Lumada Platform Services for Creating New Value

A growing number of companies have recently started implementing IoT solutions that use various types of data and new technologies such as artificial intelligence to increase the efficiency of business operations and provide new value. Linking existing systems to cutting-edge technologies is a key requirement for IoT solutions, and the continually evolving nature of these technologies has created a variety of development issues. Hitachi has responded by providing Lumada platform services that simplify the development of IoT solutions. This article provides a general description of the latest technologies in use today, along with the issues facing IoT solution development and the main components of the Lumada platform services used to solve them—Lumada Solution Hub and Hitachi digital-twin solution for manufacturing.

Hideki Nakamura
Hiroki Miyamoto
Masaaki Iwasaki, Ph.D.
Teruo Nakamura
Noboru Fujita

1. Introduction

With the dramatic rise of digital technologies, the world is entering the Internet of Things (IoT) era, which has made it possible to create new value by connecting a wide range of devices to the Internet. The rise of digital technologies has also generated a variety of innovations, forcing companies to keep up with the business environment's accelerating pace of change to increase their competitiveness or dominance in the market. In response, a growing number of companies are innovating their business operations by using the latest artificial intelligence (AI) technology to analyze data gathered from various devices and systems to provide transparency and feedback to those operations. The scope of the innovation is also increasing from individual departments to entire value chains encompassing multiple companies.

This article provides a technical overview of the Lumada platform services that are helping companies digitalize their business operations.

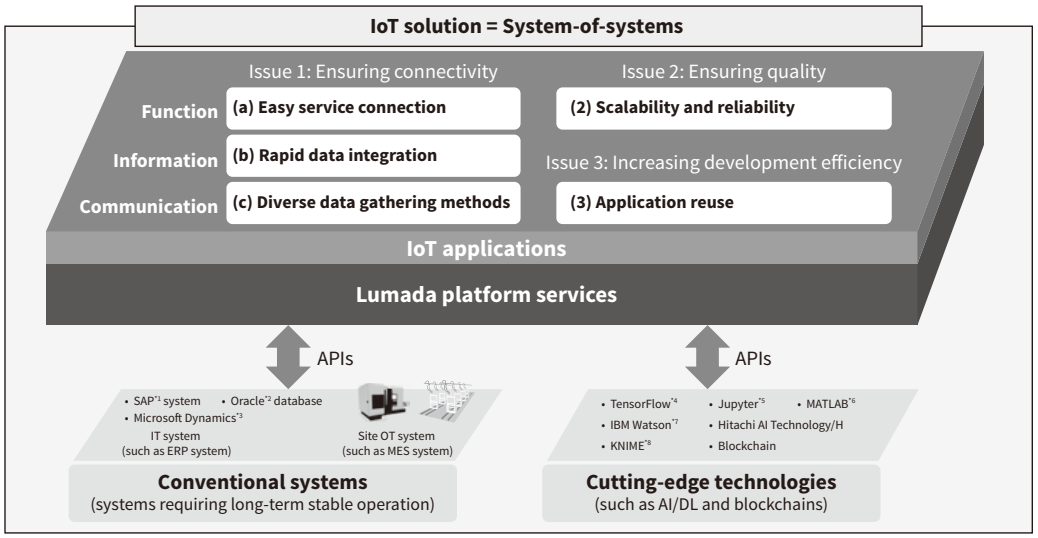
2. Overview of Lumada Platform Services

2. 1 Issues in IoT Solution Development

IoT solutions improve business operations by gathering data from existing enterprise resource planning (ERP) systems and manufacturing execution systems (MES), and using cutting-edge technologies such as AI and deep learning (DL) to uncover new value (see **Figure 1**). As they promote business reforms, these IoT solutions need to rapidly update systems in response to changes in the items being improved.

Each of the solutions can be regarded as a system-of-systems[(1)] that creates a larger system by connecting multiple systems and generates new value. Developing

Figure 1 — IoT Solutions in the Form of System-of-Systems, and Functions Provided by Lumada Platform Services
IoT solutions are systems that combine existing systems with cutting-edge technologies, and have system-of-systems characteristics.



IoT: Internet of things OT: operational technology ERP: enterprise resource planning MES: manufacturing execution system AI: artificial intelligence DL: deep learning API: application programming interface

*1 SAP is a trademark or registered trademark of SAP SE in Germany and other countries.
*2 Oracle is a registered trademark of Oracle Corporation and its subsidiaries and affiliates in the USA and other countries.
*3 Microsoft Dynamics is a trademark or registered trademark of Microsoft Corporation in the USA and other countries.
*4 TensorFlow is a trademark or registered trademark of Google LLC.
*5 Jupyter is a trademark or registered trademark of NumFOCUS, Inc.
*6 MATLAB is a trademark or registered trademark of The MathWorks, Inc.
*7 IBM Watson is a trademark of International Business Machines Corporation registered in several countries worldwide.
*8 KNIME is a trademark or registered trademark of KNIME GmbH.

this sort of system can increase the number of devices to connect and create unplanned changes, resulting in the technical issues below.

Issue 1: Ensuring connectivity

Existing systems need to be connected with AI or other cutting-edge technologies, and integrated data handling made possible. Connectivity must also be ensured in the following layers:

(a) Function: Between functions (services)
(b) Information: Between data models
(c) Communication: Between communication protocols

Issue 2: Ensuring quality

The system will have complex connections to existing systems and other components, so non-functional requirements such as performance and redundancy need to be satisfied.

Issue 3: Improved application development efficiency

IoT solutions need to be updated rapidly in response to changing goals, so application development needs to be done efficiently.

2. 2
Functions Provided by Lumada Platform Services

Lumada platform services provide solutions to the issues encountered during IoT solution development. The solutions are provided in the form of platform functions. **Table 1** shows the functions provided for handling each of the issues above.

Table 1 — Functions Provided by Lumada Platform Services and Corresponding Products/Technologies
Lumada platform services provide functions that address a number of issues encountered during IoT solution development.

	Issue		Function provided	Product/technology
1	Ensuring connectivity	(a) Function	Easy service connection	Node-RED/FCG
		(b) Information	Rapid data integration	Hitachi digital-twin solution for manufacturing
		(c) Communication	Diverse data gathering methods	OT data gathering foundation
2	Ensuring quality		Scalability and reliability	HAF/EDC
3	Improved application development efficiency		Application reuse	Lumada Solution Hub

FCG: Flow Connection Gateway HAF/EDC: Hitachi Application Framework/Event Driven Computing

Issue 1 (a): Simple service connection (Node-RED[*1]/FCG)

Lumada provides components based on a microservice architecture[2] for building IoT solutions, a development environment that configures systems by using them and enables simple connection to them, and connection assistance functions designed with access authorization and security in mind.

Issue 1 (b): Rapid data integration (Hitachi digital-twin solution for manufacturing[3])

Lumada provides a function that brings together and maintains business operation data stored separately by various business operations.

Issue 1 (c): Diverse data gathering methods (OT data gathering foundation[4])

Lumada provides a function that converts data that arrives in various different communication protocols into a uniform format.

Issue 2: Scalability and reliability [Hitachi Application Framework/Event Driven Computing (HAF/EDC[5])]

Lumada provides a function that automatically performs distributed processing in response to the load average or operational status of the system.

Issue 3: Application reuse (Lumada Solution Hub)

Lumada provides a function that stores previously developed applications in executable format and enables them to be reused for developing new applications.

Overviews of two of these functions follow below. Section 3 covers Lumada Solution Hub, a product addressing Issue 3, and Section 4 covers Hitachi digital-twin solution for manufacturing, a technology addressing Issue 1 (b).

3. Lumada Solution Hub for Accelerating the Pace of Development/Improvement Work

3. 1
Concept of Lumada Solution Hub

Among the functions provided by Lumada platform services (described in Section 2), Lumada Solution Hub is a product for solving Issue 3, application reuse. Lumada Solution Hub prioritizes interconnectability with other platforms, and is built using industry-standard open-source software (OSS). Its main features are:

(1) High application portability

Applications are built based on a microservice architecture, and each service is packaged using container technology to enable deployment as-is on private clouds or various public clouds as demanded by the client.

(2) Improved application development efficiency by promoting application reuse

Packaging applications composed of multiple microservices and storing them on a cloud platform enables reuse of developed applications, making IoT solution development more efficient.

3. 2
Architecture of Lumada Solution Hub

Figure 2 shows the architecture used to achieve the features of Lumada Solution Hub described in the previous subsection. Lumada Solution Hub is composed of three main layers. An overview of the technologies and OSS used in each layer is given below.

(1) Infrastructure as a service (IaaS)

Lumada Solution Hub uses Docker[*2] technology[6] and the Kubernetes[*3] OSS[7], which are the de-facto standard container technologies designed to operate in various infrastructure and cloud environments.

(2) Solutions

Kubernetes uses the de-facto standard package manager Helm[8] to create packages in a format called Helm charts, enabling easy deployment in Kubernetes. The packages are the applications themselves or services that can be used in application development.

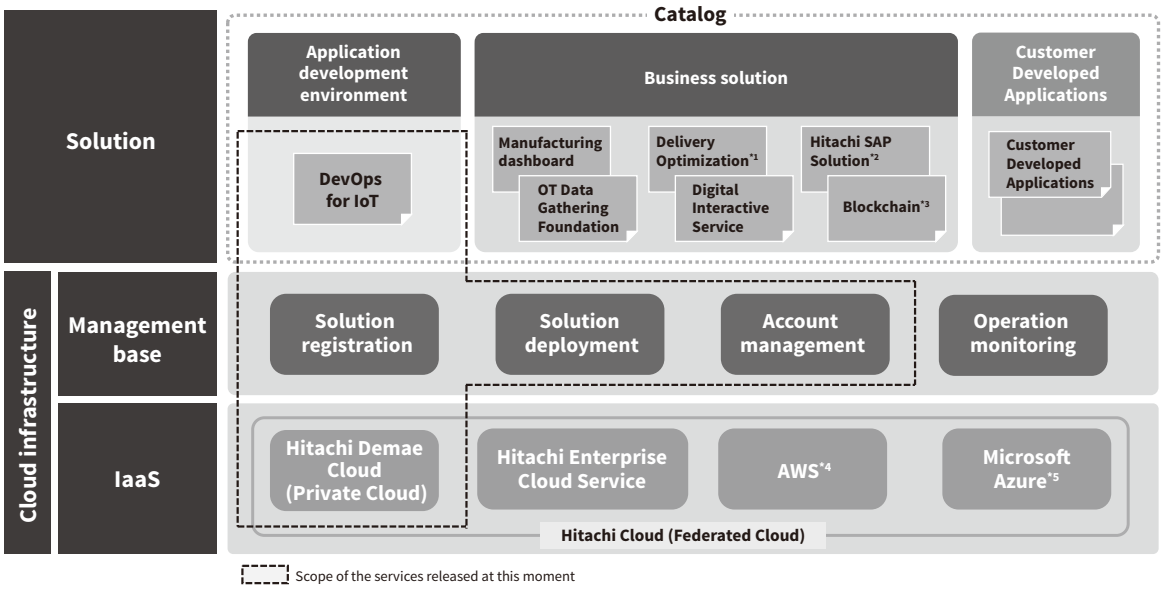
By applying Hitachi's DevOps environment provision service for IoT, developers can use Node-RED[9] [a graphical user interface (GUI) programming tool] to develop applications built by combining a wide range of services, and even users unfamiliar with IT can develop or deploy IoT solutions.

Flow connection gateway (FCG) technology is also provided, enabling various services to be easily and securely called from applications developed using Node-RED. FCG uses Istio[*4, 10], a cutting-edge service mesh technology.

*1 Node-RED is a trademark or registered trademark of JS Foundation in the USA and other counttries.
*2 Docker is a trademark or registered trademark of Docker Inc. in the USA and other countries.
*3 Kubernetes is a trademark or registered trademark of The Linux Foundation in the USA and other countries.
*4 Istio is a trademark or registered trademark of Google LLC.

Figure 2 — Lumada Solution Hub Architecture

Lumada Solution Hub is composed of a cloud platform and packaged solutions. The cloud platform is composed of IaaS and a management platform. The packaged solutions include an application development environment building solution and business operation solutions for different industries.



IaaS: infrastructure as a service
*1 Hitachi Digital Solution for Logistics/Delivery Optimization Service
*2 Hitachi's SAP HANA*6 Cloud Service, Business Management Dashboard Service
*3 Hitachi Blockchain Service for Hyperledger Fabric*7
*4 AWS is a registered trademark of Amazon Web Services, Inc. in the USA and other countries.
*5 Microsoft Azure is a trademark or registered trademark of Microsoft Corporation in the USA and other countries.
*6 SAP HANA is a trademark or registered trademark of SAP SE in Germany and other countries.
*7 Hyperledger, Hyperledger Fabric is a trademark or registered trademark of the Linux Foundation in the United States and other countries.

(3) Management platform

Lumada Solution Hub manages the packaged applications described above, and provides the solution registration, solution deployment, account management, and operation monitoring functions needed to run and operate these applications on IaaS.

4. Assisting Process Digitalization with Digital-twin Solution

4. 1 Issues in Industries

Work in industries such as the logistics, construction, and manufacturing takes shape by executing business operations segregated by function in a predetermined sequence, and repeatedly passing along the results of each operation to the next operation. This is the way that goods are transported (logistics industry), buildings are built (construction industry), and products are manufactured (manufacturing industry). The business operations performed to carry out these work activities are being made more efficient by digitalization, but diversifying market needs are creating demand for further efficiency gains.

A key requirement for creating these efficiency gains is to move away from focusing only on increasing the efficiency of individual operations, and instead to optimize the flow of business operations over the entire value chain by considering the connections among the wide range of operations that make up work activities.

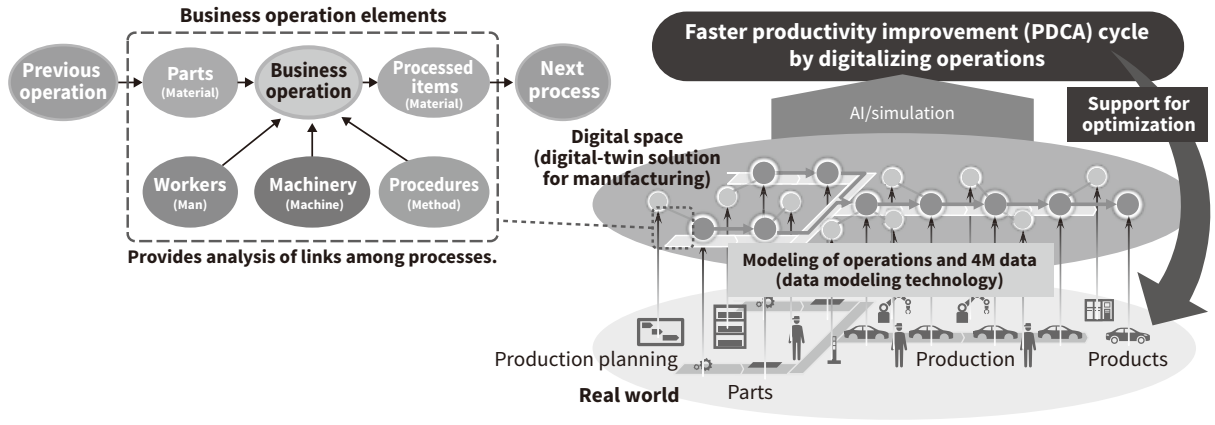
But optimizing the entire flow of business operations requires a method that enables the compilation and integrated management of massive volumes of heterogeneous data generated by each business operation system.

4. 2 Issues and Solutions in the Manufacturing Industry

The manufacturing industry is often characterized by production operations such as pressing, painting, and assembly that are connected in the form of production lines, while individual production operation systems

Figure 3 — Overview of Digital-twin Solution for Manufacturing

Hitachi digital-twin solution for manufacturing models site data and stores it in a graph database by using the relationships between business operations and process elements including people, equipment, materials, methods, and procedures.



4M: Man, machine, material, method PDCA: Plan-do-check-act

are optimized to their respective production operations and built as different systems.

Hitachi has responded by examining manufacturing industry issues resembling those described above, and developing Hitachi digital-twin solution for manufacturing. Digital-twin solution brings together a wide range of different site data scattered throughout a plant's business operations to reproduce entire production lines in a digital space. It provides a simulation space that models the real world to help visualize and analyze physical-world events related to the plant, products, and other issues. Besides plant-owning manufacturers, it can also be used to assist companies in other industries that have standardized business operation flows resembling production lines.

4. 3
Overview of Digital-twin Solution's Functions

Digital-twin solution makes it easy to bring together and maintain operational technology (OT) and IT data stored separately by various business operations. It is a data usage platform that uses AI analysis and simulations to assist ongoing productivity improvement (see **Figure 3**), and uses the connections of production operations to model site data. Specifically, it defines production operations and elements related to production operations (such as people, equipment, materials, and operating procedure manuals) as 4M[*5] data, and uses an original data model that reproduces the connections among the previous and the next production operations on the basis of the processed items created by the production operations (the 'material' element of 4M data).

Digital-twin solution can register the modeled site data in a graph database and extract site data for the production operations of each finished product. These features can create transparency by associating each finished product with the applicable production operations, equipment used, and processes performed. Digital-twin solution makes it easy to extract and integrate the required data whenever needed, without expert knowledge of production operations, helping shorten the plan-do-check-act (PDCA) cycle for data analysis.

*5 4M stands for man, machine, material, and method.

5. Conclusions

This article has provided an overview of the Lumada platform services used to simplify the work of IoT solution development, along with a general description of the development background and technologies of two of its component products/technologies—Lumada Solution Hub and Hitachi digital-twin solution for manufacturing.

The use of data to digitalize and improve the efficiency of business operations and systems will

continue gaining prominence in the years ahead, and platforms for assisting this work will play an increasingly important role.

Hitachi plans to continue developing technologies for simulating digitalized business operations and for simply and securely operating today's increasingly complex software, and applying them to Lumada platform services.

References

1) M. W. Maier, "Architecting Principles for Systems-of-Systems," Systems Engineering, 1, pp. 267–284 (Feb. 1999).
2) J. Lewis and M. Fowler, "Microservices: A Definition of this New Architectural Term," (Mar. 2014), https://martinfowler.com/articles/microservices.html
3) Hitachi News Release, "Hitachi Commences Sales of 'Hitachi Digital-twin Solution for Manufacturing' which Facilitates Production Site Data Linkage Using Unique Data Models to Help Optimize the Entire Production Process," (Oct. 2018), https://www.hitachi.co.jp/New/cnews/month/2018/10/1017.html in Japanese.
4) Hitachi, Ltd., "OT Data Collection Platform," http://www.hitachi.co.jp/products/it/IoTM2M/list/datahub/ in Japanese.
5) Hitachi, Ltd., "Hitachi Application Framework/Event Driven Computing," http://www.hitachi.co.jp/products/it/society/product_solution/telecom/infrastructure/haf.html in Japanese.
6) Docker, https://www.docker.com/
7) Kubernetes, https://kubernetes.io/
8) Helm, https://helm.sh/
9) Node-RED, https://nodered.org/
10) Istio, https://istio.io/

Authors

Hideki Nakamura
Industrial AI Laboratory, Research & Development Division, Hitachi America, Ltd. *Current work and research:* Research and development of IoT platforms.

Hiroki Miyamoto
Connectivity Research Department, Center for Technology Innovation – Electronics, Research & Development Group, Hitachi, Ltd. *Current work and research:* Research and Development of Hitachi digital-twin solution for manufacturing.

Masaaki Iwasaki, Ph.D.
Research & Development Group, Hitachi, Ltd. *Current work and research:* Research on open source software and IoT platforms. *Society memberships*: The Information Processing Society of Japan (IPSJ), the Institute of Electronics, Information and Communication Engineers (IEICE), and IEEE Computer Society.

Teruo Nakamura
Service Platform Business Division Group, Services & Platforms Business Unit, Hitachi, Ltd. *Current work and research:* Development of cloud services and Lumada platform services. *Society memberships*: IPSJ.

Noboru Fujita
Application Cloud Services Business Division, Service Platform Business Division Group, Services & Platforms Business Unit, Hitachi, Ltd. *Current work and research:* Development of Hitachi digital-twin solution for manufacturing.