# IoT Platform-driven Maintenance Digitalization

The maintenance industry has so far worked on increasing its business efficiency by using highly experienced workers to select replacement parts and review maintenance schedules. However advances in digital technologies now make it possible to detect different anomalies than usual by capturing machine status as physical data and applying data mining technology. Hitachi has used these digital technologies to create a maintenance service platform. The platform serves as a tool that allows Hitachi to work with customers to collaboratively create more advanced maintenance services and solutions that solve customers' problems. This article provides an overview of the technologies that support the maintenance service platform, and of Hitachi's future work on predictive diagnostics.

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## 1. Introduction

Responding to the changing needs of its customers, Japan's manufacturing industry has evolved from providing high-quality products to providing high added-value services and solutions. But in a survey looking at the individual fields of design and development, production, sales, and after-sales services, the Ministry of Economy, Trade and Industry reports that the extent of utilization of technologies such as the Internet of Things (IoT) is not as prevalent in after-sales services (such as predictive maintenance) as efforts toward visualization of production processes(1).

Hitachi is positioning predictive maintenance (PdM) as the solution core of its IoT platform, Lumada. Using information technology (IT) and operational technology (OT), PdM provides effective solutions that use data to create value in a variety of industries.

This article presents the Hitachi service platform that is driving the creation of more advanced maintenance services centered around Hitachi Power Solutions Co., Ltd.'s predictive diagnostics system and recognized as one of Lumada's PdM solution cores. This service platform prevents unplanned shutdowns and helps ensure stable equipment operation by collecting customer equipment sensor information in real time, predicting equipment failures, and providing remote maintenance assistance (see **Figure 1**).

## 2. Maintenance Service Trends and Challenges

Maintenance services include corrective maintenance, which is done to repair broken equipment, and preventive maintenance, which is done to prevent equipment from breaking down. Until recently, preventive maintenance in the form of regular maintenance done to periodically maintain equipment regardless of whether problems exist has been the most common

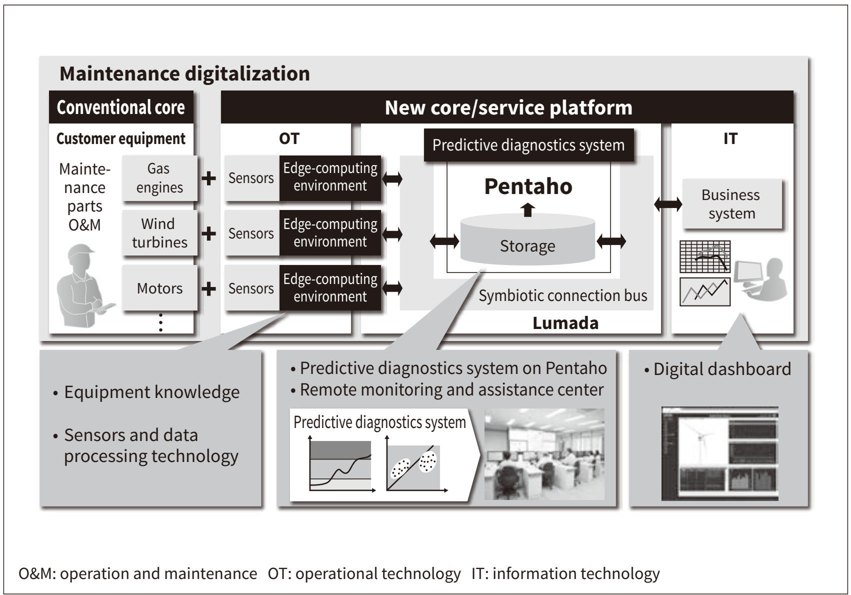



**Figure 1 — Service Platform**

The platform is designed to link OT and IT to overcome customer challenges.

form of maintenance. However today's customers are now calling for predictive maintenance that detects and handles changes in equipment status. There is also a demand for services that ensure stable equipment operation, since unplanned equipment shutdowns can have major impacts on both the customer's business and society. Ensuring stable operation requires equipment maintenance and conservation, and quality control.

### 2. 1 Equipment Maintenance and Conservation Challenges

Equipment maintenance and conservation faces the following challenges:

(1) Insufficient understanding of equipment status

Users continue operating equipment while unaware that failures have occurred, increasing the extent of their impact. Maintenance costs increase for reasons such as unexpected shutdowns caused by failures and inadequate adjustments overlooked during periodic maintenance, and costs for defective work arise that affect management indicators.

(2) Insufficient use of sensor information

The machine and equipment sensor information that has been collected until now has been used mainly for increasing productivity, and has not been used sufficiently for maintenance and conservation. Users do not know how to analyze the collected data, which prevents them from using it effectively. Analysis work is done manually, making it labor-intensive for workers.

(3) Difficulty of passing on skills

Experienced operators at manufacturing sites follow written procedures to perform the equipment inspections that they are responsible for, but many of their methods rely on experience. A lack of methods and time set aside for providing guidance to others also prevents the skills and experience of experienced workers from being passed on to the next generation.

### 2. 2 Quality Control Challenges

Quality control faces the following challenges:

(1) Accuracy of traceability

It is difficult to set control points to enable the traceability of products that are manufactured using a series of processes, and it is difficult to correlate the information that can be obtained from equipment with quality. The difficulty of understanding data analysis and a lack of standard approaches also create a low return on investment.

(2) Variations in quality of inspection equipment

It is difficult to make an evaluation when the inspection results are affected by equipment-specific variations, or when the evaluation needs to eliminate the effects of inspection equipment configuration status or the effects of differences in cumulative inspection counts.

(3) Variations in quality of inspector judgments

Accurate judgments and quantification are difficult to achieve since some anomaly evaluations rely on the skills and experience of the individual, and since extensive experience is needed to gain thorough familiarity with inspection items that span a wide range of areas.

### 2. 3 Solutions to Issues and Expected Benefits

The use of a service platform could be one approach to overcoming the challenges above—instead of just creating systems to solve challenges related to equipment and quality, these challenges need to be overcome using maintenance service solutions that are tailored to individual needs. This approach could yield benefits such as reducing maintenance costs, reducing defective work costs, avoiding major accidents, ensuring quality, and reducing loss costs.

## 3. Service Platform Concept

### 3. 1 Overview

Hitachi's service platform enables better solutions to be provided in a timely manner by creating templates of solutions driven by Hitachi's accumulated OT and expertise, and adding new solutions.

### 3. 2 Core Technologies Supporting the Service Platform

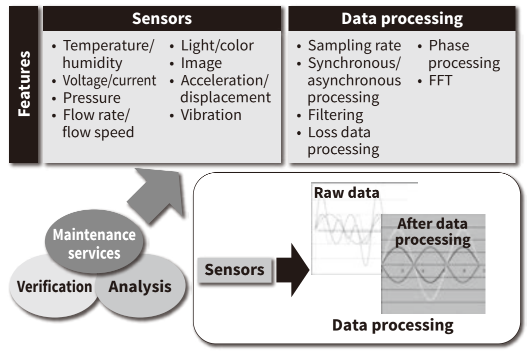
The technologies and tools that support the service platform are summarized below.

(1) Sensing and data processing

For customers with data collection or data processing issues resulting from their limited expertise in selecting or attaching sensors for given objectives or their limited experience in data cleansing and filtering, sensors are selected after first clearly defining the types of processes to be measured, the purposes of measuring them, and the environmental conditions (see **Figure 2**).

**Figure 2 — Overview of Sensors and Data Processing**

The figure lists the types of sensors and data processing supported by Hitachi's service platform.




FFT: Fast Fourier transform

(2) Predictive diagnostics system

For customers who want to prevent unplanned production equipment shutdowns or who want to pass on experienced operator skills or maintenance expertise, sensors are mounted in machinery and equipment, and the equipment sensor information (operation data) provided by the sensors is collected automatically. Hitachi's predictive diagnostics system uses data mining technology to provide early detection of changes in the collected data (see **Figure 3**).

The predictive diagnostics system applies machine learning to normal (same as usual) data, and evaluates whether anomalies are present by using the degree of deviation between the collected sensor information and the learned data. If the deviation between the normal data and the sensor information is above a preset value, the system evaluates the sensor information as anomalous. If an anomaly is detected, the sensors that affect the deviation the most are displayed on-screen to help pinpoint the cause of the failure and to determine its degree of urgency.

(3) Edge-computing environment

Implementing big data-driven PdM requires adapting to various environments such as environments that do not permit use of the cloud or that do not connect to the outside for reasons of heightened security. The predictive diagnostics system is designed to overcome these challenges and differentiate itself from cloud services. By installing devices that enable information processing on the customer's machinery and equipment, it provides an edge-computing environment that can perform a set range of information processing, and feed back the results to users, without

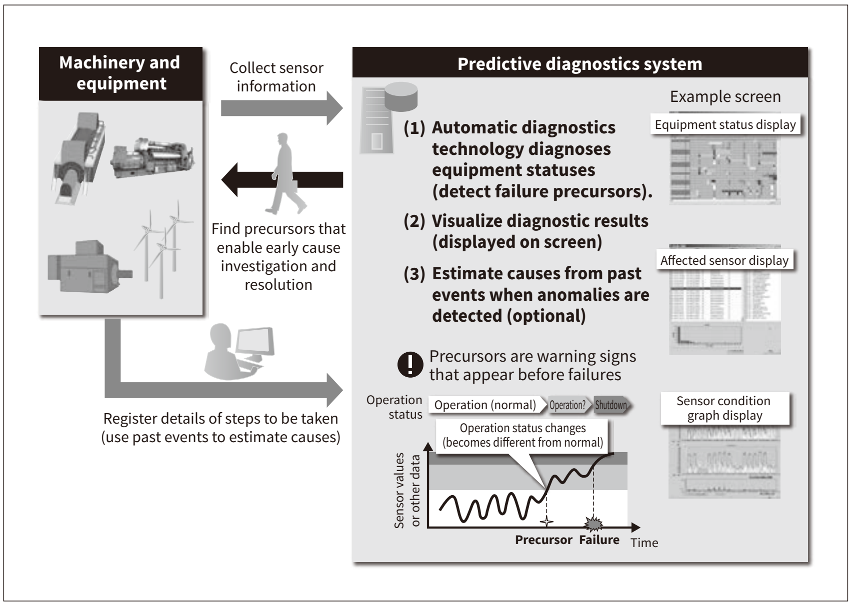



**Figure 3 — Overview of Predictive Diagnostics System**

Using sensor-measured operation data and automatic diagnostics technology, the system diagnoses equipment statuses and displays the results on a screen.

allowing the information to leave the system. This brings the speed of predictive diagnostics closer to real time, thereby meeting the needs of customers who do not want data to leave the system.

The edge-computing environment uses an off-the-shelf gateway device and comes with input functions supporting standard external interfaces [such as extensible markup language (XML) communication, Modbus* communication, supervisory control and data acquisition (SCADA) access, and file transfer]. It also has output process functions such as file transfer, database access, and email output (see **Figure 4**).

(4) Predictive diagnostics system on Pentaho

Some of the challenges facing predictive diagnostics when using big data include the extensive amount of time spent on data format integration and other types of preprocessing performed by data analysts, and the difficulty of operations for users who are not expert system engineers. Hitachi has addressed these challenges by combining predictive diagnostics system with Pentaho to enable program-free data preprocessing. Pentaho is a software product with a rich lineup of modules for data processing, and very easy-to-operate graphical user interface (GUI) functions. The GUI functions make it easy to perform analysis and evaluation repeatedly.

*Modbus is a registered trademark of Schneider Automation Inc.

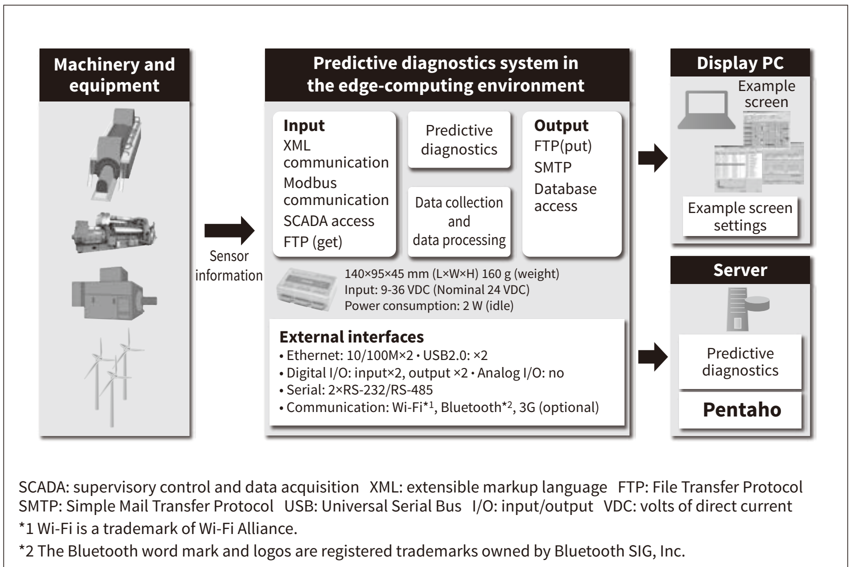



**Figure 4 — Overview of Predictive Diagnostics System in the Edge-computing Environment**

The figure shows the input and output formats of the predictive diagnostics system in the edge-computing environment.

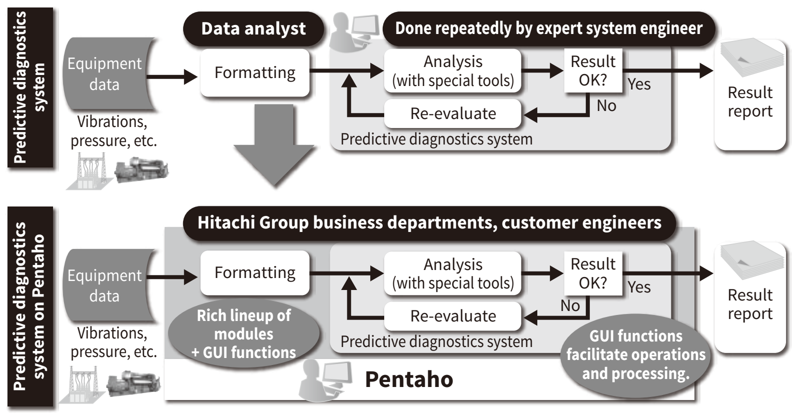



**Figure 5 — Overview of Predictive Diagnostics System on Pentaho**

The figure illustrates the use of the predictive diagnostics system on Pentaho.

Combining this system with Pentaho lets customers easily provide environments for operating predictive diagnostics systems. The customer's engineers creating the environments do not need to be domain engineers who are knowledgeable about the equipment to be diagnosed (see **Figure 5**).

(5) Digital dashboard

A key requirement for the GUI is to provide information screens that are optimally tailored to the goals of each user, ranging from managers to on-site service technicians. The digital dashboard uses centralized management technology to manage the operating conditions of equipment used in different industries, or devices made by different manufacturers. Using web push communication, it provides screens that can refresh device data in real time. The digital dashboard can also display analysis information for various device statuses along with weather information or other external information obtainable from the Internet. This ability enables evaluations from multiple perspectives.

## 4. Example Application of Maintenance Service Digital Solutions

Gas engine maintenance services are being updated from conventional modem-based data collection methods to Internet-based configurations. Specifically, by connecting a programmable logic controller (PLC) to the predictive diagnostics system in the edge-computing environment, the loading cycle for collected data can be increased from once every 30 s to once every 1 s. This faster cycle enables acquisition of more precise sensor values that can be used in applications such as alarm message analysis.

In the future, Hitachi will consider using the Message Queuing Telemetry Transport (MQTT) protocol (which is well adapted to IoT data transfer) to study how the predictive diagnostics system can be used for applications such as operation assistance done by remote operations.

## 5. Future Concept of Predictive Diagnostics Services

The core predictive diagnostics service product lineup consists of three packages of the predictive diagnostics system, one equipped with vector quantization clustering (VQC) and a local subspace classifier (LSC) analysis engine; one that runs in the edge-computing environment for on-site predictive diagnostics; and one that runs on Pentaho with enhanced GUI functions for analysis operators. There will be an additional cause estimation function designed to rapidly pinpoint causes by linking information collected as big data to history information about steps taken to resolve maintenance issues. When an anomaly is detected, this function is designed to help the user determine what type of failure may have occurred. It can create links to past events to show similar failures and the steps taken to resolve them.

In the future, it will become more important to shorten the proof-of-concept cycle for predictive diagnostics services to enable them to be developed and provided more efficiently. Hitachi is studying functions driven by technologies such as artificial intelligence for this reason. These functions will enable solutions that are co-created with customers to be reused as proprietary expertise, and will lead to the development of new service lineups that provide methods of handling equipment problems when they occur.

## 6. Conclusions

Collecting sensor information from customer equipment and devices, and effectively presenting the analysis results are key requirements for overcoming the challenges that customers face. Hitachi Power Solutions has created a service platform concept to provide the tools needed to perform these tasks. More than just a set of IT tools, this platform provides a base on which to create solutions that benefit the customer by creating links to OT.

In the future, Hitachi will work on making Lumada use cases from the solutions created on the platform. By rapidly providing solutions to customer challenges in this way, Hitachi will continue to provide highly precise diagnostics for customer equipment, helping to ensure efficient and cost-effective maintenance.

### References

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