Yokogawa's Approach to IT/OT Convergence for Successful Digital Transformation

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Although "digital transformation" (DX) has become a buzzword recently, the term is usually used to mean intelligence derived from digital data itself. In the manufacturing industry, however, the value of DX can be gained only when experts in each field fully understand and accept the intelligence and apply it to operations.

In other words, at manufacturing sites, efforts are needed to maximize the effects of DX through integrating and converging information technology (IT) and operational technology (OT). Thus, Yokogawa has refined related technology and know-how through many co-creation projects with customers. This special issue of Technical Report introduces Yokogawa's efforts, elemental technologies and solution examples in the area where IT and OT converge.

INTRODUCTION

Amid the greatly-changing business environment of the manufacturing industry in recent years, companies are seeking to create new value by using digital transformation (DX) and innovating management and production [(1)]. This trend was triggered and accelerated by technological innovations such as the Internet of Things (IoT) technology, the cloud, and AI; the spread of open innovation; and the necessity of adding more value. Digital data is easy to duplicate, process, transfer, and save. Through the use and advanced processing of digital data, DX facilitates innovation and is expected to boost corporate value.

Although the cyber-world is based on digital information, the place where digital data are obtained and where value is created by these data is the real world, namely the frontline of manufacturing and management. The cyber-world (Information Technology: IT) is a digital twin (mirror) of the real world [(2)]. Operators can simulate the behavior of the mirror plant by freely shifting the time axis among past, present, and future. With this technology, operators can predict the behavior of the real plant, make optimum, timely decisions, and carry out these decisions in the real world. This process is operational technology (OT).

The following five points are crucial to enhance the true transformation with this digital twin environment, and are also the key points for achieving DX by IT/OT convergence.

(1) Is the real world digitally and precisely mapped to the cyber-world (do sensing and modeling work appropriately)?
(2) Can new intelligence (knowledge) be created from the cyber-world?
(3) Can the created intelligence be honed by existing theories,

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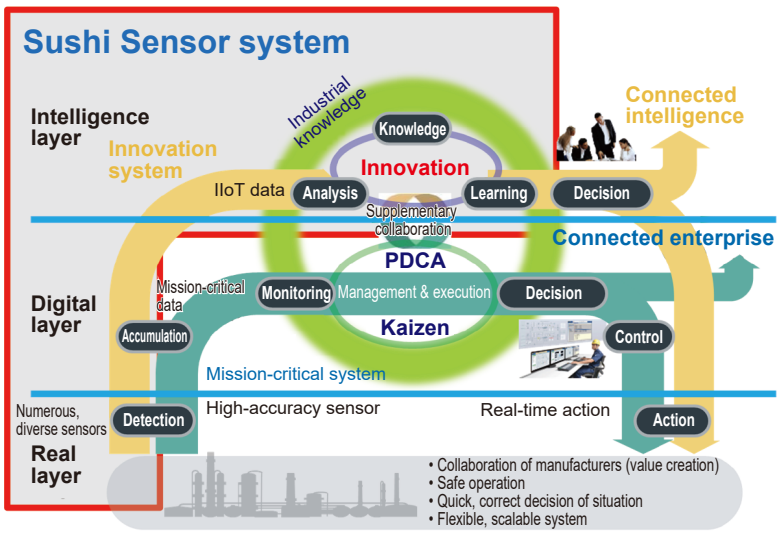

Figure 1 Yokogawa's Industrial IoT reference model (2015)

knowledge, and experience in management and operation? Can experts in the field and management accept the intelligence and transform it into new wisdom shift from sensing to sensemaking [3]?

(4) Is it possible to apply decisions based on new wisdom to the real world safely, automatically or semi-automatically?

(5) Is the safety and reliability of operation secured? Is the cyber security of related data and systems (IT) ensured?

These five points are also important factors in rolling out the Industrial IoT reference model advocated by Yokogawa since 2015 (Figure 1). As shown in Figure 1, we aim to achieve DX that brings innovation and safety to operation by coordinating the requirements for the external loop of Innovation System and the internal loop of Mission-critical System in operation (control is a typical example).

Yokogawa has gained broad experience in many projects with customers especially in the manufacturing industry and achieved safe operation. In the IT sector, we have released solutions in line with the Industrial IoT reference model, applied these solutions to projects, and worked with customers, helping them achieve their DX. This special issue of Yokogawa Technical Report focuses on how to achieve DX with this IT/OT convergence and introduces examples of field application.

REQUIREMENTS FOR ACHIEVING DX WITH IT/OT CONVERGENCE

As listed above, there are five important points to achieve DX. Their details and Yokogawa's commitments are described below.

(1) Precise digital mapping

To solve problems in the real world, it is necessary to grasp comprehensively all related matters in the real world in detail. Because problems in the real world are interlinked, it is very difficult to logically understand them. So, we first map the real world precisely to the cyber-world, where we then reproduce the target problem and identify the underlying problem. To map correctly, it is necessary to mathematically model the real world based on huge amounts of data obtained from the real world and knowledge of mathematics, natural science, and engineering, and then digitize the state of the model. These processes should be achieved and maintained within reasonable costs. Regarding mathematical modelling, Yokogawa has technology for building and operating simulators and creating related solutions. In particular, the company has a solid track record of simulators for the process industry (training simulators, MIRROR PLANT, Petro-SIM, and 3D simulators). Details of the latest application of the 3D simulator are reported in this special issue in the article, "Integrated Training System for Operation and Maintenance Using VR Plant."

Moreover, Yokogawa has succeeded in the data-driven semi-automation of this mathematical modelling. This technology helps mitigate the workload for data scientists, standardize their operation, and shorten and stabilize model construction (Data Driven Modeling for Optimization: DDMOnEX).

To synchronize the state of a mathematical model and the real world, it is necessary to digitize the state of the real world. Sensing technology plays an important role in this process. Sensors used in the real world have various technological requirements such as precise measurement, explosionproof function, environmental resistance, and wireless communication. Yokogawa has honed sensing technology required for operation and satisfies these requirements. By leveraging this technology, we have also developed and released IIoT sensors mainly for equipment in order to precisely map the state of the real world. This IIoT sensor (Sushi Sensor) is described in two articles, "Sushi Sensor for Industrial IoT Solution Achieves 'Sensemaking'" and "Sushi Sensor Series of Temperature and Pressure Sensors for Industrial IoT."

(2) Discovering new intelligence

The cyber-world synchronizing with the real world is built using data from the past to the present as well as existing knowledge. Advantageously, operating variables in operation can be changed freely and the state of the model can be simulated in the cyber-world. It is also possible to shift the time from the past to the present and the future and predict the state of a future model including its dynamics.

However, differences may arise between this simulation model and the real world. When this difference repeatedly appears and has a great influence on the KPIs of the target problem, the simulation model is not appropriate (KPIs include the yield, energy consumption, and product quality of the plant). Identifying and solving such non-negligible differences leads to the creation of intelligence and then to innovation. People involved in this creation must have good knowledge of both the real world and the cyber-world. If multiple workers gather beyond the boundaries of departments and work on co-creation together (Co-innovation), this will lead to the efficient creation of high added value.

To create innovation, the following items must be checked.

(a) Accuracy of data

Can sensors measure data precisely?

(b) Amounts of data

Are all sensing locations and the time axes of data covered to precisely map the real world?

(c) Appropriateness of logic

When statistical analysis, AI, and other technologies are applied to data collected from sensors, is there any reproducible logic to be added to the current mathematical model?

(d) Sensitivity analysis

When missing data and logic are supplemented, do they cover the numerical influence (sensitivity analysis) on the KPIs of the target problem?

(e) Agreement with the model

Do the targets (plants, units, etc.) in the real world remain aligned with the mathematical model even with the passage of time (deterioration over the years, etc.)?

Repeatedly checking these items will create intelligence that can solve the target problem.

(3) Sensemaking

The intelligence acquired in the process above is a digital intelligence created with data and their abstracted numerical models. Before applying the intelligence to the real world, there is an obstacle to be overcome.

This obstacle is whether the intelligence can satisfy or convince people who have domain knowledge. This intelligence is equivalent to solving the complex actual problem. To make it satisfactory, co-creation activities must be carried out beyond the boundaries of organizations and sections just like the task in item (2). This activity is achieved by IT/OT convergence. The intelligence that satisfies experts is sublimated to wisdom, and its usage will expand.

Yokogawa is involved in various advanced projects with customers and partners to perform items (2) and (3), as described in the article, "Challenge to Smarter Data Intelligence by Co-innovation with Users."

(4) Decision-making

Even when the intelligence has convinced experts and has been sublimated to wisdom, it can create value only when it is implemented in the real world. Appropriate methods or techniques are needed for this purpose. These methods and techniques can be collectively expressed as "know-how for operation." If this is not done, people cannot enjoy the merits of DX.

For example, assume that there is an unstable control system. After steps (1) to (3) are performed, the digital twin suggests that the control set point should be reduced by 5%. You can decrement this set point by 1 point to the target point and check the controllability while keeping the stability of operation. Or you can try another solution. Examining available options and choosing the optimum one is what constitutes operational know-how.

By leveraging its knowledge, technology, and experience of IT/OT, Yokogawa works together with customers to hone this wisdom up to the level of practical use and help customers achieve DX. Our commitment to fieldwork in operation is described in the article, "Fieldwork Support in the Digital Transformation Era."

(5) Cyber security

While it is advantageous to connect the real world and the cyber-world, some problems arise, such as cybersecurity. To introduce information technology while maintaining the stability and reliability of operation, good knowledge of IT and OT is required. As cyberattacks are now targeting the manufacturing industry, people in charge of IT infrastructure in the field, information system sections, and vendors must work together to reduce this risk. Furthermore, it is necessary to prepare measures in advance and implement them swiftly when any incident occurs. Yokogawa has long collaborated with customers on IT and systems that keep running 24/7 and has been offering various support. Regarding Yokogawa's commitment to field operation, some examples are introduced in the article, "Ideal Solutions Derived from Field Surveys: Cybersecurity Countermeasures for Next-generation Plants."

CONCLUSION

This paper discussed the merits of DX in the industry and explained the five points to be considered.

The intelligence created in the process of DX delivers value not in the cyber-world but in the real world. Therefore, the intelligence should be sublimated to wisdom and performed from the viewpoint of operation. Moreover, it is necessary to improve the underlying IT/OT infrastructure while ensuring its security and maintaining the stability and

reliability of operation.

The progress of IT/OT convergence will make operation more advanced and stable. Meanwhile, the environment surrounding operation continues to change in response to the expansion of global supply chains, diversification of energy resources, compliance with the SDGs, and other factors. Therefore, today's optimum operation is not always tomorrow's. The OODA loop is an excellent way of searching for and performing the optimum operation. Amid changing circumstances, it is necessary to carry out this loop flexibly and implement it into operation. DX can be achieved when the Innovation System and Mission-critical System is coordinated appropriately, and this process is carried out in the OODA loop.

Yokogawa will continue to work on achieving DX with customers and partners under its corporate slogan of Co-innovating tomorrow.

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