Overview

Information and Control Systems
—Open Innovation Achieved through Symbiotic Autonomous Decentralization—

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TRENDS IN SOCIAL INFRASTRUCTURE

THE manufacturing industry in particular has been home to considerable activity in recent years targeting new innovations based on the IoT[(a)]. This has included standardization initiatives and the creation of ecosystems that tie together the manufacturing and IT industries, with the launch in the USA of the Industrial Internet Consortium (IIC) led by General Electric Company (GE), and the launch in Germany of the government-led Industrie 4.0 initiative.

The aims of the IoT can be broadly divided into improving the efficiency of the producers of

(a) IoT
An abbreviation of "Internet of things." A technology for automatic recognition, measurement, interoperative control, etc. achieved by providing communication functions in various devices that, in the past, were not connected to networks and connecting them to the Internet to exchange information.

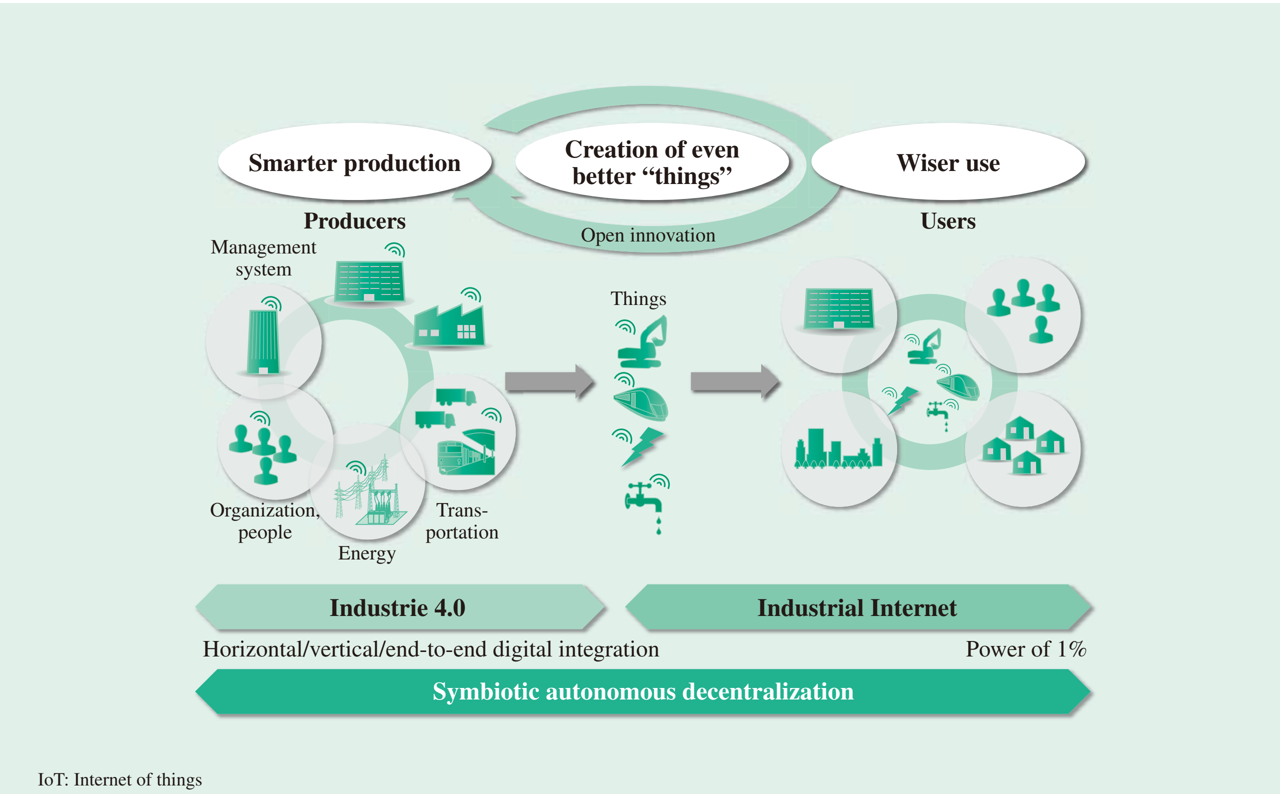


Fig. 1—Role of IoT.
The IoT enables smarter production and wiser use by utilizing information from "things," and facilitates the creation of even better "things."

things[*1], and improving convenience for the users of these things (see Fig. 1). Smarter production can be achieved by producers using the IoT in plants and equipment (as shown on the left side in Fig. 1) to deliver benefits such as higher productivity and lower inventory. Industrie 4.0 is primarily focused on this aspect, seeking to achieve three forms of integration, namely vertical integration to link management and production facilities, horizontal integration to link factories together, and end-to-end digital integration to tie together design, manufacturing, and maintenance[(1)].

Meanwhile, it is also possible to use things more wisely by collecting and utilizing data on how they are used (as shown on the right side in Fig. 1), with benefits that include optimized maintenance and more efficient ways of using these things. It is this that is the main target of the IIC, such as fitting sensors to gas turbines or aircraft engines, for example, and analyzing the data to improve things like utilization and maintenance efficiency. An improvement of 1% in efficiency can deliver significant benefits[(2)].

The progress of the Internet economy in recent years has created a variety of new practices and information links between stakeholders. This is ushering in an era of open innovation in which a steady stream of new business models are being created, such as taxi dispatch or accommodation information services. It is anticipated that this will encourage new growth by establishing new value chains and industry structures for things through cross-industry flows of big data generated from the field via the IoT[(3)].

Hitachi has long been involved in the development of the systems used in the production of things, namely the control systems used for energy, transportation, water, sewage, and other parts of the social infrastructure, and the control systems used by manufacturers of products such as steel, automobiles, and pharmaceuticals. Hitachi also has extensive experience in the development of core information systems, such as those used for finance, the public sector, and corporate information. It has proposed the symbiotic autonomous decentralization concept, which encourages new growth by drawing on the knowledge acquired through this work and supplying the value created by linking together different systems and practices to all the stakeholders involved with things.

*1 This refers not only to the products of the manufacturing industry but also to the electric power, water, and other utilities provided by social infrastructure.

This article presents an overview of the symbiotic autonomous decentralization concept and describes what Hitachi is doing to implement it.

SYMBIOTIC AUTONOMOUS DECENTRALIZATION CONCEPT

Hitachi's concept of autonomous decentralization has its origins in control systems. Drawing on advances made since the 1970s in such technologies as networks and microcomputers, Hitachi has developed autonomous decentralized control systems with excellent reliability and expandability by sharing the information required for control across controllers, servers, and other control nodes so that each node can perform its own functions autonomously based on this information. These systems have been put to use in such fields as transportation and the steel industry[(4)].

Advances in sensing, networking, and big data analytics in recent years have created the potential for open innovation through the shared use of information from plants and equipment by management and other relevant stakeholders as well as within the control system itself. In other words, control systems have evolved from being a network of things to an Internet of things that makes information more widely available. In response, Hitachi has devised its symbiotic autonomous decentralization concept, which extends the concept of autonomous decentralization described above to the system level (see Fig. 2).

In a symbiotic autonomous decentralized system, the individual systems at factories or belonging to other stakeholders act as autonomous entities. While they each operate autonomously using their own internal information, to optimize their collective operation, they also collect real-world information (sensing) and make it available in cooperating fields (shared-access platforms). The cooperating fields perform problem analyses using the wide variety of collected and archived information and plan countermeasures for optimizing both system-wide KPIs[(b)] and the KPIs for the individual autonomous systems (thinking). These countermeasures are then provided to the individual autonomous systems as feedback so that they can achieve their applicable KPIs (acting).

(b) KPI
An abbreviation of "key performance indicator." A KPI is distinguished from other indicators used to monitor the progress of business processes by pointing out particularly important indicators of performance. A quantitative index that measures the degree to which organizational objectives have been met.

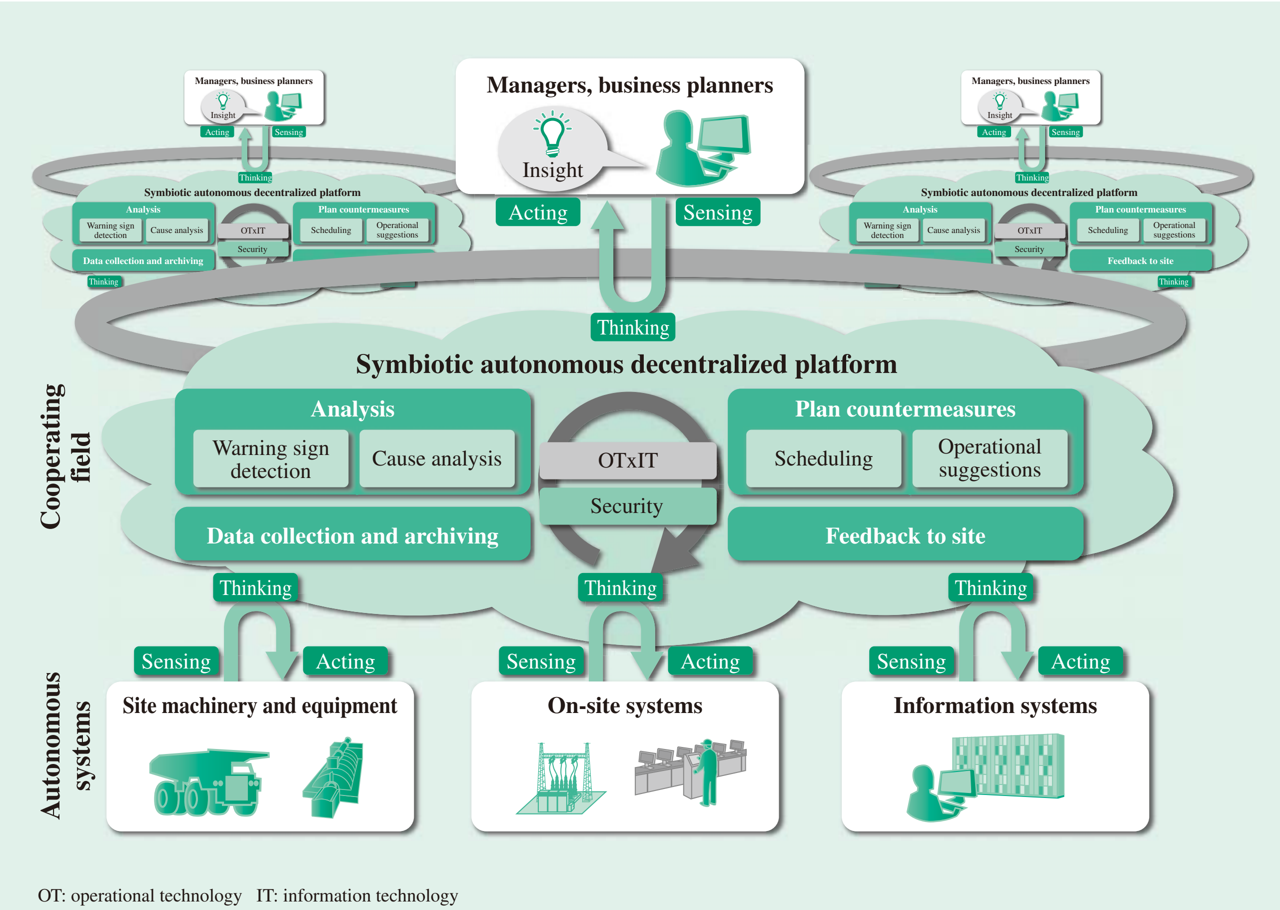


Fig. 2—Symbiotic Autonomous Decentralization Concept.
Activities can be optimized in terms of management considerations and new value chains created by collecting and archiving data from a variety of on-site systems, analyzing it and planning countermeasures, and providing information back to the site as feedback.

By using data-driven knowledge obtained via the IoT collected on the cooperating fields in conjunction with knowledge of system configurations and operation in such fields as energy, transportation, water, sewage, and manufacturing, which Hitachi calls operational technology (OT), it is possible to achieve optimal operation in ways that would not be possible by relying solely on knowledge of the individual autonomous systems. New business models can be created by sharing the various forms of knowledge generated by and collected in the cooperating fields with stakeholders from other industries.

INFORMATION AND CONTROL PLATFORM TECHNOLOGY FOR IMPLEMENTING SYMBIOTIC AUTONOMOUS DECENTRALIZATION

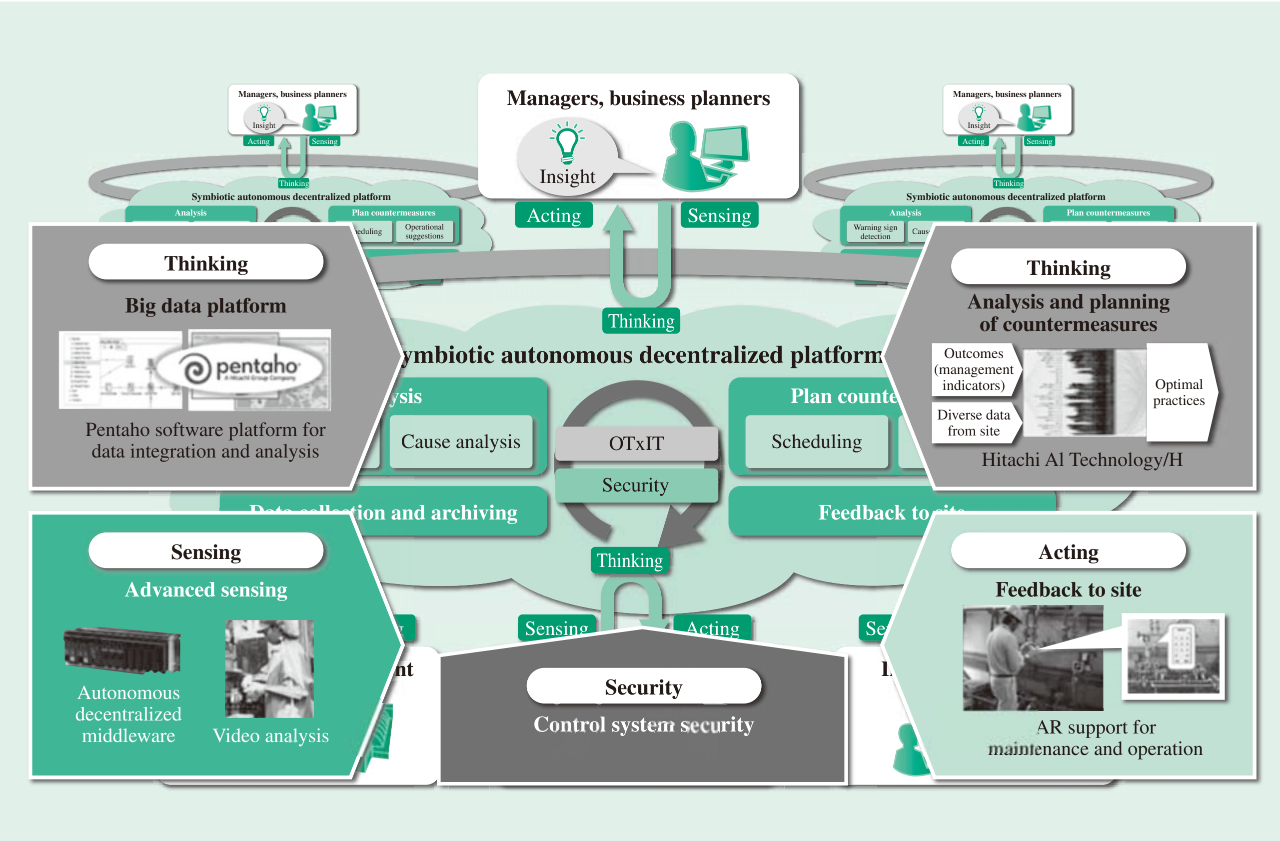
The following four requirements must be satisfied in order to implement systems based on the symbiotic autonomous decentralization concept (see Fig. 3).

(1) Advanced sensing to achieve the "sensing" objective
(2) Big data platforms for collecting and archiving a variety of data and techniques for analysis and for planning countermeasures to achieve the "thinking" objective
(3) Ways of providing feedback to the workplace to achieve the "acting" objective
(4) Security techniques to protect the cooperating fields and autonomous systems

The following describes work by Hitachi on each of these requirements.

(1) Advanced sensing

Advanced sensing requires data acquisition techniques for sending data to information systems; data that, in the past, was only used within control systems. To achieve this, Hitachi has developed communications middleware that utilizes a framework for data sharing in autonomous decentralized systems. Furthermore, as the falling cost of cameras and advances in video analysis techniques are making it possible to perform sophisticated surveillance



AR: augmented reality

Fig. 3—Technology for Building Symbiotic Autonomous Decentralized Platforms.
The required technologies include advanced sensing, big data platforms, techniques for analysis and the planning of countermeasures, techniques for providing feedback to the site, and security.

(sensing) of plant workers and equipment, Hitachi is developing techniques for tracking what is going on across entire workplaces.

(2) Big data platforms and techniques for analysis and the planning of countermeasures

Big data platforms need to deal with the three characteristics of big data, namely volume, variety, and velocity. Dealing with variety is particularly important in the implementation of symbiotic autonomous decentralization in order to handle data from a wide variety of systems. This field has seen notable advances in open-source software (OSS), and Hitachi is promoting the use of the Pentaho software platform for data integration and analysis.

For tasks such as analysis and the planning of countermeasures, there is rising demand for artificial intelligence (AI) as a way of uncovering new knowledge from large volumes of data that could not be obtained by manual methods. For this purpose, Hitachi has developed Hitachi AI Technology/H[5]. This AI takes those outcomes that are used as management indicators, and a wide variety of data from the workplace, and inputs these all at once to analyze the many relationships between this data and automatically identify the factors that have the greatest influence on maximizing the outcomes. The technology has proven its worth in a variety of fields, including logistics, plants, and call centers.

(3) Providing feedback to the workplace

This means the provision of feedback to control systems, workplace staff, and so on. In the former case, this requires modifications to systems such as MESs[c] or DCSs[d]. It is anticipated, meanwhile, that

(c) MES
An abbreviation of "manufacturing execution system." An information system used at a manufacturing plant to execute production plans. Key functions include allocation and monitoring of production resources, work scheduling, manufacturing instructions, specification and document management, plant data collection, worker management, product quality management, process management, equipment maintenance management, product tracking and product range management, and the analysis of actual data.

(d) DCS
An abbreviation of "distributed control system." The control of production or other processes in which, rather than having a single controller perform centralized control of everything, the equipment used in the system is equipped with control functions and performs integrated control with mutual coordination.

feedback to staff will become increasingly important in the future, with work proceeding on applications like the use of augmented reality (AR)[(e)] for maintenance support and the use of wearable devices.

(4) Security

Because control systems in the past tended not to be connected to IT systems, security problems were believed to be comparatively rare. In anticipation of the use of the IoT, however, control system security techniques are important for protecting systems against external cyber-attacks. Control system security requires multiple levels of defense, including security gateways that defend against intrusions from outside the system, mechanisms for detecting incidents such as unauthorized intrusions or virus infections, and security controllers that protect equipment against unauthorized intrusions or viruses. Hitachi is working on the development of these respective technologies and products.

HITACHI INITIATIVES FOR ACHIEVING SYMBIOTIC AUTONOMOUS DECENTRALIZATION

To implement the symbiotic autonomous decentralization described above, Hitachi is taking steps to apply these practices in social infrastructure and manufacturing, and is developing platform technologies. This section describes these initiatives.

Applications in Social Infrastructure

(1) Shinkansen integration system

While the Computerized Safety, Maintenance and Operation Systems of Shinkansen (COSMOS) system of the East Japan Railway Company has used an autonomous decentralized control system, the characteristics of this system were utilized in system development undertaken in preparation for extensions to the Shinkansen network (the extension of the Hokuriku Shinkansen to Kanazawa and of the Hokkaido Shinkansen to Shin-Hakodate-Hokuto[*2]). These extensions required trains to share sections of track used by other railway companies and to integrate with newly developed systems (see p. 26).

(2) Energy management for water supply and sewage infrastructure

As water supply and sewage infrastructure is a major user of energy, requirements include reducing energy costs and shifting or cutting peak demand. Hitachi is working on demand response practices that involve interoperation between water and energy systems to achieve more advanced water supply operation plans. Other work includes the optimization of treated water quality and energy consumption in sewage treatment control (see p. 34).

(3) Energy systems

The demands that will be placed on future energy infrastructure include the installation of new renewable energy capacity, upgrading of aging plants, deployment in emerging economies that suffer from skill shortages, and combining safety and security of supply with economic and environmental performance. The key to achieving these lies in stakeholders (power utilities, maintenance suppliers, equipment vendors, and users) seeking not only to find their own best solutions, but also working together to optimize the overall industry. Hitachi is working on the development of systems that minimize waste (energy losses) without compromising the autonomy of individual stakeholders by using the IoT and other information and communication technology (ICT) to collect real-world data and replicate value chains in cyberspace, and to devise measures for things like more sophisticated operation or the identification and application of knowledge (see p. 20).

Applications in Manufacturing

(1) Next-generation global production management

The objective here is to avoid major product recalls by installing cameras at assembly or machining factories to collect and analyze workplace video, including video of production machinery and workers, and by linking this video to the manufacturing execution system, so as to simplify the task of determining the scope of any defects that occur at these factories and to help in other ways such as providing feedback to production practices. Hitachi is also working on product quality improvement at a global level by consolidating and analyzing information from factories around the world to determine the cause of defects and suggest improvements (see p. 47).

(2) Steel industry control systems

Because the control systems used in the production of flat and long steel products are subject to frequent retrofits and modifications, Hitachi has long engaged in the practice of using autonomous decentralized

(e) AR
An abbreviation of "augmented reality." The overlaying of information provided by a computer onto an actual environment or object. Examples of AR techniques used in practice include providing additional information about real-world objects visible through a transparent device or camera by displaying text, images, or other electronic information over the object.

*2 The Hokkaido Shinkansen to Shin-Hakodate-Hokuto opened for business in March 2016.

systems with excellent expandability. It is also seeking to achieve more advanced control by using ICT for data collection and analysis and providing feedback to control systems in realtime. These practices have been applied to strip thickness control, and Hitachi plans to expand the scope of this use of information even more (see p. 41).

(3) Next-generation IoT-based production system for high-mix low-volume production

While Hitachi's Omika Works has engaged in improvements to design and manufacturing in the past, these initiatives have been fragmented and have not extended beyond improvements to specific areas. Accordingly, the site is building a next-generation IoT-based production system with the aim of optimizing overall operation from a management perspective while also dealing with customized products that will only grow in diversity in the future (see p. 58).

Development of Platform Technologies

(1) Vision sensing systems

Video surveillance systems are increasingly being installed to provide physical security, and Hitachi is working on the use of these as on-site sensing systems for resolving management challenges. To achieve this, Hitachi is developing video analysis techniques that can analyze video in realtime to transform it into meaningful information (see p. 53).

(2) Social infrastructure security

The risk of cyber-attack on information and control systems is growing year by year, with the increased vulnerabilities associated with use of the IoT becoming a concern. Hitachi has proposed the "Hitachi system security concept," which focuses on system-wide continuity and expandability, and supplies security solutions based on the concept (see p. 64).

(3) Information and control platforms

Implementing symbiotic autonomous decentralization requires new open-access practices for the secure collection of data from plant systems. Hitachi is developing networks, data collection middleware, and control security products that are designed for this purpose (see p. 70).

CROSS-INDUSTRY DEPLOYMENT AND OPEN INNOVATION

This article has given an overview of the symbiotic autonomous decentralization concept and platform technologies, as well as the work Hitachi is doing to implement these.

In the future, Hitachi plans to deploy this concept and technology in a variety of sectors, including energy, transportation, urban development, and manufacturing. It also aims to use open innovation to build value chains that span multiple industries, and in which diverse knowledge is shared to facilitate new growth.

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