Optimization of Factory Production Activities by Utilizing IoT

● Takeshi Jinushi ● Kazuhiro Chisaki ● Yusuke Kawakami

The individual factories of the Fujitsu Group have conducted numerous improvement activities up to now in an attempt to improve product quality and the efficiency of operations. However, those improvement activities require quantitative measurements to be taken manually, and the automation of this process has been a challenge. We have recently constructed a system that makes use of the Internet of Things (IoT) to gather, aggregate, and visualize data relating to manufacturing lines, physical objects and the environment in a timely manner. Our aim is to have these data utilized not only to make business decisions and respond to changes on-site but also to release people from the burden of carrying out measurements in factories and to create structures for improving productivity. This paper presents the approaches taken by the Yamanashi, Aizu-Wakamatsu, and Shimane factories to visualize operations as in-house cases of IoT being utilized by the Fujitsu Group companies.

1. Introduction

In countries all over the world, activities for rehabilitating and strengthening their own manufacturing industries have started recently. Japanese companies that manufacture in Japan have begun to place attention on utilizing data that makes use of the Internet of Things (IoT) to link all information from the upper processes such as design to the lower processes such as production. Meanwhile, the environment surrounding companies is also changing dramatically and enterprises need to achieve timely decision-making and response by accurately identifying and utilizing the changes as information. However, the conventional way of utilizing information, or systems of record (SoR), which aggregate and process stored data to present them as information, had a problem of requiring large amounts of time and labor.

By providing an environment that allows anybody to view data and information generated on-site, two-way communication that connects between the site and management can be realized, and this raises expectations for faster management and accelerated site activities.

In future information utilization, or systems of engagement (SoE), an environment will be built where data are gathered in real time by making use of the IoT and other means and anybody can view them right away for making timely decisions and responses. This will lead to good communication between the site and management and suggests a potential for having the positive effects of faster management and accelerated site activities.

This paper presents the approaches taken by the Yamanashi, Aizu-Wakamatsu, and Shimane factories of the Fujitsu Group companies for visualization of manufacturing lines, visualization of physical objects, and visualization of management and environment information.

2. Yamanashi Factory: improvement of efficiency of manufacturing lines

The Yamanashi Factory of Fujitsu I-Network Systems Limited mainly manufactures network products such as routers, switches, IP-PBXs, and smart meters. It has recently made use of the IoT for the manufacturing line of IP-PBXs to work on improving productivity by visualizing the manufacturing line.

The IP-PBX manufacturing line is used for high-mix, low-volume production of items and the operations often involve human intervention such as for changeovers and parts replenishment, and improving their efficiency improvement has always been a challenge. The factory had been continuously working on enhancing the efficiency of operations involving human intervention and achieved some effect by partially optimizing specific processes and equipment. To achieve total optimization with the line balance taken into consideration, it had made efforts by applying simulations, individual experience, and the results of the efforts of other factories in the Fujitsu Group. However, utilizing on-site data for optimization was only partially done and data shaping, or linking together data stored in various formats on different facilities, and gathering of new data were required.

To meet this need, we built a system that aggregates on-site data and visualizes production lines (**Figure 1**). The following describes major features of this system.

1) Edge processing of data shaping

Because the amounts of production information and device operation log data gathered can be enormous, it is important not to process all of them in the cloud but to subject them to primary processing on the edge. Accordingly, we adopted Cisco's IOx Router with middleware implemented for data processing to construct a system that provides primary processing on the edge. This has resulted in a reduced processing load on the cloud.

2) Data aggregation on the cloud

At the site, data were stored on the server in the factory in the past, and they have now been aggregated in the cloud to make them more available. In addition, using the cloud has facilitated data linking between factories and with the headquarters and linking with other business systems, and as a result information and communications technology (ICT) can be used in manufacturing.

Aggregating factory data in the cloud requires thorough network security. Accordingly, we introduced FUJITSU Network Edgiot GW1500 equipped with virtual network and proprietary relay functions and FUJITSU Managed Infrastructure Service FENICS II M2M Service to ensure security between the factory and the cloud.

3) Visualization and prediction of on-site data

For visualizing the on-site data gathered, we adopted a visualization tool developed by Fujitsu Systems East Limited (**Figure 2**). This tool can graphically display a product's production status by connecting between individual processes with the temporal axis. In addition, simultaneous mapping of operations such as changeovers, facility alarms, and site images as production information helps workers to identify the cause of any deterioration in productivity.

This approach has made it possible to grasp the production status of the manufacturing line at an appropriate timing and to make decisions on-site. In

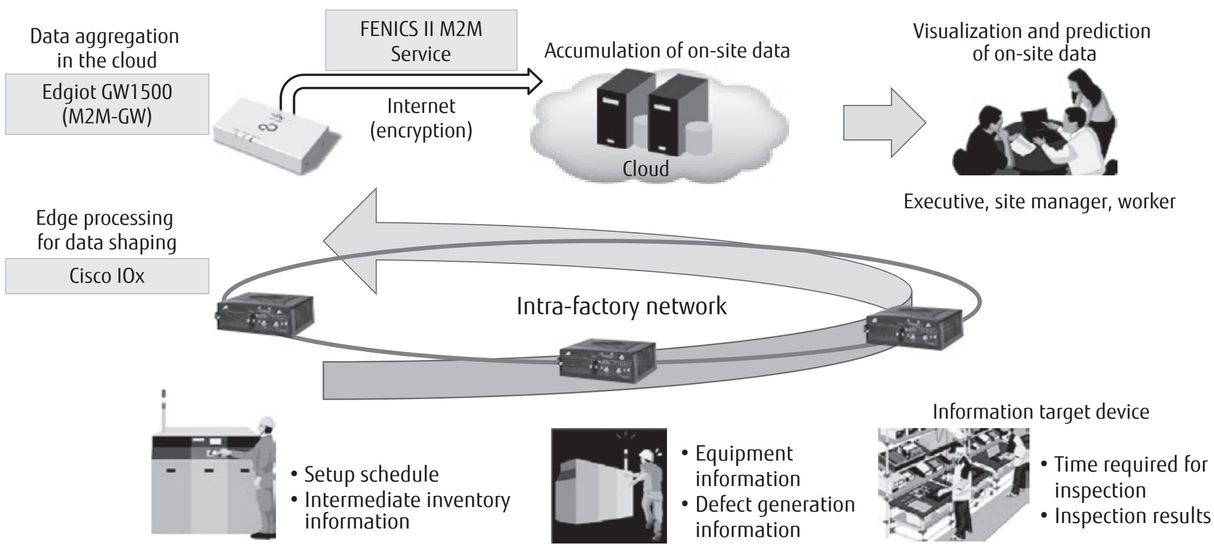


Figure 1
Outline of system for visualizing manufacturing line.

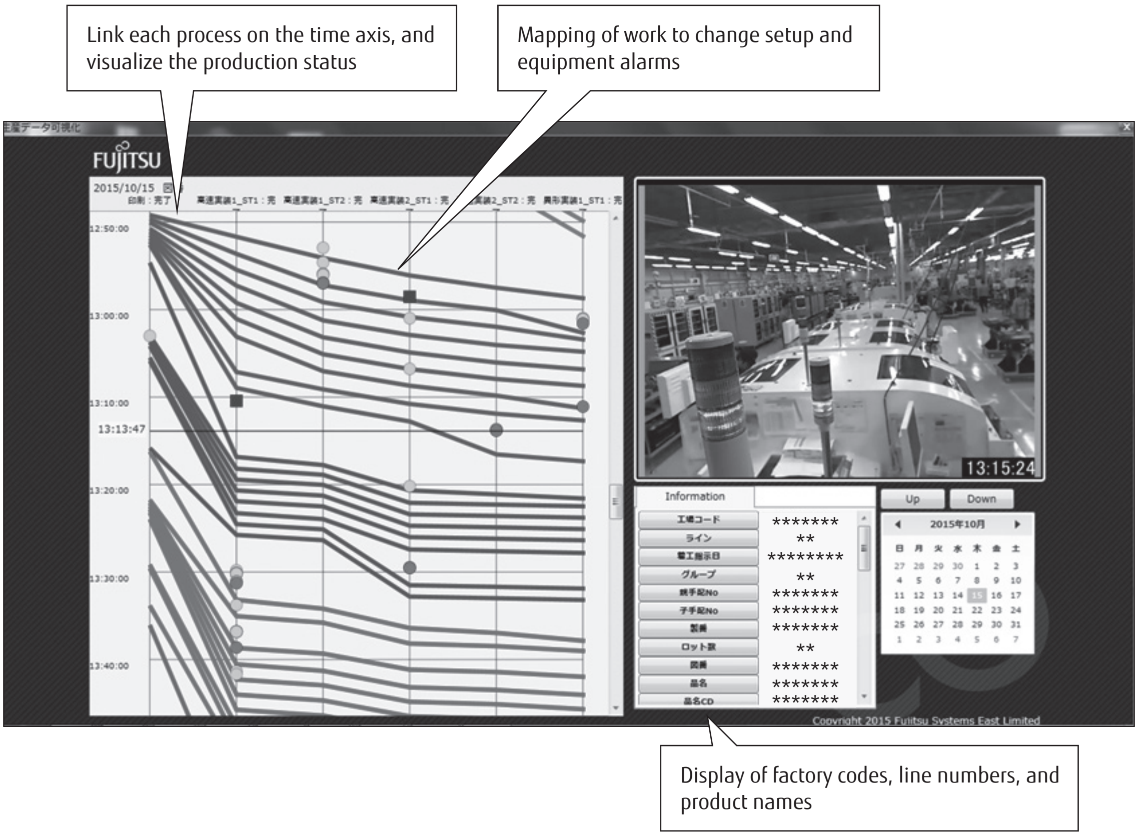


Figure 2
Visualization tool.

addition, linking between various pieces of on-site data has led to an increased number of new points of awareness, leading to formulation of more measures. Furthermore, data are already aggregated when improvement measures are evaluated, and this has eliminated the need to manually gather and process data, allowing workers to immediately evaluate the effect on the entire line balance.

In the future, we plan to predict a failure of facilities or consumption and degradation of parts by deepening the analysis of the on-site data in an effort to further improve efficiency and have higher productivity. We also intend to build an optimum line that leads to a reduced load on workers by aggregating information about their behavior and operation in addition to the manufacturing line information.

3. Aizu-Wakamatsu Factory: plant factory business approach

To help solve social issues, Fujitsu has launched new businesses set in Aizu-Wakamatsu, Fukushima Prefecture, where semiconductor manufacturing has been carried out since the 1960s. For example, we are collaborating with various partners to move ahead with the plant factory business by using the clean room that has been partially unused. We are also cooperating in the business of mega-solar power generation for snowy districts that utilizes the employees' parking lot. Further, we are involved in the regional energy control center business for managing the supply and demand balance of the power generated at regional renewable energy power plants. Among them, this section presents an approach in the plant factory business run by Fujitsu Home & Office Services Limited.

What led to the launch of the plant factory was that there were great expectations for easy access to vegetables with low potassium content by those with kidney diseases, who often have their potassium intake restricted. To *offer the joy of eating* to people with kidney diseases by using ICT was one of Fujitsu's wishes and we established the Aizu-Wakamatsu Akisai Plant Factory and started the production and sale of low-potassium leaf lettuce. By taking advantage of the clean environment of a semiconductor manufacturing factory and the Food and Agriculture Cloud Akisai[1] cloud service, we successfully mass-produced low-potassium leaf lettuce and realized the first innovation.

The next innovation is to improve quality, productivity and profitability. Quality, above all, is the lifeline of this business and it is essential to control the components closely relevant to those with kidney diseases including potassium and sodium and components that may affect the taste such as nitrate nitrogen. To that end, we must accurately grasp the types and value ranges of parameters to be controlled and the key is to quantify the practical wisdom gathered at vegetable factories up to now.

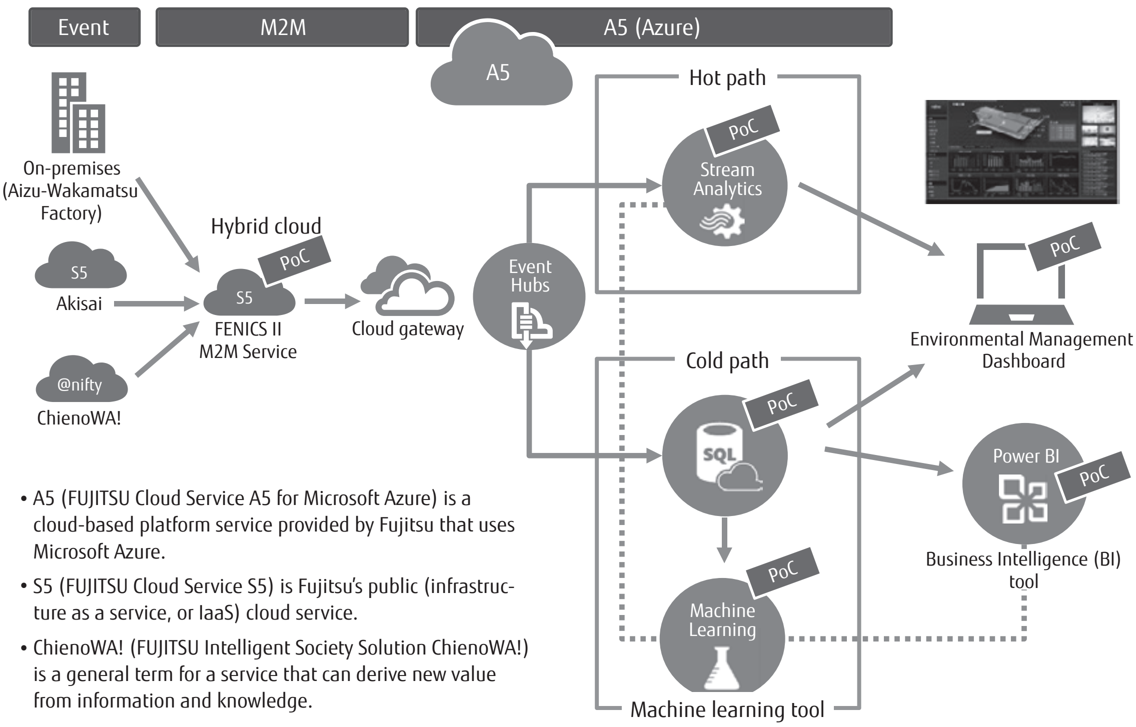
At the Aizu-Wakamatsu Akisai Plant Factory, we have been implementing proof of concept (PoC) utilizing the IoT since 2015 for realizing the second innovation (**Figure 3**). We have used FUJITSU Cloud Service A5 for Microsoft Azure based on an alliance with Microsoft for the *aggregation* of data and FUJITSU Sustainability Solution Environmental Management Dashboard for *visualization* of big data. One benefit of making use of these fundamental technologies is that the aggregation, visualization, and analysis of data are linked together on one platform.

1) Data aggregation and centralized management utilizing IoT

Conventionally, data were distributed among various places such as systems in the factory and management notebooks (paper-based) on the site. These data can be easily aggregated by uploading data managed by individuals to the Environmental Management Dashboard. From now on, it will be possible to automatically gather data from various systems in the factory by taking advantage of the IoT. This is expected to bring about greater efficiency of data aggregation and more information sharing between all users.

2) Optimization of production and management by visualization

In the past, only the primary data intended for the site such as the temperature and humidity of the clean room in the factory and the number of heads and weight of the produce were visualized in order to optimize the operations. However, this was not sufficient for facilitating decision-making from the perspective



• A5 (FUJITSU Cloud Service A5 for Microsoft Azure) is a cloud-based platform service provided by Fujitsu that uses Microsoft Azure.
• S5 (FUJITSU Cloud Service S5) is Fujitsu's public (infrastructure as a service, or IaaS) cloud service.
• ChienoWA! (FUJITSU Intelligent Society Solution ChienoWA!) is a general term for a service that can derive new value from information and knowledge.

Figure 3
Outline of proof of concept.

of the executives or the management. Utilizing the Environmental Management Dashboard to combine factors such as energy, quality, yield, and cost as the secondary data for visualization allows appropriate decision-making. One example is to visualize the basic unit (energy consumption per head). In addition, threshold-based management of the basic unit makes it possible for people to detect at an early stage when an abnormal trend begins to emerge. These measures are expected to be useful not only for early detection of quality variations and abnormalities but also for decision-making and raising awareness of those involved in production and management about the need to ensure product quality (**Figure 4**).

3) Efficiency improvement of data analysis by utilizing business intelligence (BI)

Even if abnormalities can be detected, no measures can be formulated unless the causes are analyzed. However, the conventional analysis using Excel was cumbersome and its management depended on individuals. In contrast, use of BI tools such as Power BI of Microsoft facilitates the aggregation, processing, and graphical representation of the data required for different users. This can lead to greater efficiency of the analysis operations and information sharing.

We have used the Environmental Management Dashboard, which has shown the direction to head in for the second innovation. As a future expansion, we intend to make use of machine learning tools to identify optimum setting models for the cultivation environment parameters and build them into knowledge.

4. Shimane Factory: visualization of repair process

Shimane Fujitsu Limited manufactures notebook PCs and tablets for the Japanese and overseas markets. In order to prevail in global competition, Shimane Fujitsu has set a business goal of "pursuing excellent manufacturing capabilities, and developing into a service provider that takes advantage of the manufacturing capabilities." And to accomplish this goal, Shimane Fujitsu introduced the Fujitsu Production System (FJPS), which is based on the Toyota Production System (TPS) and makes use of ICT. By using the FJPS, Shimane Fujitsu is working on made-to-order production for filling custom orders and visualization of manufacturing lines and continuously pursuing the optimization of production.

We aimed to improve the efficiency of operations up to shipping by making use of the IoT to grasp the positions of products found to require repair (hereafter, target products), associate them with the production control information, and visualize the information. In order to grasp the positions of all target products in the work area, it is necessary to gather and visualize position sensor information with an accuracy

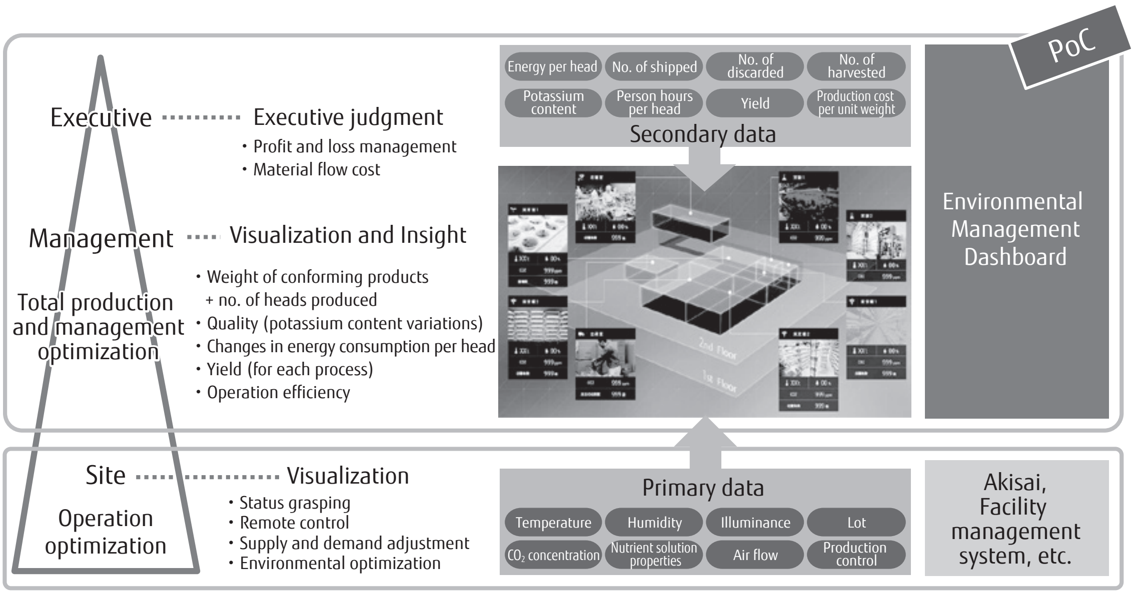


Figure 4
Environmental Management Dashboard.

of approximately 1 meter. Accordingly, we utilized Bluetooth Low Energy (BLE) sensors to do this. For this project, we incorporated a system in which the BLE radio wave reception environment was adjusted, equipment accommodating hundreds of sensors was selected and the target products associated with the position information and production information obtained from the equipment were visualized in real time (**Figure 5**).

The following describes the features of this system:

1) Position detection by sensors

As small sensor beacons that use BLE, Fujitsu's UBIQUITOUSWARE Location Badges (prototype model) and FDK Corporation's ultra-thin sensor beacons were attached to the target products at the start of repair work. At that time, barcodes attached in advance on the sensors and a device management table were read so as to add the production information to the visualization information, and this allowed the positions to be grasped.

2) Position information gathering by gateways

The equipment that aggregates large volumes of sensor information and sends them to the IoT platform via the network is composed of Fujitsu's gateway Edgiot and Intel's IoT Gateway. At the time of installation, we tuned the installation locations and orientations of the gateways and confirmed the communication states between the gateways and sensors installed in the respective areas to improve the accuracy of position detection.

3) Linking of visualization system with production control system

Linking between the visualization system and production control system allowed the workers to promptly grasp the progress of repair work against the production plan. In addition, the screen display allows production managers as well as the site workers to check the conditions of the entire repair area in real time, which has made production control easier (**Figure 6**).

This approach has realized real-time grasping of the progress of repair such as the estimation of the end-of-work time based on the product retention locations and priority order. Furthermore, early determination of the priority work to be completed by workers has

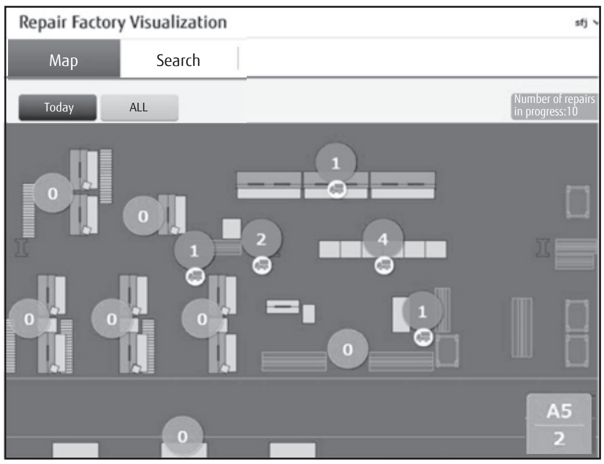


Figure 6
Screen of Shimane Factory's repair visualization system.

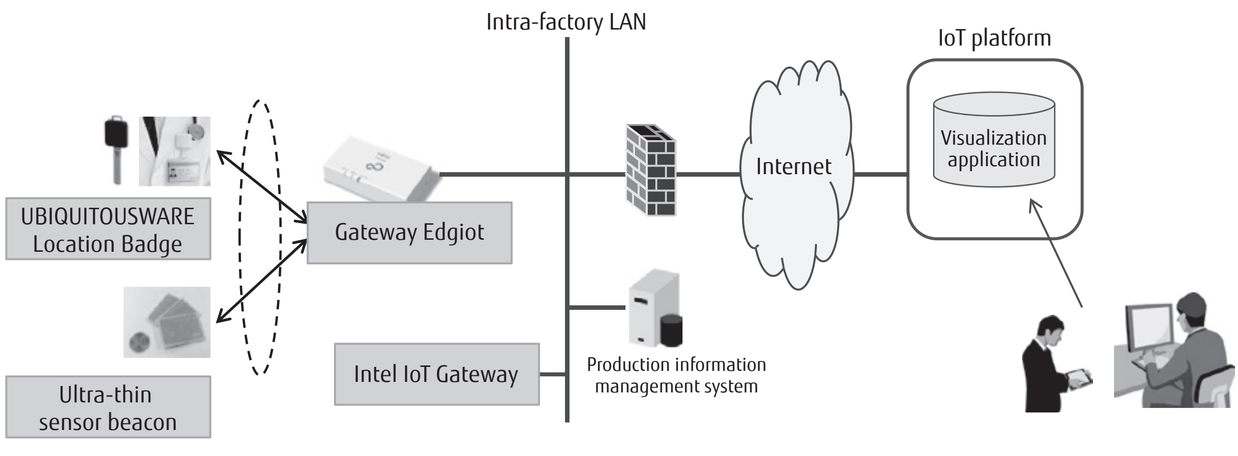


Figure 5
Configuration of Shimane Factory's repair visualization system.

improved the person-hours required for incidental work generated before shipment. As a result, each worker has come to be able to concentrate on their primary operations, which has led to improved work efficiency.

From now on, we intend to analyze videos of workers and devices in the testing process and analyze correlations with test logs in order to further improve the shipping rate of the final products and improve work efficiency. In the future, we aim to enhance the efficiency of the entire manufacturing process by expanding the scope of visualization to the whole supply chain including between factories.

5. Conclusion

This paper has described a way to optimize improvement activities relating to the production of the individual factories by data aggregation, data visualization, and linking with other systems, while utilizing the IoT at individual factories of the Fujitsu Group.

In the future, we intend to pursue further utilization of the IoT for improved quality by monitoring symptoms and optimizing the supply chain. We will do this by expanding the scopes of target data and linked systems.

The plant factory business approach at the Aizu-Wakamatsu Factory presented in this paper was implemented as an advanced agricultural production system field trial adopted by the Reconstruction Agency and Ministry of the Economy, Trade and Industry.

References

1) Introduction of Fujitsu's Food and Agriculture Cloud "Akisai."
http://www.fujitsu.com/global/documents/about/ir/library/presentations/presentation-20150226-01.pdf

Takeshi Jinushi
Fujitsu Ltd.
Mr. Jinushi is currently engaged in development of solutions making use of IoT technology.

Kazuhiro Chisaki
Fujitsu Ltd.
Mr. Chisaki is currently engaged in development of solutions making use of IoT technology.

Yusuke Kawakami
Fujitsu Ltd.
Mr. Kawakami is currently engaged in sales promotion of Environmental Management Dashboard for factories that makes use of IoT technology.