Yokogawa's Plant Healthcare Service

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While producing products, plants output a variety of valuable data. However, it is often difficult for plant owners to effectively use the data to ensure the health of the system. Yokogawa's plant healthcare service helps solve this issue; its digital transformation (DX) platform periodically collects data from customers' operational technology (OT) assets, analyzes the data, and determines the condition of the assets. Based on this output, customers can precisely assess risks and optimize and implement a maintenance plan. This paper explains the value brought by this service to customers, its three core features, and its future development.

INTRODUCTION

As operational technology (OT) assets become more intelligent, a large amount of data is generated in various places and forms in plants. However, many plant owners struggle to use such data effectively. This paper provides an overview of the plant healthcare service (PHS). The PHS collects data from various OT assets, processes them on the Managed Service Suite (MSS), a type of digital transformation (DX) platform, and addresses customers' issues. The PHS offers three types of service: PHS for security, PHS for system assets, and PHS for field assets. According to the structure of the Purdue model[(1)], each service fits into layers of L1 to DMZ, L1 to L3, and L0, respectively (Figure 1).

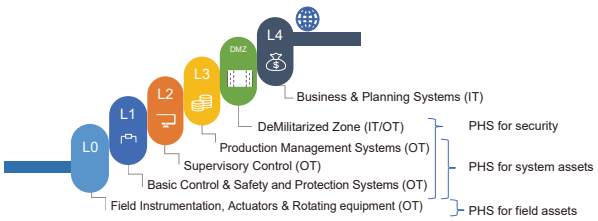

Figure 1 Scope of PHS services according to the Purdue model

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CUSTOMER VALUE DELIVERED BY PLANT HEALTHCARE SERVICE

The PHS processes a large amount of data and visualizes only meaningful data, enabling customers to easily take action focusing on the information. This feature helps improve maintenance efficiency, reduce maintenance costs, improve the performance of OT assets, and prevent unplanned plant shutdowns. Table 1 lists the advantages of the PHS for customers.

Table 1 Values brought by the PHS to customers

Customer value	Security	System assets	Field assets
Improved maintenance efficiency and reduced costs	✓	✓	✓
Improved performance of OT assets	-	✓	✓
Fewer unplanned plant shutdowns	✓	✓	✓

PLANT HEALTHCARE SERVICE FOR SECURITY

In recent years, an increasing number of control devices are based on general IT technology. In Yokogawa's control systems, human machine interface (HMI) applications run on general operating systems such as Microsoft Windows. In addition, various devices and software are used as components of the control system. These include security software (e.g., anti-virus software), auxiliary software (e.g., domain controllers and backup software), and IT network devices (e.g., network switches and firewalls).

These devices and software can retain and output their own configuration and logs. Such information is diverse and useful, including software, hardware behavior in daily operations, and security related operations. In many cases, however, the output is too detailed and complex to grasp the meaning. Some logs appear meaningless when handled independently, but when they are compared with logs obtained from other network devices and systems, they help detect suspicious behavior such as intrusion and tampering through the network.

Since customers' main job is plant operation and maintenance, they do not have enough time to collect the many logs from multiple devices and software covered by the control system and identify trends. PHS for security collects and analyzes this information through the MSS, monitors the security status of the control system, and if necessary, conducts additional investigations and takes defensive or corrective actions in cooperation with customers.

Reporting Service

PHS for security collects security data from the customer's system through the MSS, analyzes them, and issues periodical reports to the customer.

Figure 2 shows the workflow of reporting. Data collected from the customer's system ("Customer") are sent to a global operator team ("Operator Team"). Some of the data are analyzed by Y-SOC (see below), and the Operator Team compiles the results into a report. Overseas affiliates check whether the report reflects the actual situation and then the report is submitted to the customer. In the log analysis, logs collected from a large number of devices must be compared and analyzed to identify the trend. Yokogawa's in-house security operation center (Y-SOC), which analyzes internal security logs, undertakes this work in this service. Y-SOC's analysis system analyzes communication logs collected through the MSS and Windows event logs. This helps promptly gather findings in security analysis and eliminates the need for additional investment in the system.

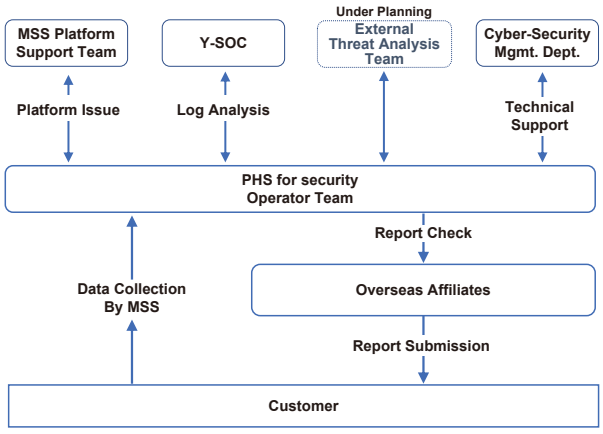

Figure 2 Workflow of the reporting service

OT-SOC Service

To expand the reporting service, we are planning to set up an OT security operation center (OT-SOC), which monitors customers' systems 24/7 and reports and corrects security problems when they occur. Although its workflow is similar to that of the reporting service, we will add some innovations based on the knowledge obtained from the reporting service. For example, we will automate the analysis logic to quickly detect and respond to security incidents.

PLANT HEALTHCARE SERVICE FOR SYSTEM ASSETS

The human interface station (HIS) and the field control station (FCS) are components of the distributed control system (DCS). Their status information indicates the health of the plant assets, such as CPU and memory usage rates, loads on the plant's Ethernet network, and event logs. To successfully shift from maintenance work based on the conventional failure response to preventive maintenance, it is essential to monitor this information and detect signs of abnormalities quickly. The MSS collects this status information, displays it on a dashboard, and manages it in an integrated manner. PHS for system assets uses the data to provide an alarm notification service via e-mail and a reporting service. Figure 3 outlines this service. When a variable being monitored deviates from the predetermined threshold, the e-mail notification service sends an e-mail to registered customers. This service enables them to immediately recognize abnormalities even when they are unable to check the dashboard. In addition, the information is shared with the managed service team, which works together with the customer to determine necessary actions. The managed service is described in other papers in this special issue.

In the reporting service, Yokogawa's service desk analyzes the trend of the information collected through the MSS and accumulates the results. By examining the information in depth, the service desk identifies risks that are not apparent from the real-time information alone, and helps the customer to draw up an optimal maintenance plan to mitigate these risks.

PHS for system assets can also work with the online diagnosis unit (ODU), a device for environmental diagnosis. This combination can collect environmental data via the MSS and diagnose them. Factors affecting the life of the system include temperature, humidity, corrosive gases, and dust. These data can be incorporated into the reporting and e-mail notification services.

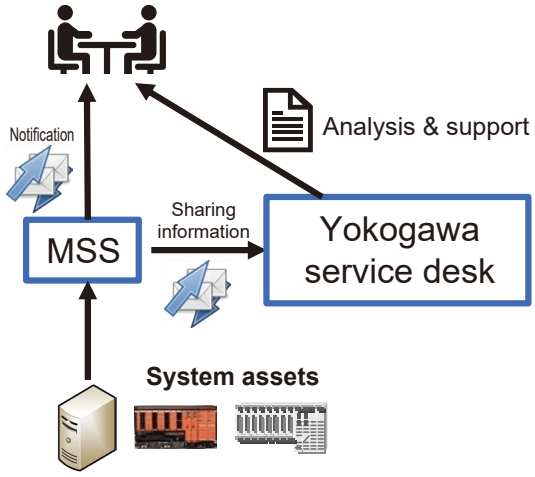

Figure 3 Overview of PHS for system assets

The remote functions of the MSS will also help provide the following services.

■ Alarm & Event (A&E) causality analysis

Various efforts are under way to make plant operations more efficient with fewer personnel. To do this, it is indispensable to streamline alarms that are issued by the system. If a large number of non-urgent alarms are left unattended, critical alarms may be missed. In addition to quantitative analysis, A&E causality analysis extracts priority alarms requiring attention by using machine learning to analyze causal relationships among alarms and examine what action should be taken in response to alarms. This helps reduce the time required to handle non-urgent alarms and improve efficiency.

■ Procedure Analysis for SOP Optimization

Standard operating procedures used in the field are sometimes left in their original form, not updated even if they are no longer appropriate for the current situation. Such documents are not referred to, causing variations in work procedures among operators. The Procedure Analysis for SOP Optimization uses machine learning to visualize work procedures based on the collected DCS operation logs and identify differences between the procedure manuals and actual operations, as well as variations among operators. Based on the results, we hold workshops with customers to determine optimal operations and standardize and optimize procedure manuals.

■ Comparative Effective Analysis

Comparative analysis can identify issues to be improved in operations. This method compares the operation in a customer's plant with that in plants in the same industry or other plants using the same system. The Comparative Effective Analysis automatically collects and calculates the effectiveness index, which indicates how effectively the industrial automation (IA) system is used, and compares it with the values of other plants. Based on the results, we make proposals to achieve optimal plant operations.

PLANT HEALTHCARE SERVICE FOR FIELD ASSETS

Sensors conforming to HART, FOUNDATION Fieldbus, and other communication protocols can transmit not only process values but also status information such as self-diagnosis and process diagnosis. Although such information is often dealt with as of low importance, it is crucial to monitor its trend to prevent critical troubles. Unlike process information, however, it is not easy to handle status information for maintenance purposes; it is difficult to secure dedicated personnel and establish a daily workflow for dealing with this information. PHS for field assets collects the status data from sensors and positioners as health information and displays it on a dashboard or delivers it to the customer as a report. In addition, this service works together with customers to identify the causes of problems, devise countermeasures, and improve maintenance work. Figure 4 shows the flow of this service.

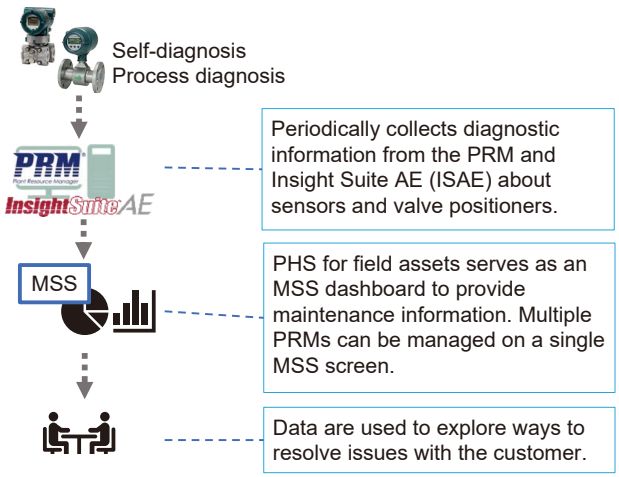

Figure 4 Flow of PHS for field assets

In this service, alarm monitoring focuses on newly generated status errors. However, most devices show some kind of status error just after the start of operation. Therefore, it is difficult for many customers to identify new and meaningful ones from among a large number of status errors. Detailed analysis has shown that most status errors are related to misconfiguration such as wrong range settings or unconfigured backup sensors. To effectively use status errors for maintenance work, it is necessary to exclude misconfiguration and other non-urgent errors at the time of introducing the service. PHS for field assets uses the NAMUR signal classification to report status errors to the customer in four categories: Failure, Out of Specification, Maintenance Required, and Check Function. Apart from failures, which require immediate action, we recommend focusing on status errors in the category of "Out of Specification."

The report to the customer describes not only status information but also an analysis of the cause, risk, and corrective action for the status error. To monitor device status

in detail, the collection of status information should be set to a shorter cycle. However, devices usually use the same bus for both operation and maintenance, so an increase in the traffic in this bus must be avoided. Therefore, we interview the customer to narrow down the list of facilities with high priority and those that have been in use for many years, and then suggest putting priority on these critical facilities.

Yokogawa has long worked closely with customers and worked hard to find optimal solutions based on its decades of experience in managing field devices. PHS for field assets leverages the experience gained in the Asset Performance Report (APR), a predecessor service. The following are two usage cases of the APR.

Case 1: Identifying device status through the frequency of alarms

At a customer's site, maintenance personnel used plant asset management (PAM) to check the status of field devices once a day. When combined with the process information, this method effectively detects permanent errors. Although the PAM judged that a certain device was normal, the APR reported that it frequently switched between normal and abnormal states, and a routine maintenance confirmed that its sensor unit had deteriorated. Since the APR's report showed not only the status of the device but also the frequency of alarms, the customer was able to quickly respond to the deterioration before it resulted in failure. Figure 5 shows an excerpt from the actual report.

Worst Device Ranking

Comm. Type	Vendor	Model	Rate (%)	Frequency	Latest Status
HART	BROOKS_INSTRUMENT	38XXVA	100.0	1	01 Jan 2018
HART	Fisher Controls	DVC6000	100.0	1	01 Jan 2018
HART	Manufacture_252	Device_239	99.3	40	24 Jul 2018
HART	MAGNETROL	MODEL_705_3X	[illegible]	4	02 Mar 2018
HART	Fisher Controls	DLC3010	58.8	1	13 Apr 2018
HART	MAGNETROL	MODEL_705_3X	30.6	1	17 Mar 2018
HART	Rosemount Inc.	5300	22.4	39	29 Jul 2018

This value shows the number of alarms issued during the analysis period.

Figure 5 Excerpt from the actual report

Case 2: Identifying only valves that need maintenance

Overhaul of valves is expensive and time-consuming. A customer chose the APR to monitor the condition and evaluate the need for maintenance. The APR helped the customer to identify only those valves that needed an overhaul, greatly reducing the time and cost. Figure 6 shows an example of an on-site valve.

Figure 6 Example of a valve installed in the site

PROSPECTS FOR PLANT HEALTHCARE SERVICE

We will increase the variety of dashboards for the MSS that can monitor equipment status in real time. We also build, maintain, and operate processes so that the OpreX Managed Service delivery team can respond quickly. While accumulating know-how in this service, we would like to build an organizational structure so that customers feel secure in outsourcing their maintenance work to Yokogawa.

REFERENCES

(1) ANSI/ISA-99.00.01-2007, Security for Industrial Automation and Control Systems Part 1: Terminology, Concepts, and Models, ISA, 2007, pp. 69-73