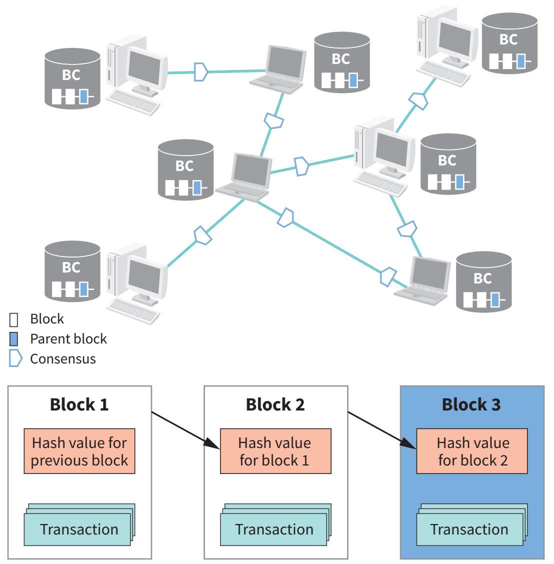
Technology Innovation

Services & Platforms



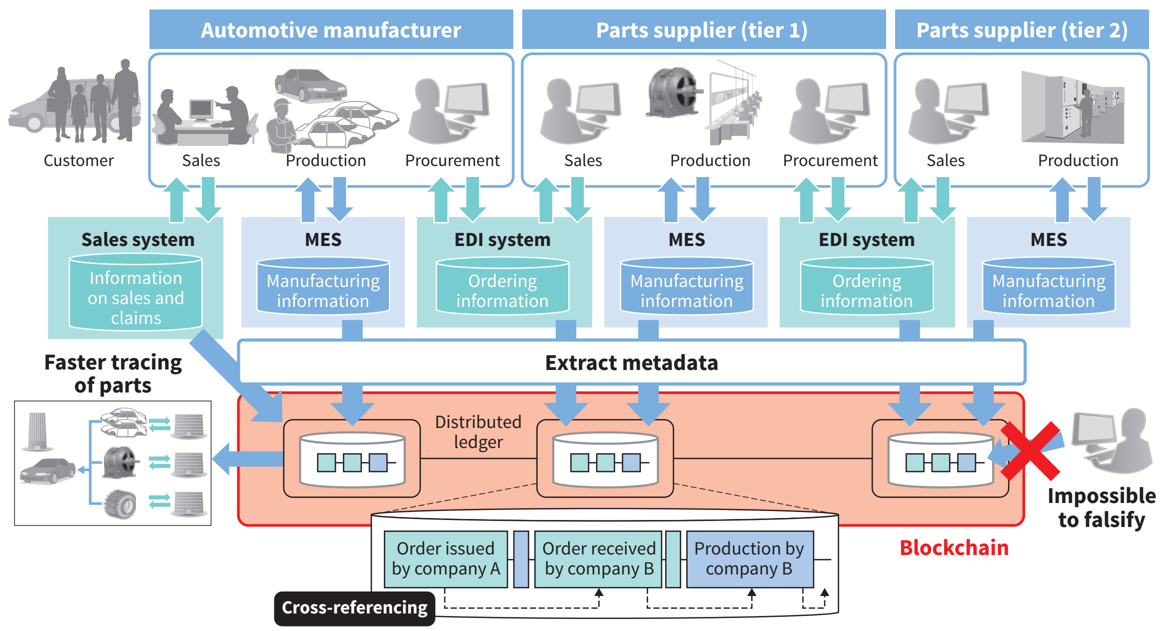
1 Conceptual overview of blockchain system

1 Contribution to Development of Hyperledger Fabric v1.0

Blockchain technology has characteristics that include being distributed and immutable with information transparency, and is expected to be applied to faster settlement, supply chain management, traceability management, energy management, and so on. For enterprise use, Hyperledger under Linux Foundation is developing a blockchain platform, Hyperledger Fabric, as open source software (OSS). Hitachi joined Hyperledger, the expected de facto standard, as a premier member and became a board and technical steering committee member. For the release of Hyperledger Fabric v1.0 in July 2017, Hitachi contributed to the reliability and stability of the blockchain platform through the activities of the OSS community. Hitachi will support the customer's next generation system development with the knowledge and experience of Hyperledger Fabric that it gained through OSS development.

2 Blockchain-based Traceability Management System

The blockchain has attracted attention as a new technology that is highly resistant to



2 Blockchain-based traceability management system falsification, and Hitachi is working on its use in enterprise applications that include finance and manufacturing.

In manufacturing, as epitomized by the automotive industry, the consequences of recalls are becoming progressively broader in scope. For example, because parts procurement involves companies with operations across the globe, it takes two months to determine the scope of a recall when one occurs and to validate information on parts ordering and production.

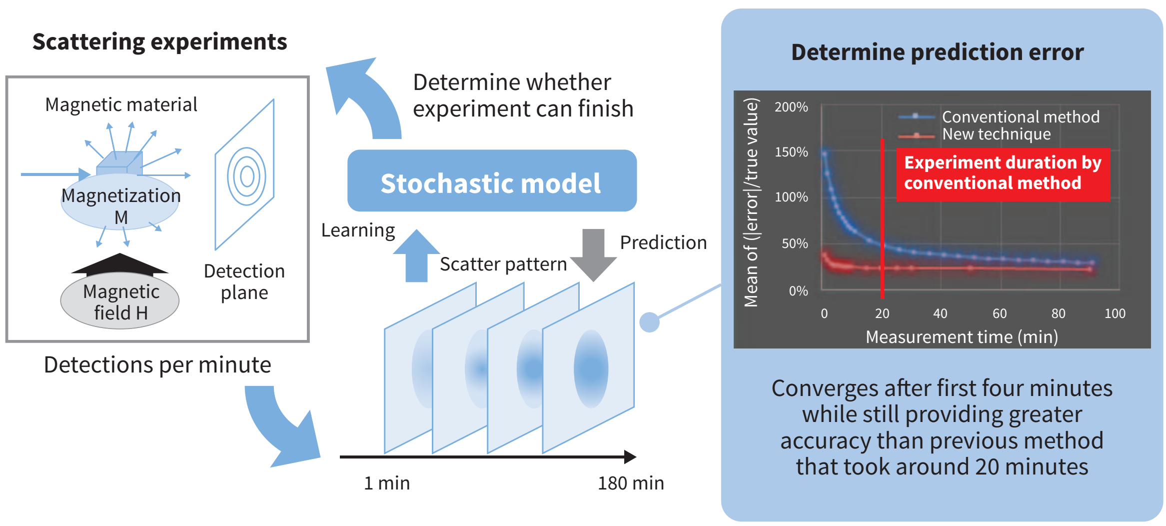
Hitachi has developed a traceability management system that can extract the metadata needed to trace parts from records of parts ordering and production, storing this information in a blockchain with the associated cross-referencing. The high level of integrity provided by using a blockchain means the system is able to eliminate the need to validate the information and can shorten the time taken to determine the scope of a recall to just one minute.

Along with developing ways to administer systems that use blockchains (including their monitoring and backup) to enable commercialization in enterprise applications, Hitachi also intends to establish and implement development methodologies for such systems through collaborative creation with customers.

3 Experiment Prediction for Materials Informatics

While research and development in the field of materials science has traditionally proceeded by trial and error with repeated experimental testing, the trial process has been shaken up in recent times by the development of techniques in materials informatics that use information and communication technology (ICT) to significantly shorten testing times. Hitachi has launched a business that supplies ICT platforms to support materials informatics and utilizes a variety of analytics techniques proven from past use in a wide range of business sectors, providing even those materials scientists who lack in-depth knowledge of ICT with the ability to perform data analyses such as those used to predict experimental results.

While one of the requirements of materials informatics is the ability to identify factors relating to material properties in large amounts of experimental data, it is difficult in practice to perform a sufficient number of tests to establish such relationships. In response, Hitachi has developed a technique that fits experimental data collected over a short time period to a stochastic model of the experimental process so as to predict future experimental outcomes, then assesses the level of uncertainty in the predictions to determine when a sufficient level of



3 Example of how prediction shortens time taken for measurements on a new material certainty has been achieved in the experimental results. In the case of scattering experiments, the technique has demonstrated an ability to complete testing in one-fifth the time taken previously*.

In the future, Hitachi intends to help speed up research and development in the field of materials science by expanding the scope of application of this prediction technique.

* In trials conducted in collaboration with the Inter-University Research Institute Corporation High Energy Accelerator Research Organization and Toyota Motor Corporation.

of intelligent communication with people using data it collects itself and from external sources. Hitachi has, since 2016, been trialing the robot with customers to identify the issues that arise in such environments, and also working to improve the technical level of the robot with a view to practical applications, including its operational performance and interactivity.

Hitachi intends to continue with these trials to press ahead with introducing commercial robotics services and to create new digital solutions that use data collected by robots.

4 EMIEW3 and Robot IT Platform

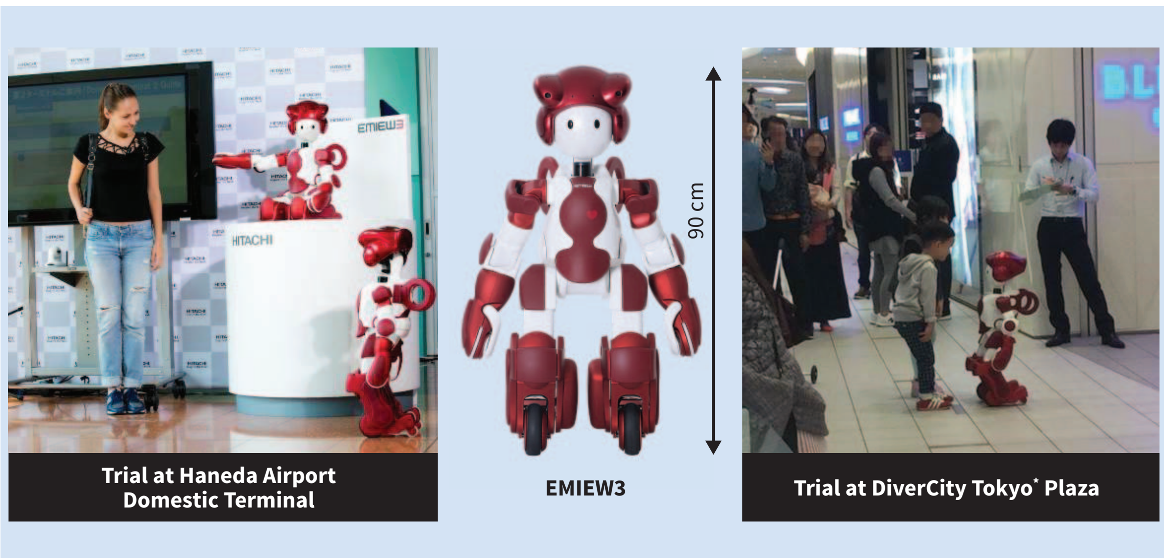
Recent years have raised hopes for achieving a "Super Smart Society" that utilizes robotics and artificial intelligence (AI) to help overcome societal challenges such as the aging population and low birthrate. In response, Hitachi has developed the EMIEW3 humanoid robot and a robot information technology (IT) platform for robot knowledge processing and the remote operational monitoring and control of multiple robots across multiple sites with the aim of establishing new service businesses that utilize robotics through collaborative creation with customers.

EMIEW3 has a small, lightweight body (90 cm high with a weight of 15 kg) that is able to move smoothly and safely, and is capable

5 3D Visualization of People Flow Data

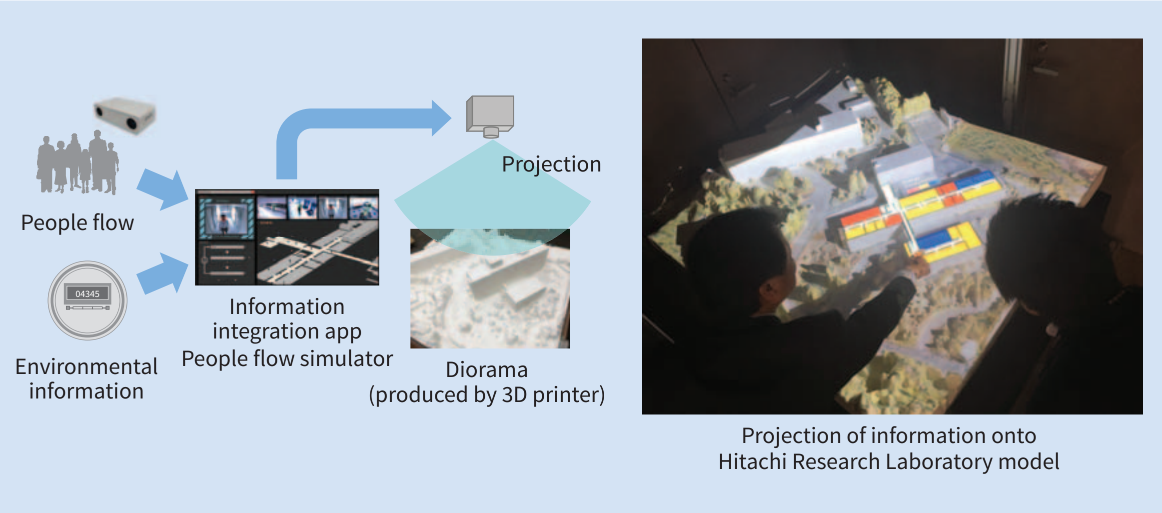
In urban development and the design of offices, shopping centers, and other buildings, considerable work in recent years has gone into the use of sensing to determine the flow of people and goods, and for ways of utilizing this data to provide more comfortable spatial designs.

Hitachi has now developed a three-dimensional (3D) diorama interface that uses a building model (diorama) to present a 3D view of people, goods, and environmental information. While methods are already available for presenting such information on a personal computer (PC) screen, projecting information such as people flow predictions based on collected data, power consumptions, and temperatures



* See "Trademarks" on page 148.

4 EMIEW3 humanoid robot and example scenes of its testing



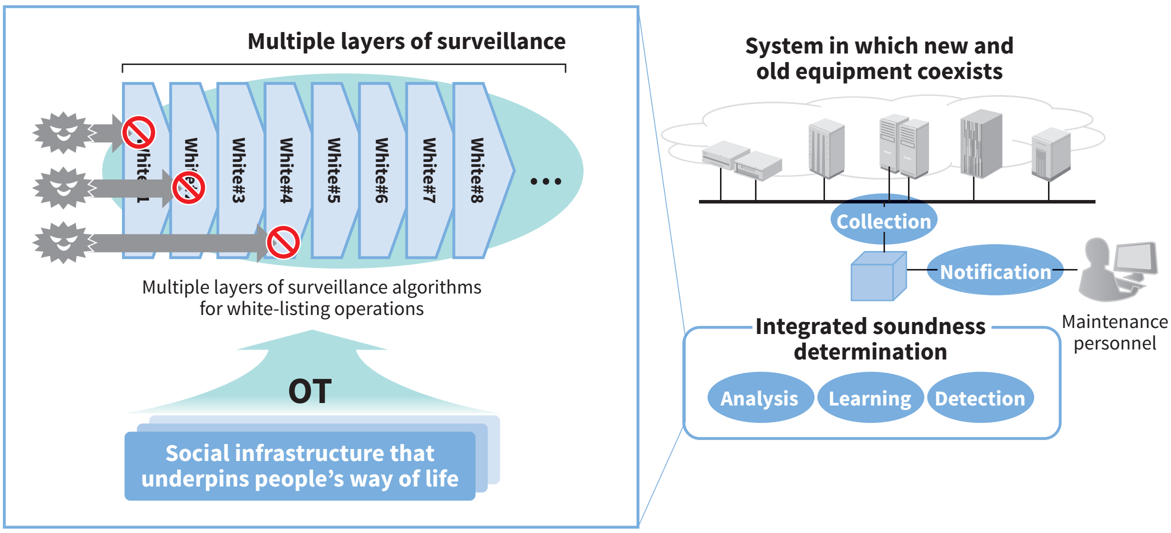
5 3D diorama interface

onto a diorama presents an overview that can be viewed by a number of people at once, enabling collaborative creation to be accompanied by in-depth mutual understanding with the customer. Along with projecting information onto the diorama, there is also scope for providing greater immediacy by using 3D sensing for gesture-based control to give users real-time control over what information to include, such as switching between building layouts or showing different information

In the future, Hitachi intends to utilize the technique in practical applications and a wide variety of different fields while also conducting trials by collecting information on the people and things in a building over a wide area.

6 Cyber Security for Society 5.0

Along with greater system integration as part of the shift to Society 5.0, there is a rising risk of cyber-attacks that manifest over the networks that link cyber- and physical spaces. Accordingly, recognizing the importance of service continuity (availability), critical infrastructure systems that involve interoperation between a number of different sub-systems need advance warning of the latest threats and the business implications of potential cyber-attacks. It is also essential, if such an attack does occur, to detect it at an early stage and to respond before the business implications eventuate. Hitachi has developed



OT: operational technology

6 Assessment of overall soundness

7 Organizational activity levels obtained from wearable nametag sensors and associated advice (left) and people wearing the sensors (right)

the following technology to overcome these challenges*.
(1) A high-level risk assessment model that identifies business risks in a general-purpose manner, considering the various elements that make up the business (operations, people, systems, services, products, and so on)
(2) An information sharing platform on which user organizations and service providers work together by sharing information to prevent any further losses from the cyber-attack
(3) Integrated soundness determination that identifies small changes in operational communications from a variety of perspectives for the early detection of attacks

In the future, Hitachi intends to contribute to improving security by utilizing this technology in the design and operation of critical infrastructure systems.

* This work was supported by the Council for Science, Technology and Innovation (CSTI), Cross-ministerial Strategic Innovation Promotion Program (SIP), "Cyber-Security for Critical Infrastructure" (funding agency: NEDO).

7 Technique for Using Organizational Activity Level to Advise on Working Practices

Hitachi is looking at the level of activity of people and organizations and the relationship between productivity and a sense of well-being to undertake research and development for the measurement and analysis of organizational activity levels using wearable nametag sensors for measuring human behaviors such as communication together with the Hitachi AI Technology/H (AT/H).

A technique has been developed that can automatically issue advice on the working practices that represent the strengths of individuals by classifying the behavior data collected by the wearable nametag sensors based on factors such as the time of day or who people are talking to, and providing this as input to AT/H. An in-house trial to verify how working practices relate to business performance and staff satisfaction that was conducted at 26 sales departments (totaling approximately 600 people) found that the amount of change in organizational activity levels was correlated to the number of orders acquired. Specifically, departments that experienced rising levels of organizational activity during the trial period achieved orders in the following quarter (October to December) that were on average 27% higher than those at departments where levels fell.

Hitachi intends to support enhancements to working practices and improvements in corporate productivity by developing and trialing techniques for providing useful feedback to augment staff thinking about how they go about their work.

8 Robotic Process Automation

A variety of companies are currently adopting robotic process automation (RPA), whereby software robots are used to automate auxiliary tasks to alleviate labor shortages and improve work productivity. Like a conventional robot, the term "software robot" refers to software that performs tasks in the same way as a human. The RPA currently being introduced is class 1 (the automation of tasks that can be clearly defined by rules), while class 2 (the automation of tasks that require intelligence, such as recognition and decision-making) is expected to attract rising interest in the future.

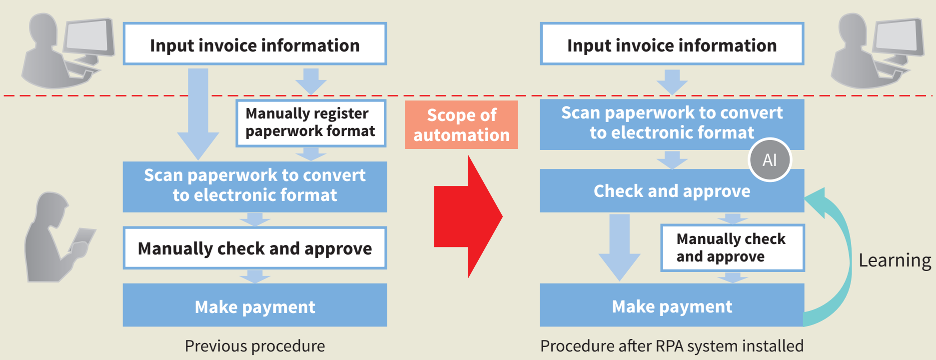
In terms of class 2 RPA, Hitachi is working on research into automating, (1) Recognition of input data in diverse formats, and (2) Decision-making under a variety of circumstances where the formulation of rules is difficult. For (1), Hitachi has achieved successful automation by using previously developed recognition techniques for things like text, images, audio, language, and human behavior as a base. For (2), automation has been achieved by collecting data handled by the business and using it for learning. Trials have already been conducted at Hitachi businesses for the following three activities.

(1) Accounts documentation checking

A system was developed to automate the work from the scanning of accounts paperwork through to approval. The system automated the checking process used to identify payments (including who and how much to pay) from accounts paperwork by utilizing documentation checking techniques designed for financial institutions and knowledge acquired by using data from past accounts handling work for learning. Whereas this accounts data had to be checked manually in the past, the ability to acquire the knowledge for accounts documentation checking from past data made it possible to implement a low-cost documentation checking system. A trial of accounts handling work at Hitachi found that 70% of accounts paperwork could be checked automatically. The technique was incorporated into the business system and commenced operation from October 2017, with the aim of commencing full-scale use in FY2018 (see **Figure 8.1**).

(2) Inquiry handling

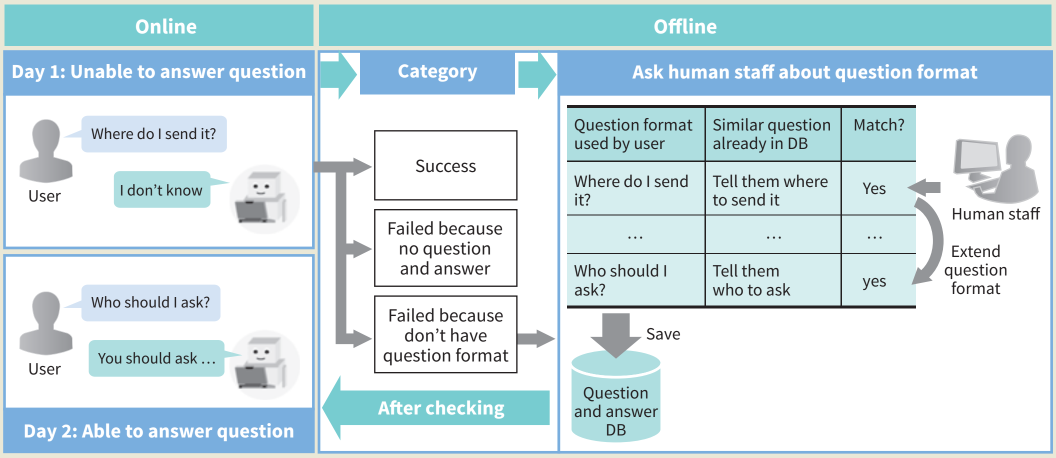
A system was developed to provide automatic responses to inquiries about in-house procedures. A technique was developed for the efficient collation of an inquiry database from past data held by the company on responses to inquiries, and also another self-growing interaction technique that builds knowledge of how to respond to inquiries by requesting more information on those inquiries that are not able to be answered. While the automation of inquiry handling requires an efficient way to build up a database of inquiry responses, these techniques enable this to be done by computer in a semi-automatic manner. In a pilot study involving actual inquiry handling at Hitachi, the system was able to respond automatically to more than 60% of inquiries. A full trial commenced in October 2017 (see **Figure 8.2**).



8.1 Flowchart of accounts handling after automation of documentation checking

Research & Development

Technology Innovation: Services & Platforms



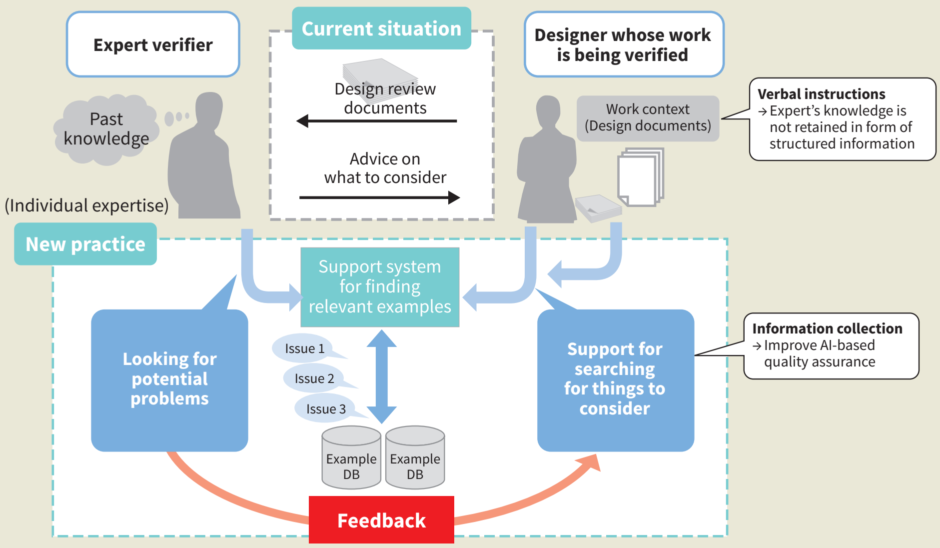
DB: database

8.2 Presentation of things identified by system as requiring confirmation, and associated outcomes

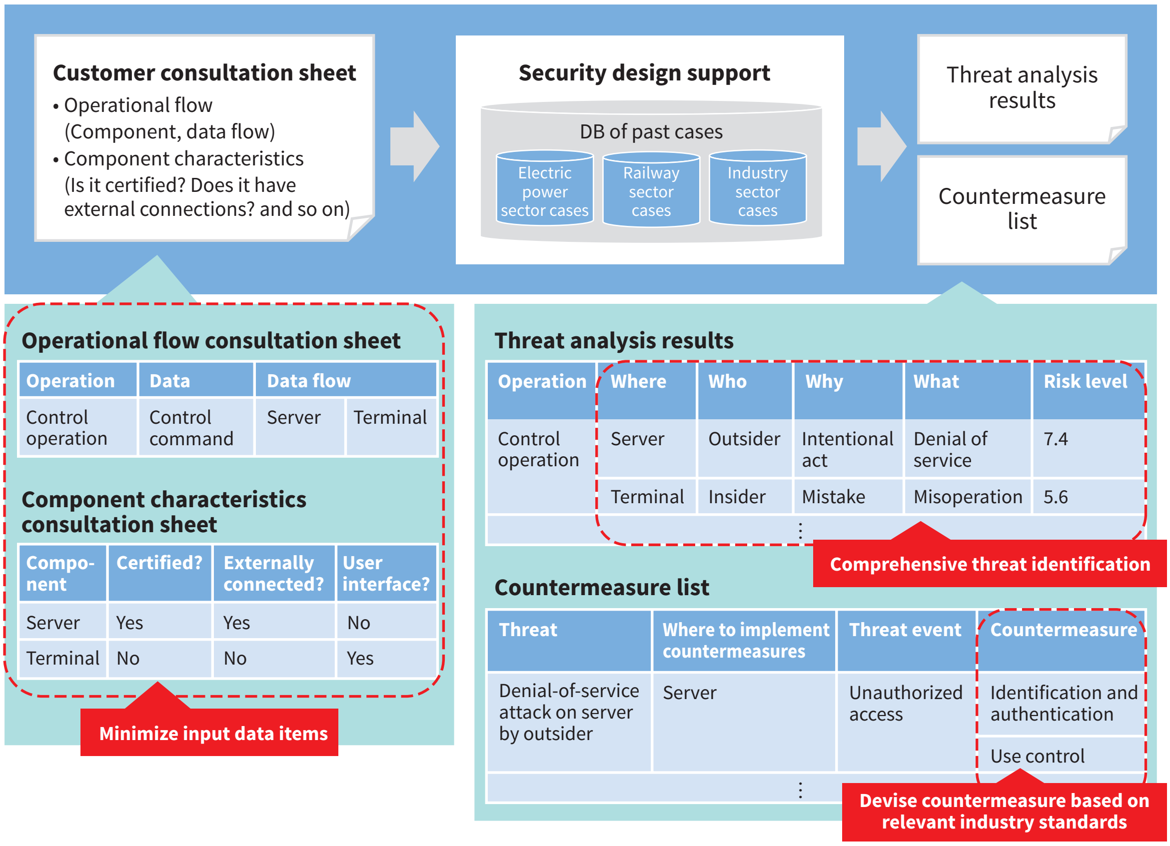
(3) Quality assurance

A system was developed to provide relevant examples of past non-compliance for use in the design review process. The system first performs learning using a database of past non-compliance examples. The documentation for the design being reviewed is then loaded into the system to help identify past examples and things that designers should look at. The system also seeks to improve its accuracy through ongoing learning of how expert staff select from search results. A trial is currently in progress in collaboration with an operational department. The trial commenced in October 2017 aimed at verifying the benefits for design review efficiency of providing an efficient way to look for relevant examples of past failures (see **Figure 8.3**).

The AI techniques used in these newly developed RPA systems for tasks that require intelligence have extensive potential applications for auxiliary tasks, such as recognition and decision-making. Accordingly, they have been defined as Lumada use cases to facilitate their practical deployment in Hitachi and elsewhere. While one of the challenges of AI is the time taken for the learning phase, including changing the techniques used based on the nature of the task, this work has accelerated the development of solutions that use AI by utilizing, across different applications, techniques with benefits that have already been demonstrated using in-house business data.



8.3 Interactive solution using self-growing technique for interaction



9 Security design support for IoT and control systems

9 Security Design Support for IoT and Control Systems

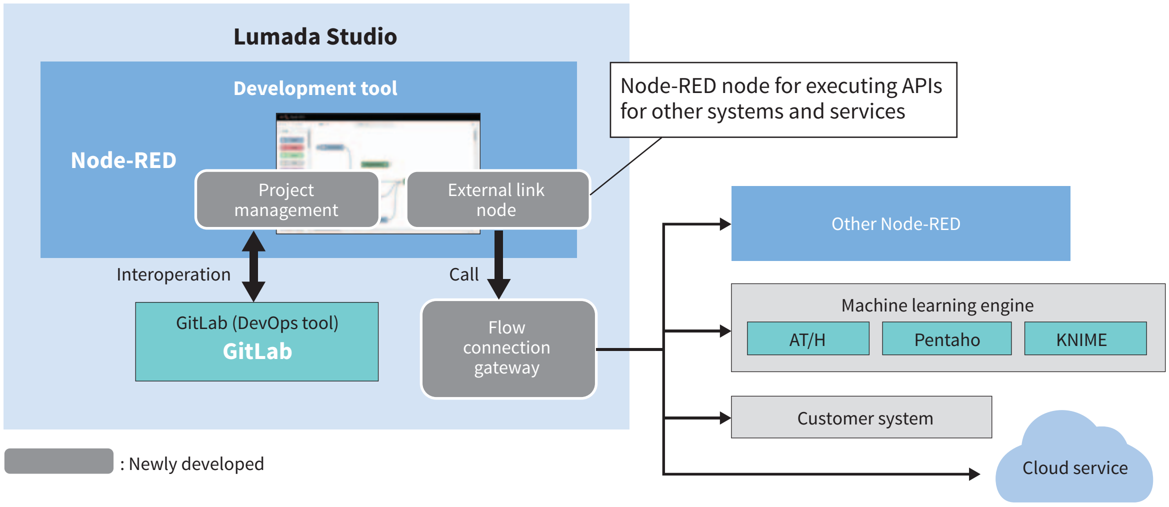
With the rising threat of cyber-attack on the Internet of Things (IoT) and control systems, it is becoming essential to determine the security threats to which a system is vulnerable and to take appropriate security measures. The problem with this, however, is that, because the IoT and control systems are made up of so many different components, it takes a lot of time to analyze threats and devise countermeasures. In response, Hitachi has developed ways of doing this quickly that are based on security design techniques built up by Hitachi over time and that work by decreasing the data items needed for threat analysis and identifying related threats that have occurred in the past. The technology is being deployed in systems in the electric power, railway, industrial, and healthcare sectors. In the case of an electric power system with around 200 different components, it succeeded in reducing the security design cost by about 80% compared to past practice.

In the future, Hitachi intends help improve the safety and reliability of social infrastructure by utilizing the technology in other areas such as water supply, sewage, and gas.

10 Integration with Node-RED OSS

There is increasing interest in digital solutions for business improvement that use AI or machine learning to analyze data collected from existing customer systems. The use of machine learning requires considerable trial and error, including the establishment of teams to try different machine learning engines based on the problem being addressed, with likely team members including application system engineers (SEs) who have an understanding of customer data and data scientists who specialize in data analysis.

As its development environment for supporting team development and trial and error, Hitachi has adopted Node-RED, an open-source development tool that can integrate with



API: application programming interface

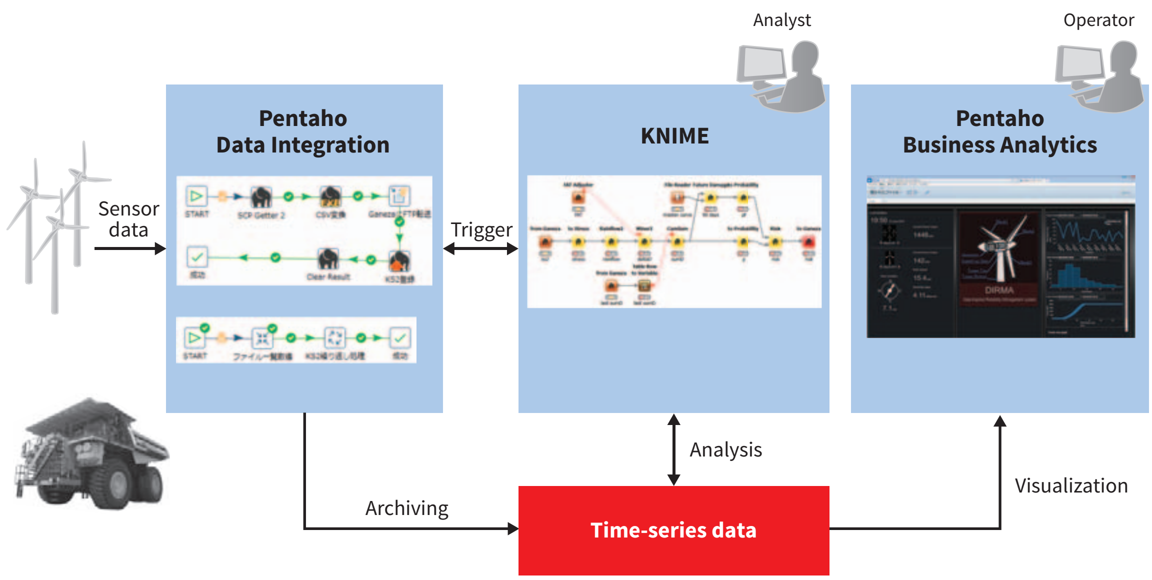
10 How new technology fits in with Lumada Studio

customer systems and try different combinations of machine learning engines without the need for programming. Hitachi has also extended Node-RED by adding a project management function to facilitate team development, and developed a "flow connection gateway" to facilitate interoperation between Node-RED and other software, including machine learning engines.

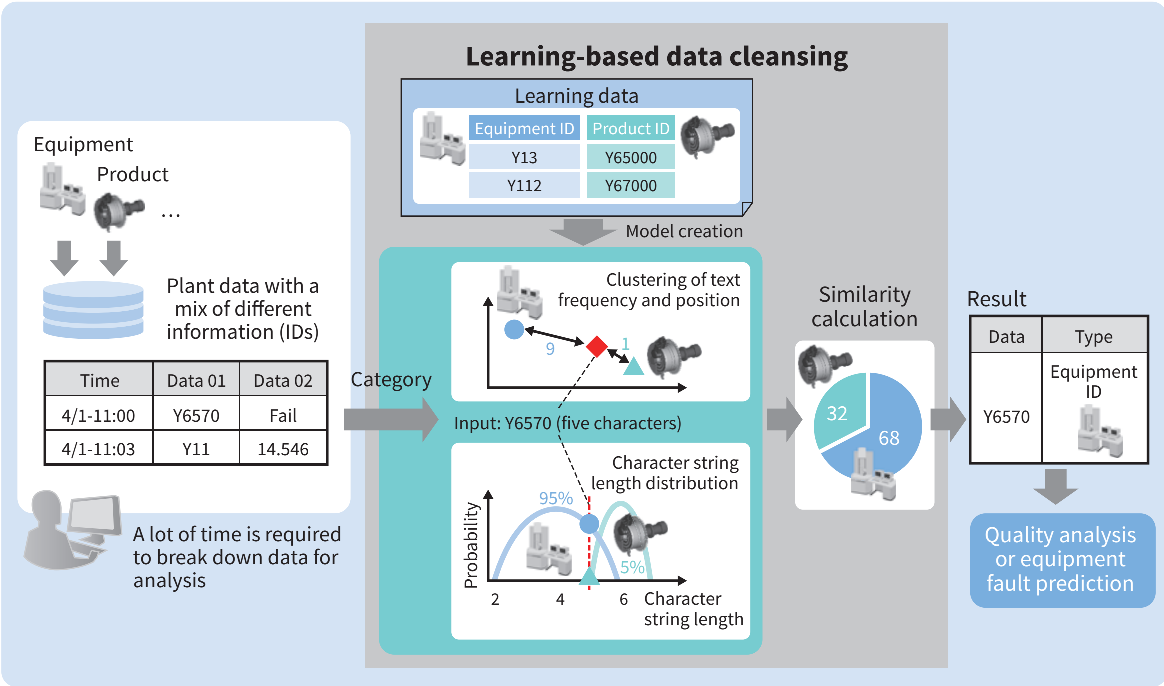
In the future, Hitachi intends to incorporate this new technology into the Lumada Studio development platform and continue contributing to the Node-RED community.

11 Collaborative Analysis of Time-series Data

Systems that ensure reliability by collecting operational data for on-site equipment to quantify failure risks and take pre-emptive countermeasures are needed to keep social infrastructure equipment operating reliably over long periods. Moreover, because a wide variety of different failure risks exist for equipment, such as fatigue fracture or damage by disasters, and because a wide variety of different analyses are needed, including damage prediction and maintenance planning, an environment is needed in which a



11 Use of collaborative analysis of time-series data to analyze coordinated operation of social infrastructure equipment



ID: identifier

12 Example use of learning-based data cleansing on manufacturing industry data

number of analysts can work together to build up sophisticated analyses.

Accordingly, Hitachi has developed a technique for the collaborative analysis of time-series data that standardizes analysis data structures and analytical methods to help people undertake the work together. The analysis data is managed centrally, divided into time-series data and structured statistical data for particular intervals with specific start and end times. For the analytical methods, the risk analysis logic is divided into components such as damage analysis using the KNIME* platform, which is workflow based. This means that new analyses can be got up and running quickly by mixing and matching these analysis components.

In the future, Hitachi plans to utilize these techniques in its operation and maintenance (O&M) services for ensuring the reliability of a wide variety of its products.

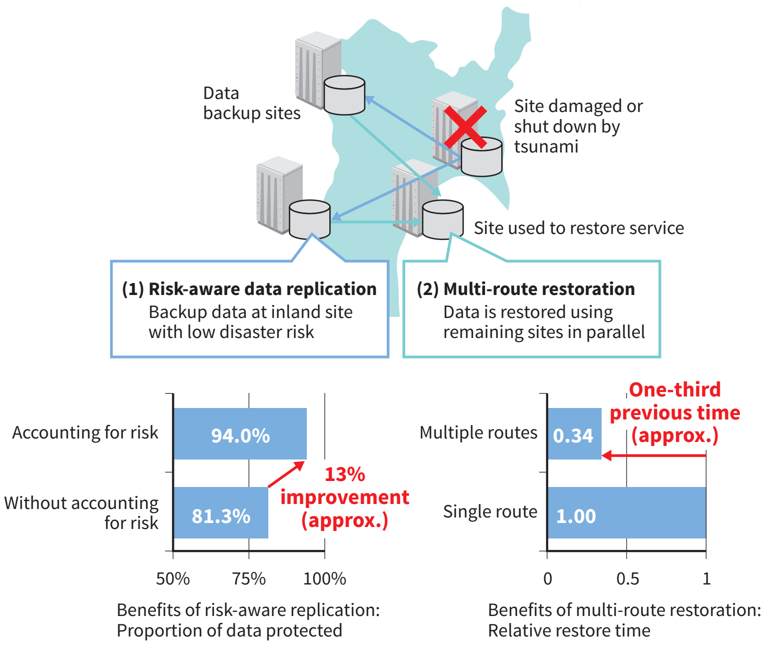
* An open-source workflow-based platform developed by the University of Konstanz in Germany

12 Learning-based Data Cleansing

Advances in IoT technology have heightened interest in the collection of a wide variety of real-world data and its use to improve performance indicators. Unfortunately, the disordered nature of real-world data brings with it the problem that preparing data for analysis takes a lot of time. In manufacturing, for example, there is potential for quality improvement through the early analysis of defects and productivity improvement through equipment fault prediction. In many cases, however, a diverse mix of information about equipment and production processes is collected from manufacturing plants and the time it takes to sort through this data is an impediment to timely action.

In response, Hitachi has developed a learning-based data cleansing technique that performs learning on the characteristics of text data, especially character string lengths, and can quickly and accurately sort through real-world data containing a diverse mix of information. When applied to plant data containing four different types of information (including equipment and product identifiers), the technique reduced the time taken to break the data down by 90%.

Hitachi intends to utilize the technique to contribute to timely quality improvement and higher productivity in manufacturing.



13 Features of proposed distributed storage system

13 Distributed Storage System with High Resilience to Disaster

Hitachi has developed core technology for establishing distributed storage systems that can sustain information services for areas damaged by a serious disaster as part of "Research and Development on Highly-functional and Highly-available Information Storage Technology*" project sponsored by the Ministry of Education, Culture, Sports, Science and Technology. The Great East Japan Earthquake of 2011 damaged not only data storage appliances, but also the wide area networks linking the affected area with the outside world. This highlighted how hard it was for conventional disaster recovery systems, which replicate data to remote data centers, to restore local information services prior to the recovery of these wide area networks.

In response, Hitachi's involvement in the project included proposing a distributed storage system for copying and protecting data at multiple sites within the region, and building a prototype.

The main features are as follows.

(1) Risk-aware data replication

The proportion of data protected was increased by taking account of disaster risks in choosing safe data backup destinations for each site.

(2) Multi-route restoration

The unavailability of information services is shortened by transmitting restoration data in parallel from the multiple data backup sites still in operation after a disaster.

In the future, Hitachi aims to deploy this new technology in disaster resilience solutions for local government and medical institutions.

* Period: FY2012 to FY2016; Project leader: Hiroaki Muraoka, Research Institute of Electrical Communication, Tohoku University; Participating organizations: Tohoku University, Hitachi, Ltd., and Hitachi Solutions East Japan, Ltd.