Smart Maintenance System for Railway Operators

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Abstract

In recent years, railway operators have been working to improve the efficiency of maintenance work for their traction substations and other facilities by using Information and Communication Technology (ICT) to implement Condition-Based Maintenance (CBM) and reduce the labor required for walk-around inspections.

To meet this demand, we have developed a smart maintenance system that uses our IoT controller.

In addition to measurement data from on-site equipment, this system has the ability to collect and store data in real time, such as temperature and humidity, from sensors attached to the equipment, meter values analyzed from images of the equipment meters, and then transmit these data to an upstream system.

1 Preface

Railway operators need to operate their traction substations and other equipment stably without stopping them, so they need preventive maintenance to deal with accidents before they happen, rather than reactive maintenance, which is done after an accident occurs.

In addition, there is a demand for efficient preventive maintenance of railway facilities due to a lack of successors to field-service engineers caused by the declining birthrate and aging population. As an efficient method of preventive maintenance of equipment, Condition-Based Maintenance (CBM) is beginning to be used. CBM monitors the status of equipment in real time and predicts abnormalities due to equipment aging. In addition to Time-Based Maintenance (TBM) is also conducted and periodically performs visual inspections and part replacement.

In recent years, advances in sensing technology and Information and Communication Technology (ICT) have made it possible to obtain low-cost sensors that can acquire various data (e.g., temperature, humidity, vibration, and acceleration) that is required for real-time monitoring of the facility status.

We have developed a smart safety system that collects and stores equipment measurement information and sensor information using a data collection panel equipped with our IoT controller and transmits it to an upstream system. This paper introduces the smart maintenance system we developed for railway operators.

2 System Configuration

The smart maintenance system is composed of a data collection panel that transmits measurement data collected from on-site devices such as sensors. The panel sends data to an upstream system. Fig. 1 shows an example of the system configuration. The interface with the upstream system conforms to ETHERNET transmission (IEC 60870, HTTP). The interface with the downstream system conforms to HLS (Hi-speed Link System) transmission and ETHERNET transmission (Modbus/TCP).

3 Upstream Data Transmission Function

The upstream data transmission function of the smart safety system uses the IEC 60870 protocol to transmit equipment measured information and sensor information collected on the data collection panel to an upstream system.

It also has a web server function, so the collected data can be viewed on a connected PC using a web browser on the Human Machine Interface (HMI). Fig. 2 shows the data viewing screen.

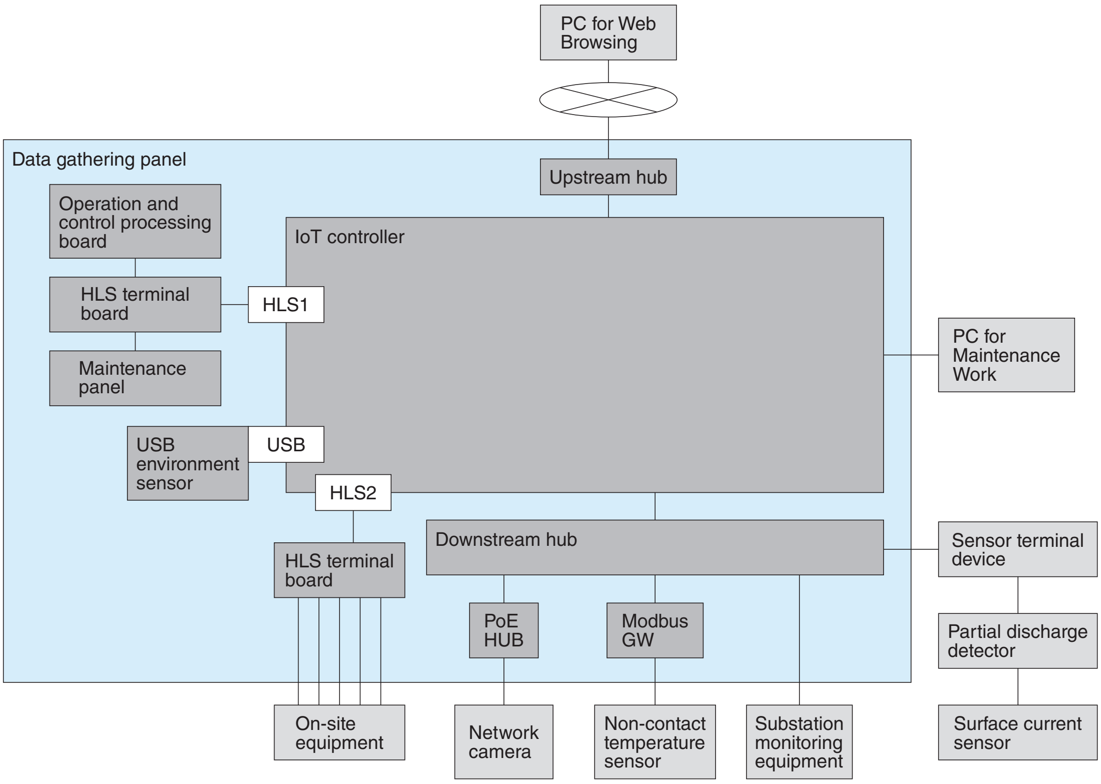

Fig. 1 Example of System Configuration

An example of system configuration of the smart maintenance system is shown.

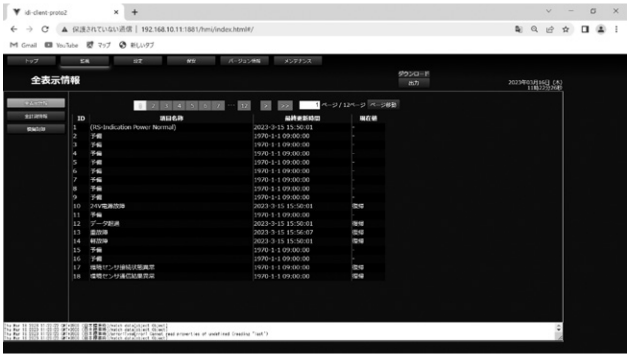

Fig. 2 Data Viewing Screen

This shows a data viewing screen of the data collected by the data collection panel.

Table 1 Types of HLS Transmission Data and Maximum Number

This shows the outline of I/O data via HLS transmission by the data collection panel.

Data types	Maximum number of data
Analog input	96 Quantity
Pulse input	16 points
Digital input	64 points
Digital output	16 points

4 Downstream Data Collection Function

The downstream data collection function of the smart maintenance system realizes data input and output by HLS streaming protocol. Table 1 shows the types and maximum number of data that can be input and output by HLS streaming protocol.

In addition, measurement data can be obtained from various measuring devices connected by ETHERNET using the Modbus/TCP protocol. Table 2 shows the devices that can be connected and their general information.

Of these devices, the sensor terminal device also performs the same sensor terminal function inside the IoT controller. This performance was made available by using container virtualization technology by Docker. The sensor terminal function is virtualized at the OS level. Therefore, even if the IoT controller is alone without connecting the sensor terminal device, it is possible to obtain meter values analyzed from meter images taken by a network camera and measurement data of USB environmental sensors. Fig. 3 shows the Docker containerization (container virtualization) of the sensor terminal device.

Table 2 Devices that can be Connected via ETHERNET

This shows an overview of the devices that the data collection panel can connect to via ETHERNET.

Devices	General Information
Network camera	Images of the photographed meters are acquired.
Sensor terminal equipment	The meter values are read based on the meter images photographed by the connected cameras. Data of temperatures and humidity from the connected environment sensors are measured.
Partial discharge detector	With the use of the connected surface current sensor, partial discharge is detected, that is a premonitory phenomenon of insulation breakdown.
Substation monitoring equipment	Various sensor data about substation equipment like transformers, switchgears, and high-tension panels are monitored and gathered.
Non-contact type temperature sensor	Infrared thermometer capable of wide-range measurement.
Temperature and humidity transmitter	Capacitance type humidity sensor and platinum resistance type temperature sensor are adopted.

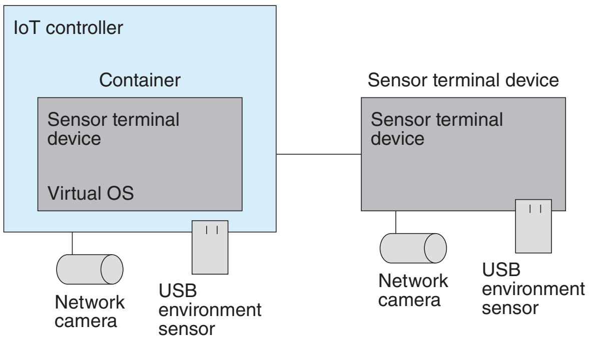

Fig. 3 Docker Containerization of Sensor Terminal Device

The IoT controller is provided with a function equivalent to that of sensor terminal device.

5 Data Storage and Recording Function

Fig. 4 shows the IoT controller. The smart maintenance system stores data collected from downstream devices on a CFast card inserted in the IoT controller. This allows the stored data to be transmitted to the upstream system after recovery, even if the collected data cannot be transmitted to the upstream system due to a communication error or other reason.

In addition, log data such as processing errors and communication records in the smart maintenance system are also recorded on the CFast card, so they can be retrieved and investigated when a failure occurs.

The smart maintenance system can store collected data and log data for up to about 10 days.

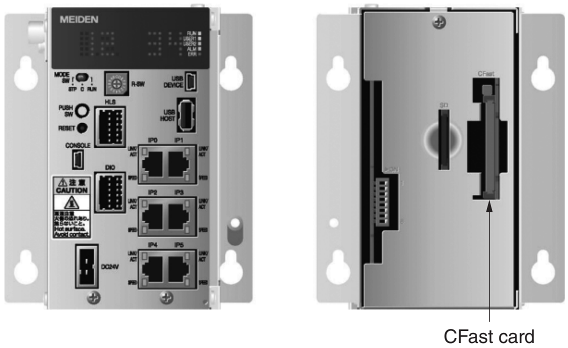

Fig. 4 IoT Controller

A CFast card can be inserted into the IoT controller.

6 Abnormality Prediction Function

The smart maintenance system generates an alarm when the ON/OFF value of any digital input item changes.

In addition, upper and lower limits can be set for any analog input item, and an alarm is generated when the input value exceeds this range.

By setting such alarms for data obtained from sensors installed in field equipment, it is expected that abnormalities can be predicted quickly.

7 Postscript

We introduced the smart maintenance system we are working on for railway operators. Using a data collection panel equipped with our IoT controller, we were able to collect and store the measured data required for preventive maintenance from a variety of sensors and other devices.

In the future, we intend to apply this technology to develop products that can monitor the status of railway operators' facilities in real time, thereby helping to reduce maintenance costs.

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