings, clean energy supply, food safety and security, etc. It has done this by continuing to innovate in the fields of energy and environmental technology and using competitive components and sophisticated control technology. Today we are more quickly implementing efforts to create higher customer value*2 by practically applying IoT.

This paper describes the current status and future outlook for efforts for new value-creating solutions with the use of such IoT by Fuji Electric.

2. World Trend in Customer Value-Creating Technology with Use of IoT

IoT and value creation utilizing IoT has been studied actively on a global scale.

This chapter describes the trends in Germany, the United States and Japan.

2.1 Germany

Industrie 4.0, an issue tackled since 2013 in Germany, has changed its direction toward expansion from the viewpoint of value creation. It has gone from searching for a place to apply the concept to value creation and value improvement by cooperation and linkage with other fields. Hence, its concept has matured and proliferated steadily.

Linkage not only within Germany but also with the United States and China has been developed from the viewpoint of cooperation and linkage. A cooperation agreement with Japan was made in March 2015, and it has led to specific activities such issuing a joint statement.

In addition, a study on standardizing technology is also underway. It is remarkable that proposals for using the existing and specific standardizing technology, represented by the information model, OPC-UA and AutomationML, are progressing steadily.

2.2 United States

The Industrial Internet Consortium (IIC) established in 2014 under a civilian initiative has steadily increased its members. More than 260 companies including Fuji Electric and other Japanese companies have joined the consortium.

The 2 main activities in IIC and their statuses are as follows:

(1) Study on technology and security architecture

Discussions about Reference Architecture, disclosed also to non-members, are held continuously. Its own level of maturity has been developed and peripheral detailed technology arrangements are making progress. Security-related discussions have been active and other organizations are paying attention to the situation.

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***1: IoT**

Abbreviation of the Internet of Things. In a narrow sense, it refers to a system where anything is connected to the Internet and information exchange is mutually executed. Currently it refers to the whole service realized with the system that generates new values. This concept comes from the fact that we now have Internet connection and data distribution and control at low cost along with information communication technology innovation.

***2: Customer values**

It refers to values recognized by customers to be appropriate for products, services, human resources and images.

(2) Field verification (test bed)

The ecosystem*3, centered on IIC members, is formed and architectures and concepts are demonstrated and verified. More than 80 companies participate and test beds are proposed actively, and 29 cases have been proposed and approved as of May 2018. Some cases indicated efforts beyond the frame of simple demonstration and verification. One example is "Intelligent Urban Water Supply" test bed, which aimed for water-supply operation optimization and improvement, where the demonstration target has been commercialized and many providers have actually verified the possibility of its introduction. In addition, a liaison conclusion has been completed with 38 organizations who participate in Industrie 4.0 as of May 2018, expanding the connection with other organizations.

2.3 Japan

In March 2017 in Japan, the Ministry of Economy, Trade and Industry proposed the Connected Industries concept as the direction for industries to head in. Each organization continues activities to realize this concept, and some organizations such as the Robot Revolution & Industrial IoT Initiative and the Industrial Value Chain Initiative disclose their activity results.

In addition, to use results and experiences in field systems that are a Japanese advantage, a study on "Edge Computing" that creates values in high-speed near equipment or machines without the Internet and LAN is underway. Ecosystems such as the "Field System" and the "Edgecross Consortium" have been formed since 2017.

3. Fuji Electric's IoT and Efforts for Customer Value Creation

3.1 Position of IoT in Fuji Electric

Fuji Electric positions power semiconductors and sensors as key devices and has a line-up of high-performance and high-functionality components that use the key devices. Furthermore, we contribute to the creation of responsible and sustainable societies through power generation, energy solutions, industry solutions, food distribution and other fields with these components, engineering technology, service technology, advanced optimal control technology and various solution technologies. We position the IoT system, which is a framework to digitalize any information of customer fields and create new customer values in cyberspace, at the core of the system solutions as shown in Fig. 1.

3.2 Customer value and creating technology

Fuji Electric classifies customer values in individual manufacturing industries into 4 categories: energy use optimization, facility operation optimization, operation optimization and human resource utilization optimization (see Fig. 2).

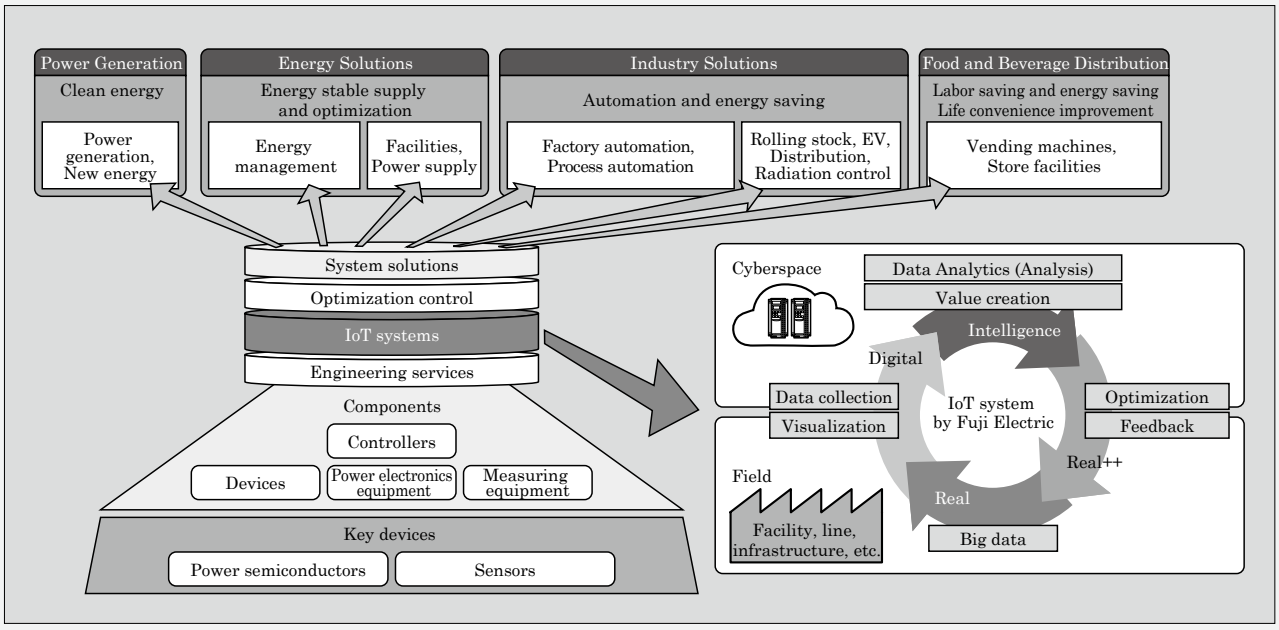

Fig.1 Fuji Electric system solution and IoT positioning

***3: Ecosystem**

Originally it meant an "ecological system" in biology. In management and IT fields, it is a system where multiple companies establish a partnership in product development and business activities for coexistence and co-prosperity beyond the industry frame and boundary utilizing each other's technologies and capital, involving developers, agencies, sales shops, advertising media, consumers and societies.

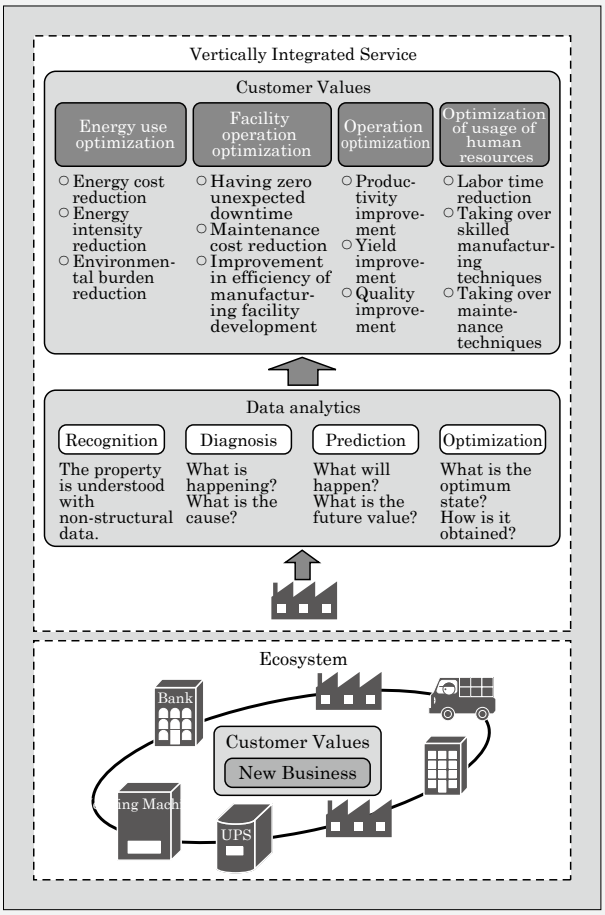

Fig.2 Customer value and creating technology

The technology to create these values is called data analytics and it consists of 4 technologies: Recognition technology, diagnosis technology, prediction technology and optimization technology. We provide a one-stop service from field data collection to customer value creation using data analytics and call the service a vertically integrated service.

Furthermore, the ecosystem, where companies of different industries cooperate with their strengths, generates new values.

3.3 Customer value creation solutions

This section describes the development cases for the customer value creation solutions described in Section 3.2.

(1) Energy optimization solutions

Reinforcement of energy regulations and standards has been progressing globally to reduce CO_2 emissions as global warming countermeasures. The target value for energy operation efficiency for companies has become severer as part of this effort. To achieve the high target, a company must make efforts integrally under a unified control method. ISO 50006, the energy management international standard, specifies that various energy optimizations (energy intensity reduction, energy conversion efficiency improvement, etc.) are managed by a unified method. This is accomplished by defining the energy management unit (EMU) for each building and device which are energy management targets, and then defining the energy intensity*4, operation efficiency and other energy performance indicators (EnPI*5) for each EMU. Fuji Electric has developed an energy management system which conforms to this standard. When the energy intensity worsens, the degree of deviation from the target, etc. can be monitored and energy loss factor analysis, which conventionally has been dependent on experienced engineers, is executed by automatic diagnosis with data-analytic system using result data (refer to "Improvement of Energy Efficiency According to International Standards-EMS Add-On Functions Using Data Analytics" on page 109).

Energy used at steelworks is classified into purchased energy and by product energy generated in production. The most important challenge for energy management in a steelworks is to balance the demand and supply of these energies according to the production situation and reduce wasted energies. For overseas steelworks, we have developed the "EMS-Package LITE" energy optimization package for power generation facilities that can be introduced and operated at low cost to settle this issue. This system automates the act of preparing a demand prediction model and plant model that conventionally required trial and error by an expert for several months. Energy management operators in a customer company enter power generation facility information (the number of boilers and turbines, facility characteristics information, etc.) and the past operation result data in the steelworks into an Excel sheet with the specified format. When this Excel sheet is uploaded to the system, data-analytic system automatically generates 6 models (purchased power cost, power receiving cost, dissipation

***4: Energy intensity**

Total consumption amount of power, gas, oil and other energies required to produce products of the unit amount. It is used as an index to see the energy saving progress status because it indicates the energy efficiency.

***5: Energy performance indicator (EnPI)**

Measureable results related to energy use amount, energy use purpose, and energy efficiency are together called energy performance. Specifically, they are energy use amount, peak power, energy consumption amount by purpose and various energy efficiency items. Their quantitative values (or scale) specified by an organization are called energy performance indicators (EnPI). They correspond to a ruler to measure energy performance and any indicators can be used for each purpose at the judgment of the organization.

amount, boiler fuel distribution, turbine steam distribution and turbine bleeding distribution) by improvement purpose and visualizes the scope for improvement to display it on a monitor. Furthermore, data-analytic system automatically generates an optimal operation plan for a power generation facility that is required for improvement. When the operator of the power generation facility executes the optimal operation according to this plan, the energy operation efficiency target value can be reached (refer to "'EMS-Package LITE' Energy Optimization Package for Power Generation Facilities" on page 114).

(2) Labor time reduction solutions

Labor shortages and an increase in personnel costs are growing in domestic convenience stores with an aging population and lower birthrate in Japan. It is difficult to immediately make convenience stores unmanned like ones overseas because they mainly have characteristics as a social infrastructure and provide various services; however, labor saving by improving the current work is required. Fuji Electric has been developing element technologies for smart showcases to achieve unmanned stores for labor saving in the future. In convenience stores, generally goods such as rice balls, sandwiches and lunch boxes are displayed while arranged in columns. There are many operations to be executed by a clerk, such as constantly monitoring the state of goods displayed, moving items to the front side when the head item is purchased, refilling and checking the freshness of goods. Smart showcases automatically detect the names, quantity and states of the displayed goods to reduce the work. This system consists of the product identification technology that uses image recognition technology with a camera and the product position recognition technology that uses the panel sensors using projected capacitive touch panels allocated in matrix state on a shelf surface. Especially the quantity and position of goods are recognized while the bottom surface shape of goods is detected with the panel sensor. For rice balls, sandwiches and others whose bottom surface shape differ individually, data analytics technology removes noise elements for higher recognition accuracy (refer to "Smart Showcase That Contributes to Labor-Saving of Store Work" on page 132).

(3) Ecosystem solutions

Fuji Electric has a line-up of digital signage vending machines which display product images on a large display. This digital signage vending machine has a system to download image information of products to be sold and backgrounds via the Internet. If the vending machine is assumed to be an image display terminal installed inside a building or on a street, it can be applied to various businesses. Accordingly, we have developed the advertisement distribution function and demonstrated the possibility of using it as the advertisement distribution business. This business is the ecosystem that consists of Fuji Electric which provides the digital signage vending machine and the advertisement distribution system, advertising agency, advertisement owner, vending machine operator, location owner (railway company, supermarket, hospital, etc.) and consumers. We have mounted a camera to the digital signage vending machine and implemented a function to collect market information such as the number, age, gender and visual line of consumers and time in addition to distributing and displaying advertisements. The demonstration test result indicated that this market information was valid for an advertising agency in recruiting advertising owners because response of advertising targets could be estimated. In addition, it was found that for a vending machine operator, the information was valid for predicting sales based on the data and making an appropriate product allocation plan. New values are created with the ecosystem whose core is the vending machine (refer to "New Information Service Solutions Utilizing Vending Machines" on page 127).

(4) Manufacturing solutions

Fuji Electric has been tackling quality improvement and cost reduction with digitalization and utilizing IoT systems for in-house manufacturing (refer to "Manufacturing Reform Utilizing IoT Technology" on page 122).

(a) Digitalization of production preparation

Digitalizing product design information allows 3D-CAD and other simulations. Therefore, simulations on a computer are available for manufacturability verification for process design, production line optimal layout design and automation facility software verification, for which actual machine verification was prerequisite. This drastically shortens the time needed to launch a manufacturing line.

(b) Quality improvement and labor saving with data analytics

For the semiconductor sensor manufacturing process, analyzing the past manufacturing result data with a diagnosis function using data analytics makes it possible to specify the factor of low production yield. For the press process, constantly monitoring various data of a press machine and detecting signs of defects (slug float) with the diagnosis function in the same way allows for higher quality and fewer monitoring personnel.

(c) Taking over skillful techniques

Welding work often depends on the high skill of experienced engineers. Therefore, welding work is digitalized with various sensing technologies and the data are used for skill education. In addition, a robot for difficult welding work has

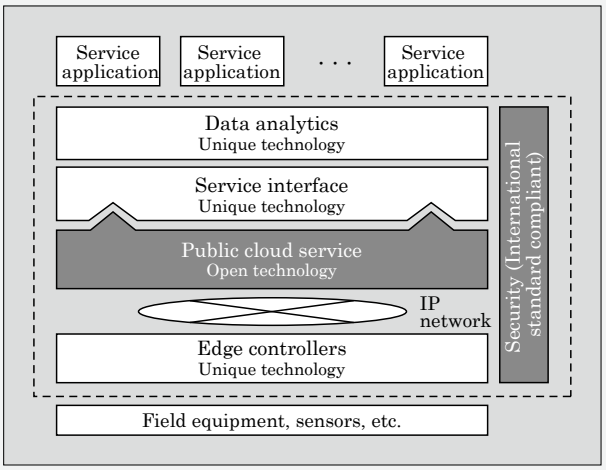

Fig.3 Structure of IoT platform

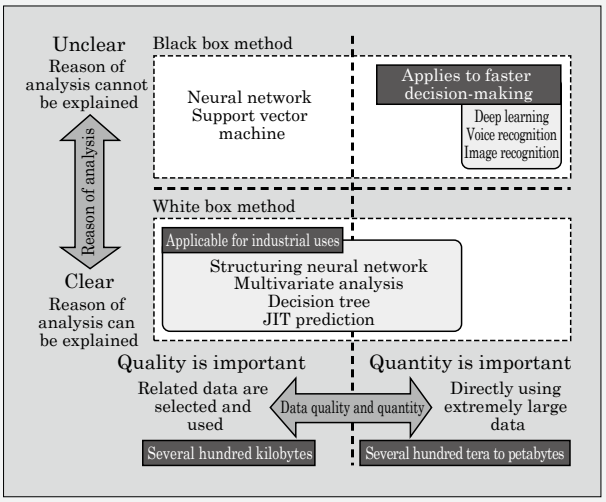

Fig.4 Classification of machine learning

been developed that uses sensing technology with image recognition to try to improve quality.

(5) IoT platform

To apply IoT systems to various solutions, it is essential to have a technology base that integrates field data collection technology, data analysis technology and advanced security technology to handle data safely. We have developed an IoT platform as such technology base. Figure 3 shows the IoT platform range, with its structure indicated by broken lines. A shortened development period, application portability and differentiation were realized with a combination of open technology such as an open source service and Fuji Electric-unique technologies (refer to "Overview of Fuji Electric IoT Platform" on page 136).

4. Future Outlook

4.1 Data analytics technology expansion

The machine learning-based analysis and reasoning technologies can be classified as shown in Fig. 4 with axes of data quality and quantity and analysis result basis. Especially for industrial use purposes, data quality and clearly indicating reasoning are regarded as important from the viewpoint of safety and reliability. Fuji Electric has focused on this area previously and continues to develop distinctive technologies and tools that can be mastered even by users who are not dedicated data scientists.

4.2 Field side value creation

The main purpose of edge controllers is to securely connect field equipment and other things to cyberspaces. Furthermore, it is necessary to enhance data values at the field side (called context data creation) such as by carrying out primary processing of collected data and synchronizing with image data so as to reduce IP network traffic. Fuji Electric has developed "OnePackEdge System" to respond to these requirements (refer to "Creating Value in Data with 'OnePackEdge System'" on page 118). In the industry and power generation fields, value creation such as diagnosis and analysis requires a response performance in milliseconds in many cases. It is impossible to satisfy these requirements via an IP network and cyberspace. Therefore, we satisfy the requirement to create values at the field side by mounting data analytic function to the OnePackEdge System.

4.3 Beyond IoT

IoT technologies, which connect things to cyberspaces, will develop to the form where things autonomously connect with each other in the future. The definition of things will include activities such as human resources and operations, and will be expanded to service*6. For services to be connected with each other, a network as a route, interface to the network (OPC-UA, etc.), information model as a common language between services and the description method (AutomationML, etc.) must be standardized. The IEC and ISO already have been jointly working on Smart Manufacturing-related standardization work. Standardizing interfaces between services allows a manufacturer to select the optimal manufacturing facility of another company

***6: Service**

A method where components are created with various operation applications or part of the functions of the applications and a new application system is designed by selecting and combining the components as needed is called service oriented architecture (SOA). The unit of the components is called Service. Although the object concept in the object orientation is included, the characteristic is that Service has a looser coupling than object so that Service can be coordinated on a network.

any time and entrust manufacturing according to the order received, for example. Simultaneously, various services can be shared by companies. This means that a company will be able to procure from the outside the innovation that is currently required and easily embed it into a system of its own.

There is an open innovation beyond IoT.

5. Postscript

This paper describes the current status and future outlook for solutions for new value creation and technical aspects of Fuji Electric while summarizing value creation with IoT which is being developed on a global level.

Fuji Electric will continue to make efforts for customer value creation paying attention to the world standardization trends and concentrating on our unique technology development.

Preferences

(1) Kondo, S; Fukuzumi, M. Instrumentation and Control Solutions in the New Age of the IoT: Current Status and Future Outlook. FUJI ELECTRIC REVIEW. 2016, vol.62, no.3, p.132-140.

(2) "Current Standards Landscape for Smart Manufacturing Systems". National Institute of Standards and Technology U.S. Department of Commerce. https://dx.doi.org/10.6028/NIST.IR.8107, (accessed 2018-07-20).

(3) "PLATFORM INDUSTRIE 4.0 working paper Aspects of Research Roadmap in Application Scenarios". Federal Ministry for Economic Affairs and Energy (BMWi), https://www.plattform-i40.de/I40/Redaktion/EN/Downloads/Publikation/aspects-of-the-research-roadmap.pdf?__blob=publicationFile&v=10, (accessed 2018-07-20).

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