IoT-compatible Equipment and Business Development for the Industrial Sector

In the manufacturing industry around the world, industrial equipment is being made IoT-compatible in a move toward the realization of smart factories that utilize massive amounts of data. Hitachi Industrial Equipment Systems Co., Ltd. provides two industrial IoT solutions that collect and utilize data based on the company's long experience in supplying products to the industrial sector. The first of these is a lifecycle management service that optimizes the operation and maintenance of facilities and equipment. A service that can monitor the status of equipment through the cloud was launched. The other is a programmable automation controller system that optimizes the operational control of production systems, and provision of the HX Series Industrial Controllers for IoT Applications that forms the core has commenced. The HX Series has been applied to the Hitachi Industrial Equipment Systems inverter production line and is accumulating know-how on productivity improvement activities. Moving forward, Hitachi will link information between these two industrial IoT solutions to contribute to further optimization.

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1. Introduction

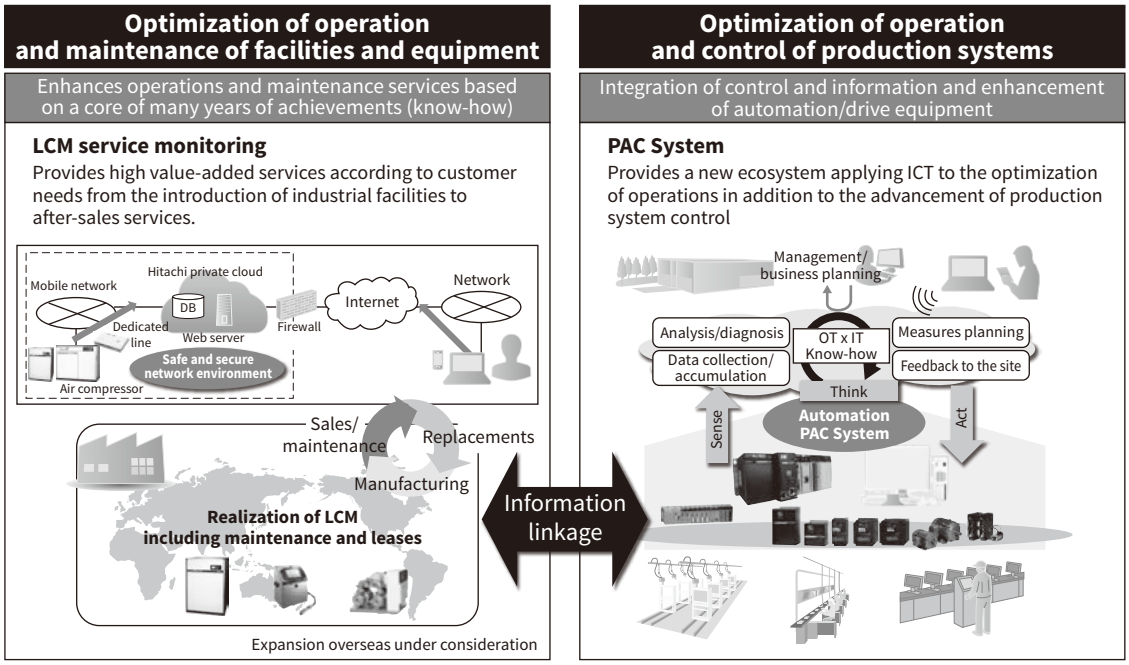
In recent years, the trend in the manufacturing industry has been to utilize huge amounts of data to realize smart factories. This is called the Industrial Internet in the USA and Industrie 4.0 in Germany. Both are aimed at realizing smart factories by collecting data from the sites and the external environment, and utilizing the data to perform optimization utilizing operational experience and knowledge.

Production systems and equipment in the manufacturing industry have become more advanced over the years through technological innovation. Production systems and equipment undergo advanced control according to large quantities of information, data and various field networks. Recently, information exchange between the supply chain, delivery chain, and factory has started, and the importance of data and information processing technology is increasing.

In one form of smart factory, a large number of business establishments and companies mutually interact to ultimately provide products and services. These business establishments and companies are connected to each other via a network. Furthermore, connecting suppliers, factories, logistics, and consumers to this network would enable real-time information sharing,

Figure 1 — Industrial IoT Solution by Hitachi Industrial Equipment Systems

Hitachi Industrial Equipment Systems will work on the realization of smart factories via two approaches: optimization of operation and maintenance of facilities and equipment, and optimization of operation and control of production systems.



DB: database ICT: information and communication technology IoT: Internet of Things IT: information technology LCM: lifecycle management OT: operational technology PAC: programmable automation controller

the creation of data on human work and know-how, and the accumulation and application of know-how and knowledge. As a result, a wide range of decisions can be made quickly in real time in the manufacturing process and manufacturing can be visualized from individual processes to overall production. Based on this, quality and troubleshooting capabilities are expected to improve, and furthermore, the benefit of being able to accumulate human-dependent know-how as data is expected through utilizing innovative information and communication technology (ICT) (see **Figure 1**).

2. Industrial IoT Solutions of Hitachi Industrial Equipment Systems

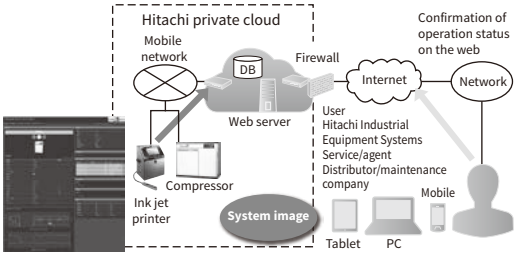
Hitachi Industrial Equipment Systems Co., Ltd. has supplied products to the industrial sector for many years. Based on these achievements, the company has launched initiatives on industrial Internet of Things (IoT) solutions that collect and utilize data and feed back the results in order to respond to expectations for smart factories.

Based on the concept of "can connect, can be connected," Hitachi Industrial Equipment Systems products contribute to the realization of smart factories through manufactured items and services.

Specifically, a lifecycle management (LCM) service and programmable automation controller (PAC) system are introduced below as two industrial IoT solutions that Hitachi Industrial Equipment Systems is working on.

Figure 2 — IoT Cloud Monitoring Service in the LCM Service

An outline of the monitoring system configuration is shown. This aggregates equipment information on the cloud and makes it available for viewing on the web. This strengthens links between customers and maintenance service networks, leading to the provision of added value.



PC: personal computer

The LCM service strengthens operations and maintenance services based on a core of many years of achievements (know-how) with the aim of optimizing the operation and maintenance of facilities and equipment (see **Figure 2**). An IoT cloud monitoring service is applied to enhance the LCM service. The concept of the LCM service is to provide high value-added services according to customer needs from the introduction of industrial facilities to after-sales services.

The PAC system integrates control and information to enhance automation and drive equipment in order to optimize the operation and control of production systems. Various solutions cultivated over the years are applied for this purpose. The concept of the PAC system is to provide a system that applies ICT to the optimization of operations as well as the advancement of production system control.

Hitachi will mutually link these two IoT solutions to contribute to further optimization.

2. 1
LCM Service

This section describes the LCM service and IoT cloud monitoring service for equipment at industrial facilities.

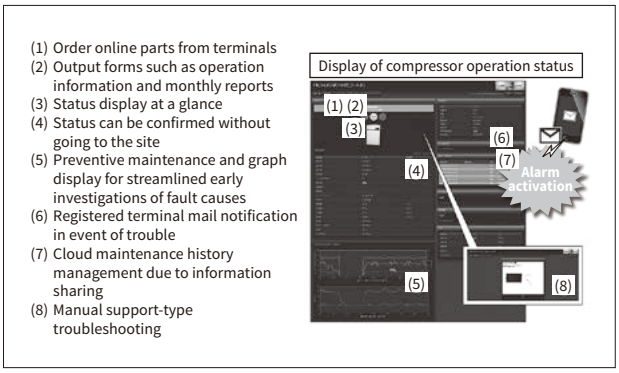
The Hitachi Industrial Equipment Group has a full-service network. Using this, the LCM service supports "safe, secure, and stable operations" according to the customer's needs from introduction of equipment to after-sales service, and provides high added-value through things such as labor reduction, simplification, efficiency, and optimization.

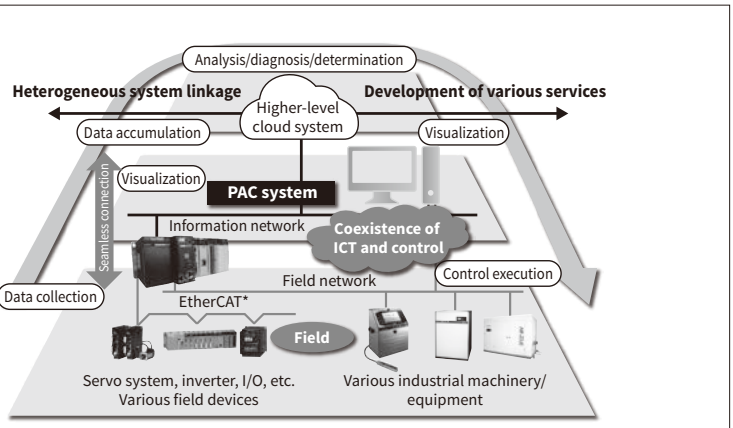
To realize this LCM service, Hitachi Industrial Equipment Systems launched an IoT cloud monitoring service.

Air compressors are one of Hitachi Industrial Equipment Systems' main product lines. For example, the application of the IoT cloud monitoring service to the LCM service of these air compressors contributes to the realization of one-stop maintenance by enhanced coordination with the maintenance services of retailers and dealers. Data such as discharge temperature, current value, and power consumption are gathered in the cloud from the air compressor using a mobile network, and the data can be monitored on a dedicated screen (see **Figure 1**).

Figure 3 shows the monitoring screen of an air compressor. Operation data and graph displays, inspection and fault histories, troubleshooting guides, and other information are prepared so that the operating state of the air compressor can be seen at a glance. In addition

Figure 3 — Example of Monitoring Service Screen and Report
In addition to confirming operation data, inspection histories, and other information, it is also possible to output operation reports.





I/O: input/output
*EtherCAT is a registered trademark of and licensed by Beckhoff Automation GmbH.

Figure 4 — Conceptual Diagram of PAC System
The PAC system is positioned between the production system and the higher-level system, enabling a seamless connection between the systems. Therefore, an environment can be quickly constructed for data collection, analysis, determination, and so forth.

to the monitoring screen, operation reports and the like are also submitted.

2. 2
PAC System

Next, this section introduces the PAC system, which optimizes the operation and control of production systems. The system realizes manufacturing and service innovation through application of the IoT. A conceptual diagram of the PAC system is shown in **Figure 4**.

At the production site, automation and drive equipment controls the machinery and equipment that constitute the production system. The PAC system focuses on the data and control content handled by the automation/drive equipment, and seamlessly connects the production system to the higher-level systems in the factory or the cloud system.

The features of the PAC system are that it enables the production system control and ICT to coexist, and that it simplifies connection with the host system, which was problematic with conventional systems from an information systems perspective.

These features make it possible to quickly construct an environment for the collection of data and visualization of the production site; the accumulation of data in higher-level systems; the analysis, diagnosis, determination, and visualization of the data; and the execution of control based on the analysis results. This enables flexible modifications thereafter.

The accumulated data in the higher system can be linked with heterogeneous systems and developed into various services.

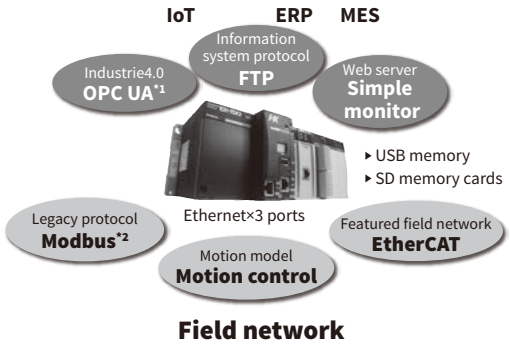
3. Industrial Controllers for IOT Applications HX Series

This section introduces the Industrial Controllers for IoT Applications HX Series, which were developed as the core controllers of the PAC system.

3. 1
PAC System

The main point regarding IoT-compliant communications is the enhancement of communication functions and open access. **Figure 5** shows a diagram of this.

Figure 5 — Feature Functions of the HX Series
The HX Series is compatible with many communication methods and saves space by integration of control and communication functions.



ERP: enterprise resources planning FTP: File Transfer Protocol
MES: manufacturing execution system OPC UA: Object Linking and Embedding (OLE) for Process Control Unified Architecture USB: Universal Serial Bus
SD: Secure Digital
*1 OPC UA is a registered trademark of OPC Foundation.
*2 Modbus is a registered trademark of Schneider Electric USA, Inc.

This includes Object Linking and Embedding (OLE) for Process Control Unified Architecture (OPC UA), File Transfer Protocol (FTP) servers, and simple monitor functions, all of which support ease of connection with the production system from an information systems perspective, as well as Modbus support, which has been used for many years on site, the recently popular EtherCAT support, and motion control that operates above it.

In addition, the HX Series is equipped with Universal Serial Bus (USB) memory, Secure Digital (SD) memory, and three Ethernet ports, integrating control and communication functions and achieving space savings.

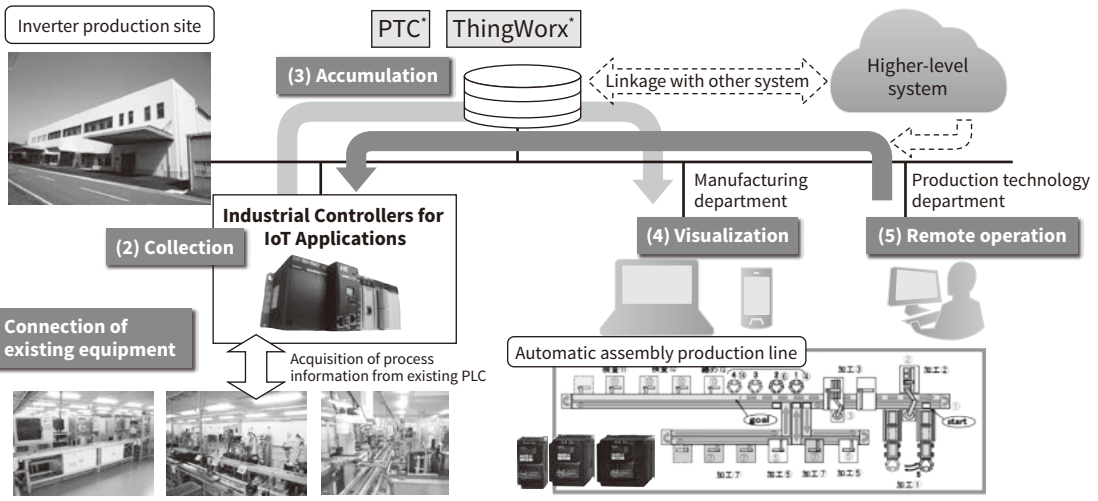
3. 2
Application Examples for the HX Series Production System

Hitachi has applied the HX Series to one of its production lines and used information system functions to commence trials of IoT solutions that support production improvement activities.

The HX Series was applied to a Hitachi inverter production line, continual improvement processes were established, and support for continuous productivity improvement activities and accumulation of know-how is being promoted (see **Figure 6**).

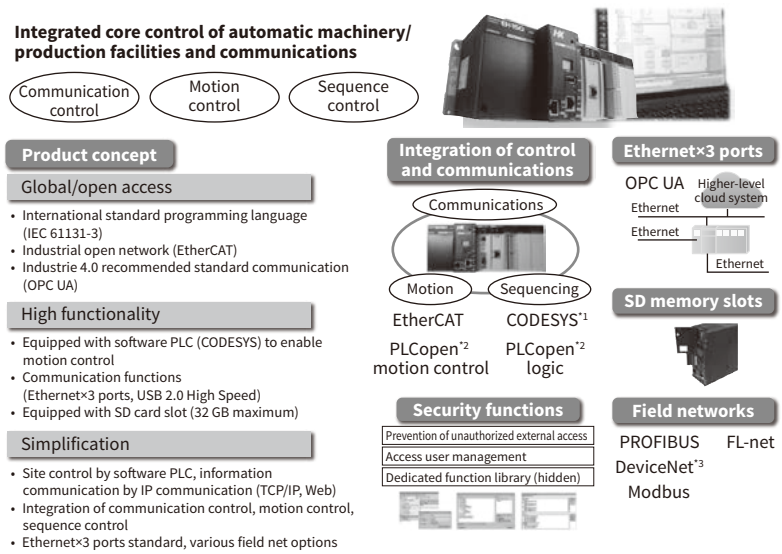
Figure 6 — Examples of Application to Production Lines

The HX Series was applied to a Hitachi inverter production line. Data acquired from the production facility were accumulated on a server. Using these data to visualize the operating status promotes improvement activities at the production site.



PLC: programmable logic controller
*PTC, ThingWorx are trademarks or registered trademarks of PTC Inc. or its subsidiaries in the U.S. and in other countries.

The HX Series is installed in an automated inverter production line that has been in operation since 2010. The process information is acquired from an existing programmable logic controller (PLC), and data are accumulated on ThingWorx by PTC on the factory-owned servers. By utilizing these data, the operating status was visualized on the computers or mobile devices of relevant persons in such a way that it could be understood at a glance. In addition, monitoring of the detailed status of the HX Series itself has been made possible along with remote operation of programs and setting changes from the office.



IEC: International Electrotechnical Commission IP: Internet Protocol TCP: Transmission Control Protocol
*1 CODESYS is a registered trademark of 3S-Smart Software Solutions GmbH.
*2 PLCopen is a registered trademark of PLCopen.
*3 DeviceNet is a trademark of ODVA, Inc.

Figure 7 — Concept and Features of the HX Series

The concept is open/global access, high-performance, and simplicity.

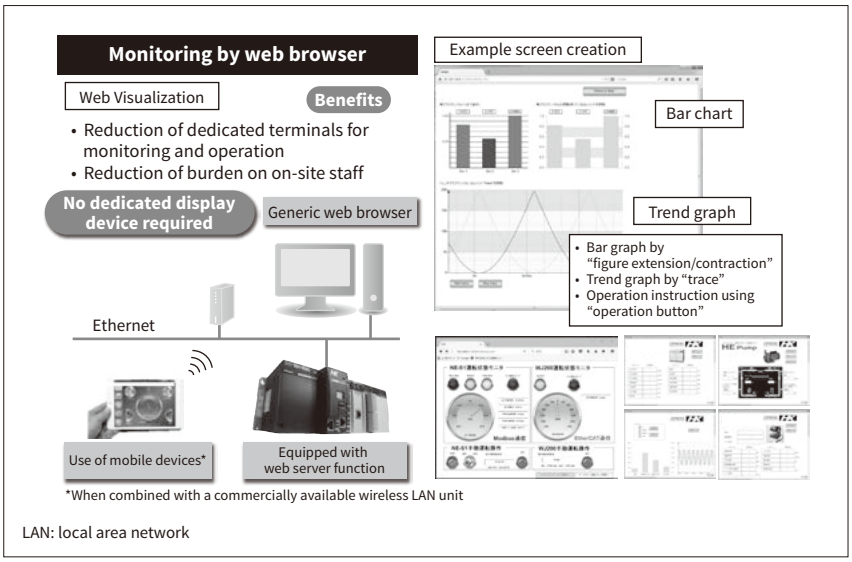


Figure 8 — Monitoring by Web Browser Function
Data in the HX Series can be displayed without using a dedicated display.

The period for adding and launching the HX Series was about two months without stoppage of work done at the factory. Thereafter, the system has been continually used through incorporation into ongoing daily improvement activities at the production site.

A feature of this system is that the existing PLC, which controls the whole production line, utilizes the control data, thereby making a small start toward productivity improvements. Moving forward, the HX Series will be applied to improvement activities for continuous production activities.

3. 3
Features of the HX Series

As shown in **Figure 7**, the HX Series units collect data in the information management field while conducting control in the industrial field. The units utilize the collected data and enable the seamless coordination of control based on the analysis results. As a new industrial controller that integrates core control and communications for automatic machinery and production facilities, the product integrates communication control, motion control, and sequence control based on the concept of global/open access, high-performance, and simplification.

Regarding global/open access, the HX Series has support for international standard programming languages, EtherCAT, and OPC UA communication. For high performance, the series is equipped with functions that enable motion control, communication control, support for SD cards, and so forth. Regarding simplification, the on-site control is made into a software PLC, information communication can be done through Internet Protocol (IP) communication, each control is integrated, and options for various field networks are also supported in addition to three independent Ethernet connections.

Furthermore, control security measures are implemented by means such as prevention of unauthorized access from the outside, management of user access, and hidden display functions for dedicated function libraries.

By way of a linking function with the information field, the HX Series has a function for data visualization. Conventionally, a dedicated display device such as a PLC is required to display data, but it has become possible to display graphs and control panel-like displays as shown in **Figure 8** in the browser of a handheld personal computer (PC) or mobile device. Concerning the pictures and variables to display in the HX Series, programming software is provided to enable visualization even without a dedicated display unit.

The series is equipped with OPC UA server functions for connection with a higher-level system.

OPC UA is a protocol that enables secure and reliable vendor-independent transmission from a sensor or site level to the manufacturing level, production planning, or enterprise resources planning system.

Conventionally, in the case of constructing a system using supervisory control and data acquisition (SCADA) or a manufacturing execution system (MES), communication software suitable for use

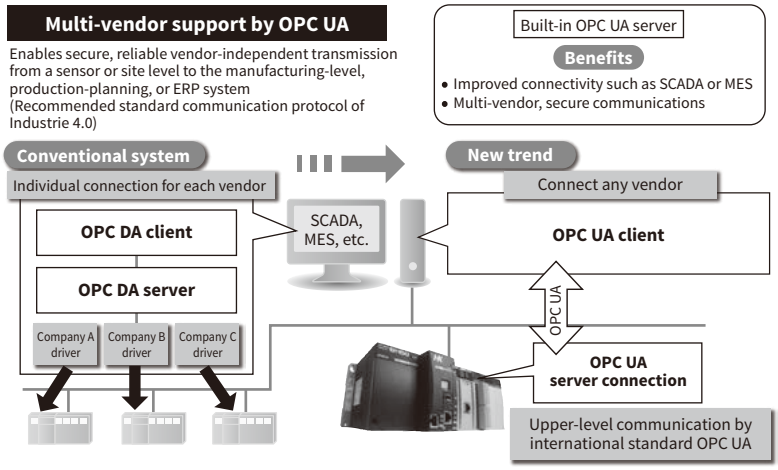


Figure 9 — Multi-vendor Support by OPC UA
The HX Series is equipped with OPC UA server functions for connection with higher-level systems. Enables vendor-independent data transmission when connecting with SCADA, MES, or ERP.

of the PLC was prepared, an OPC server was constructed on a PC or server, and SCADA or MES software was executed that carries out screen display and operation instructions.

SCADA, MES, and a controller supporting OPC UA eliminate disjointed communications by various companies and enable multi-vendor compatibility (see **Figure 9**).

The HX Series is equipped with functions that make it easier for information engineers to manage, and SD memory and FTP servers can be used in addition to visualization functions and OPC UA.

A file can be created in the SD memory by using a function block for turning the data in the HX Series into a file [e.g., a comma-separated value (CSV) file]. This file can be retrieved and read out by a PC (see **Figure 10**). It is also possible to retrieve and write files remotely by FTP operation.

At the Hitachi Industrial Equipment Systems production line introduced earlier, a CSV file was created from the data collected by the HX Series, the data were viewed using the visualization function, and the system was constructed while ascertaining the situation in detail. An engineer specializing in parallel information systems created a screen to confirm and display data on a desktop PC by FTP operation.

Next, the control programming of the HX series is described (see **Figure 11**). The HX Series employs

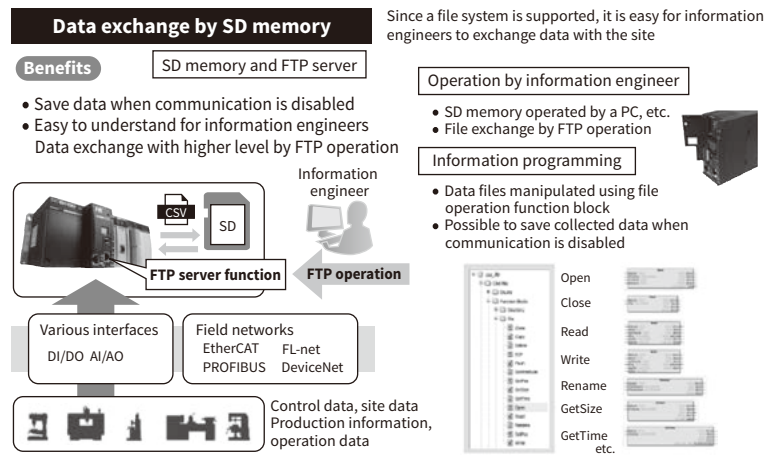
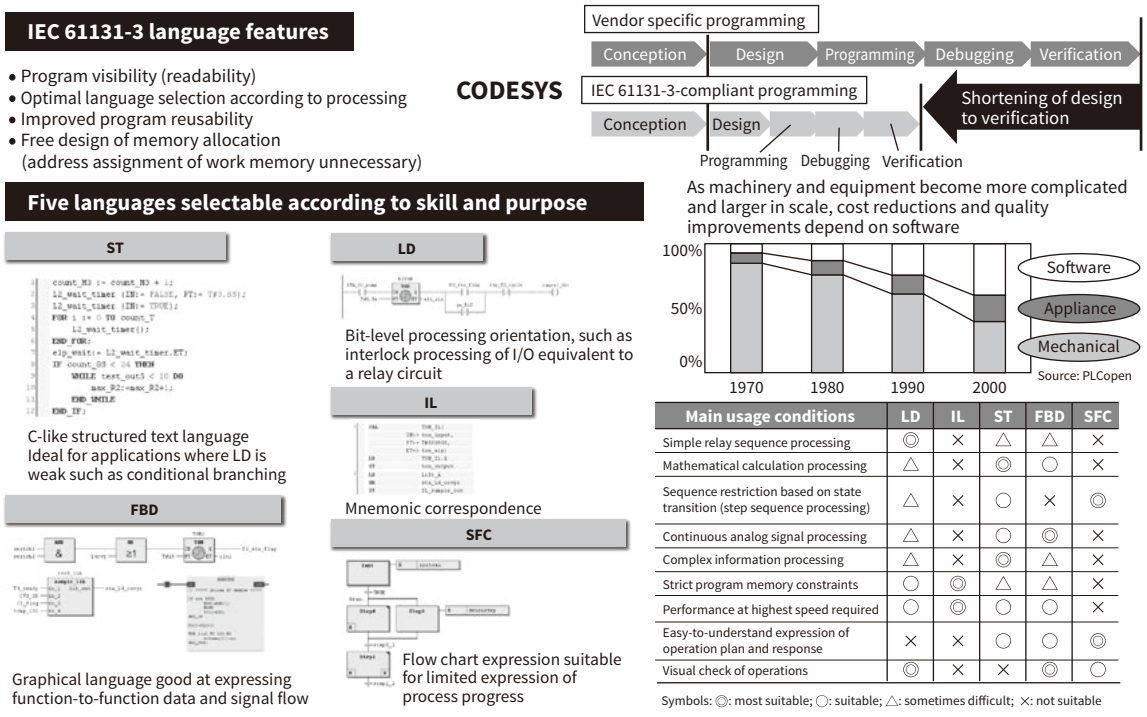


Figure 10 — Data Exchange by SD Memory
The HX series is compatible with the SD memory commonly used with PCs and other devices. It can be used for exchanging data and can temporarily store data when communication is not possible.

Figure 11—IEC 61131-3 Programming Software

The HX Series can be programmed in languages conforming to international standards. Five different languages can be used according to the purpose. Software development efficiency can be improved compared with conventional vendor-specific programming methods.



Main usage conditions	LD	IL	ST	FBD	SFC
Simple relay sequence processing	◎	×	△	△	×
Mathematical calculation processing	△	×	◎	○	×
Sequence restriction based on state transition (step sequence processing)	△	×	○	×	◎
Continuous analog signal processing	△	×	○	◎	×
Complex information processing	△	×	◎	△	×
Strict program memory constraints	○	◎	△	△	×
Performance at highest speed required	○	◎	○	○	×
Easy-to-understand expression of operation plan and response	×	×	○	○	◎
Visual check of operations	◎	×	×	◎	○

Symbols: ◎: most suitable; ○: suitable; △: sometimes difficult; ×: not suitable

IL: instruction list LD: ladder diagram FBD: function block diagram SFC: sequential function chart ST: structured text

software called the International Electrotechnical Commission (IEC) 61131-3 Development System CODESYS. There are more than 400 vendors equipped with CODESYS, and tens of thousands of users worldwide.

IEC 61131-3 has five different languages which can be used according to the purpose. Many motion control libraries are provided together with CODESYS. Software development accounts for a large proportion of the cost in system construction, so by adopting IEC 61131-3, software development efficiency for users is enhanced in comparison with vendor-specific programming methods.

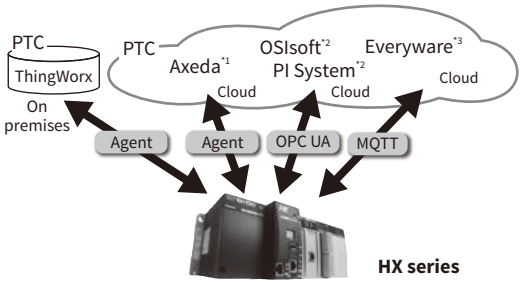
3. 4
Linkage with IoT Platforms

This section describes connections with various information system IoT platforms.

In addition to ThingWorx of PTC described in the Hitachi production system trial above, connection operations with Axeda of PTC, PI System of OSIsoft, LLC, Everyware Cloud[*3] of Eurotech, and others are being trialed, enabling flexible support through open access and expanding the potential of various kinds of connections (see **Figure 12**).

Figure 12—Linkage with the IoT Platforms of Each Company

The HX Series can connect with the IoT platform provided by each company.



MQTT: Message Queuing Telemetry Transport

*1 Axeda is a trademark or registered trademark of PTC Inc. or its subsidiaries in the U.S. and in other countries.

*2 OSIsoft and PI System are trademarks or registered trademarks of OSIsoft, LLC.

*3 Everyware, Everyware Cloud are trademarks or registered trademarks of EUROTECH S.p.A.

For Lumada, connection is being promoted for the operational technology connection part utilizing the HX Series within the Hitachi Group to enable data links to various solutions.

4. Conclusions

This paper described IoT solutions for industrial facilities and IoT-compatible equipment. The LCM service using cloud monitoring for facilities was introduced as a solution and the Industrial Controllers for IoT Applications HX Series was explained by way of IoT-compatible equipment. Furthermore, an initiative to apply the HX Series to an actual production line and support production improvement activities was described.

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