Establishing International Standards for Information Exchange Between Platforms to Realize Connected Monozukuri

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Due to the diversification of customer preferences, industrial products are becoming more complicated. For a manufacturing business to respond quickly to the needs of customers, it must facilitate the cooperation and sharing of diverse information across the organizational barriers between various departments, such as planning, design, manufacturing, and maintenance. This collaboration can be difficult if each department works with different types of information, data formats, interfaces, and so on. It is, therefore, important to ensure that this cooperative activity is properly organized. As a national project conducted jointly with the National Institute of Advanced Industrial Science and Technology (AIST), Fujitsu is studying and demonstrating the standardization of information exchange platforms for Monozukuri (representation of Japanese philosophy about manufacturing) using the concept of "profiles." This paper describes the international standardization trends of information exchange between systems related to Monozukuri, and discusses Fujitsu's approach.

1. Introduction

Since around 2010, there have been growing calls around the world for a rebuilding of manufacturing industries. This has led to concrete activities such as Germany's Industrie 4.0 (I4.0) initiative, and the establishment of the Industrial Internet Consortium (IIC) in the United States. In Japan, the concept of Monozukuri (representation of Japanese philosophy about manufacturing) has been adopted as part of Japan's revitalization strategy, and various measures are now under way to implement this concept.

The purpose of these efforts is to reform the manufacturing sector by making full use of the capabilities of ICT to increase productivity and create new businesses with the manufacturing site as their starting point. The implementation of these reforms result in a state called "smart Monozukuri." It is difficult for a company or organization to achieve smart Monozukuri in isolation, so it is important to engage in co-creation and information exchanges as part of a framework that crosses the boundaries between businesses and organizations. In particular, it is important to establish connections between manufacturing-related information sourced from disparate production sites and systems.

However, to achieve this, it is necessary to negotiate various contracts with cooperating companies and organizations. If these contractual agreements can be standardized in the same way as international standards, the process will run much more efficiently. The abovementioned I4.0 and IIC initiatives are already drawing up standards that favor their own interests to promote activities aimed at improving their market position.

Japan's national strategy has been to promote various measures and activities, mostly involving the Ministry of Economy, Trade and Industry.[1)] At Fujitsu, we are engaged in a joint project with the National Institute of Advanced Industrial Science and Technology (AIST) to propose new international standards. To achieve smart Monozukuri, we need to establish a "connected Monozukuri" mechanism to connect the Monozukuri information of companies and organizations.

In this paper, we discuss the standards related to information exchange between systems, which is essential for implementing connected Monozukuri, together with the trends of relevant organizations both within and outside Japan, and some examples of national projects in which Fujitsu is involved.

2. Importance of connected Monozukuri

Smart Monozukuri innovation has proven nearly impossible for a single organization or business entity to achieve. However, our aim is to achieve it through the use of ICT. For example, in a "mass customization" process where individually specified products are manufactured using mass production lines, the first step is to use IoT to collect diverse site data, which is then visualized to improve factory operations. Next, to optimize the supply chain, including the component suppliers and consignees, the required information is coordinated between different organizations. This requires the construction of a structure that can immediately respond to market trends and other changes and fluctuations in the external environment.

For an efficient exchange of Monozukuri information within and between companies, it is necessary to establish various protocols to describe how this information should be communicated, what terminology should be used, and how it is formatted.

The use of a platform (PF) can be cited in this way as a means of information gathering for connected Monozukuri implemented across a framework of companies and organizations. In May 2017, Fujitsu launched a digital place called FUJITSU Manufacturing Industry Solution COLMINA as a means to support Monozukuri.[2)] The digital place is not only an information platform, but every stakeholder can gather to collaborate on it.

However, not only is a different PF selected for each company, but the specifications also differ depending on the targeted work. It is, therefore, important consider how each of these PFs can be adjusted to achieve smooth information exchange. Furthermore, there are currently no suitable international standards for exchanging information with foreign companies or organizations via PF. For this reason, each country is working on standards that favor its own domestic industries.

3. International standards related to Monozukuri

International standards include de jure standards drawn up by international organizations, and de facto standards drawn up by general consensus. In this section, we describe de jure standards that are clearly positioned as international standards.

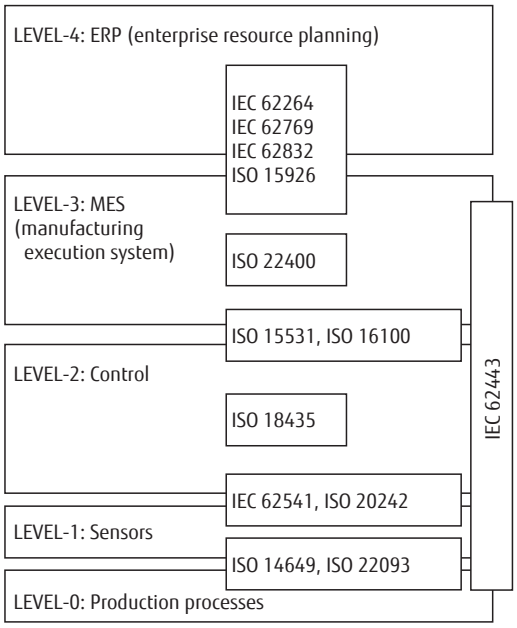
The word "Monozukuri" is currently used to mean various things. Sometimes it refers broadly to the entire life cycle of a product (design, manufacture, maintenance, and disposal/recycling), while at other times it refers only to manufacturing in a narrow sense. There are several international standards related to Monozukuri.

Typical examples of organization that draw up Monozukuri standards include the International Organization for Standardization (ISO) and International Electrotechnical Commission (IEC). In addition, academic institutions like the Institute of Electrical and Electronics Engineers (IEEE) create standards. The national standards organizations of each country, such as the American National Standards Institute (ANSI), Deutsche Industrie Normen (DIN), and Japanese Industrial Standards (JIS) are also closely related to international standards.

Figure 1 shows a part of the international standards defined as a functional hierarchy from the viewpoint of manufacturing stages (factories) by the International Society of Automation (ISA), an international organization concerned with the automation of Monozukuri. Levels 0–2 indicate entities with a physical existence. Level 0 corresponds to manufacturing processes, Level 1 corresponds to sensors and adjustment devices, and Level 2 corresponds to control equipment such as programmable logic controllers (PLCs). Level 3 corresponds to on-site factory management systems, and Level 4 corresponds to systems for manufacturing scheduling and management.[3)]

Figure 1 is superimposed with some of the international standards related to each level. Many international standards have already been developed for the various situations that arise within levels and between levels. In addition to the international standards shown in this figure, there are also other international standards that are essential for data exchanges with the design domain, such as ISO 10303 (Industrial automation systems and integration—Product data representation and exchange).

As mentioned above, most of the international standards related to Monozukuri remain at the level of factories, organizations, and corporations. Meanwhile, the creation of international standards for connecting between corporations and between PFs is being actively studied by various organizations.



IEC 62264	Enterprise-control system integration
IEC 62769	Field Device Integration (FDI)
IEC 62832	Industrial-process measurement, control and automation - Digital factory framework
ISO 15926	Industrial automation systems and integration -- Integration of life-cycle data for process plants including oil and gas production facilities
ISO 22400	Automation systems and integration -- Key performance indicators (KPIs) for manufacturing operations management
ISO 15531	Industrial automation systems and integration -- Industrial manufacturing management data: Resources usage management
ISO 16100	Industrial automation systems and integration -- Manufacturing software capability profiling for interoperability
ISO 18435	Industrial automation systems and integration -- Diagnostics, capability assessment and maintenance applications integration
IEC 62541	OPC Unified Architecture
ISO 20242	Industrial automation systems and integration -- Service interface for testing applications
ISO 14649	Industrial automation systems and integration -- Physical device control -- Data model for computerized numerical controllers
IEC 62443	Industrial communication networks - Network and system security

Figure 1
International standardization related to manufacturing.

4. Mechanism for connecting information

The implementation of connected Monozukuri requires the use of data profiles to ensure that information models can be cross-referenced. In this section, we discuss these data profiles and the requirements of PFs capable of implementing them.

4.1 Information exchange within organizations

In Monozukuri-related fields, if site information is used for a single purpose, it can be aggregated and passed over to a system. This can be regarded as a part of typical system integration work. In recent years, large numbers of information exchange PFs have been announced for the utilization of site information for multiple purposes, including future re-use. Many of these PFs organize the collected information into some sort of structured data and store it in a database. The site information also includes unstructured data such as audio and images, so there has also been a rise in the use of databases such as NoSQL that can organize a wide variety of data at high speed.

In collaboration with AIST, Fujitsu is currently engaged in a project called "Construction of a Platform for the International Standardization and Popularization of Smart Manufacturing" commissioned by the Ministry of Economy, Trade and Industry (METI). In this project's information exchange PF, D-COMII, we decided to organize and store data in a form that conforms to the format of PSLX3 information profiles.[4)]

PSLX3 is a PF proposed for the manufacturing industry by PSLX (Planning and Scheduling on Lifecycle information eXchange) Forum, which is a consortia managed by the incorporated nonprofit organization Monozukuri APS Promotion Organization. By arranging data at the factory site in a form that matches the data profile specified by the PF and storing it in D-COMII, this eliminates the need to consider the systems that use this information. On the other hand, by extracting information in accordance with a data profile, the system that uses this information can do so without detailed awareness of the site details (**Figure 2**). In this case, PF is positioned between Levels 3 and 4 shown in Figure 1, where it can mediate the information exchange.

The information profile of PSLX3 consists of three

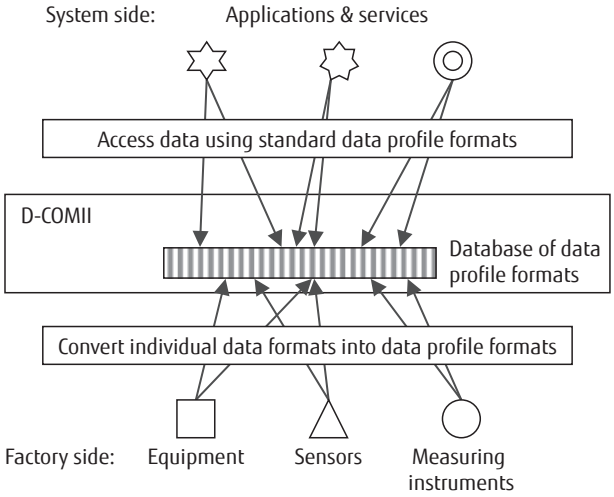


Figure 2
Separating system-side data accesses from factory-side data uploads using data profiles.

layers, models, objects, and items, and is a template originating from Japan that is suitable for representing Monozukuri work as an information model. However, there are some cases where data cannot be sorted out by the PSLX3 information profile alone, and it is necessary to add objects and items independently. Therefore, a D-COMII profile has a part that uses PSLX3 directly and a part that extends it independently.

4.2 Information exchange between organizations

Figure 3 shows an example of the information exchange mechanism between organizations. The flow of information indicated by the arrow corresponds to the case where organization B uses information collected at the site of organization A. For example, one might envisage a situation where the company responsible for the next process of a supply chain is used to gather the state of progress made by the company responsible for the previous process.

However, as mentioned above, care must be taken when connecting with other organizations in situations where each organization has an information profile for each PF. Some of the cases where problems can occur are as follows:

1) The compliant information profiles are different. In this case, since the terminology used by these profiles is also assumed to differ, the exchanged information itself will have to be reconstructed.

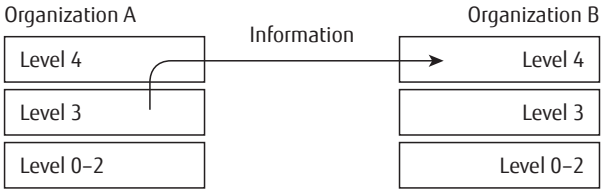


Figure 3
Information exchange between organizations.

2) The information conforms to the same information profile, but includes different additional items. In this case, the additional items cannot be included in the information exchange.
3) The additional items have the same meaning, but are named differently. In this case, since a simple comparison is not possible, a name collation task has to be performed.

These issues are currently unresolved, and measures for solving them should be formulated as international standards. Factors such as data ownership and control over the level of data provision for different information exchange partners should also be considered.

For this reason, the national project we are involved with is considering submitting proposals to international standard bodies on the basis of the following ideas:

1) Enumerate and recommend information profile groups that can serve as references. Determine in advance the methods to be used for information exchange between reference information profiles.
2) Keep records whenever an item is added or modified, and make these records available for reference when a comparison is required.
3) Register details such as the names of added items in a common dictionary to facilitate their replacement.

Furthermore, we plan to document detailed procedures and propose them to international organizations. However, it is necessary to make allowances because excessively strict definitions not only impair usability but are also liable to impede the popularization of this system.

The formulation of international standards requires the agreement of participating countries, and is generally a long-term activity that can take several

years to complete. At Fujitsu, we hope that our active participation will help to speed things up as much as possible.

5. Conclusion

In this paper, we described the standardization of protocols for the establishment of information exchange, which plays a key role in realizing "connected Monozukuri."

Fujitsu provides a digital place called FUJITSU Manufacturing Industry Solution COLMINA that facilitates the exchange of all sorts of Monozukuri information related to design, manufacture, and maintenance by clients in the manufacturing industry. The realization of connected Monozukuri is an important activity supporting the development of COLMINA. We will continue to work towards implementing international standards in partnership with various related groups both inside and outside the company.

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