Technotalk

Creating New Value in Social Infrastructure Systems through Fusion of Control, Information, and Components

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The demands on social infrastructure have become greater and more sophisticated in recent years. In emerging economies experiencing rapid urbanization and population growth, the requirement is to provide and operate infrastructure at low cost and in harmony with the environment. In developed economies with decreasing birth rates and aging populations, on the other hand, the requirements include further measures for dealing with the environment, more efficient equipment operation, and the upgrading of obsolete equipment. Hitachi has been involved in the provision of reliable, high-quality social infrastructure systems for many years, primarily in Japan. By combining advanced IT with control technologies built up through this work, Hitachi aims to deliver new value to social infrastructure throughout the world.

Responding to Needed System Innovations and Cutting Operating Costs

Hotta: The circumstances surrounding social infrastructure are undergoing major transformations prompted by environmental changes in Japan and elsewhere. To begin with, can you explain the recent trends and issues in electric power and railway infrastructure?

Seiji: In the field of electric power infrastructure, there has been growing interest in grid stabilization technologies in response to ongoing power system reform and measures aimed at expanding the use of renewable energy. While this period of change can be seen as an opportunity, price competition and compliance with international standards have become issues as more overseas supplies enter the market. Meanwhile, it is essential that we maintain those characteristics that are recognized as strengths of Hitachi by our customers, including our attention to detail and ability to see jobs through. Having been personally involved in information systems such as electricity and gas billing, primarily business systems for the electric power sector, I believe it is important that we consider what form future systems should take, and in doing so, that we develop a broad vision of all aspects of social infrastructure, including water and gas as well as electric power.

Ide: Since wider use of home photovoltaic power generation and other small renewable energy systems will result in a large number of generators being connected to the grid, it will make control techniques for electric power distribution even more important than before. And, since accurate purchasing mechanisms will be needed if generators in the home or elsewhere are to be able to sell their excess electric power, there will be a need for infrastructure capable of reliably performing this function. My background is in the development of generators. At the Energy and Environment Research Center where I now work, we are involved with a wide range of technologies, including renewable energy, nuclear power technology, proton beam therapy systems (an application of nuclear technology), high-voltage power electronics, information and control systems for the electric power industry, heat and energy management, wireless communications, and security. We have recently been working to develop technologies that will provide new value in the era of electricity deregulation, including operating techniques that utilize numerical analysis to predict the future state of systems such as those used for electric power distribution.

Kurokawa: In the case of railway infrastructure, reducing the cost of maintaining fixed assets remains a major challenge. While the practice in the railway industry to date has been to replace parts or perform inspection before reaching a fixed length of service or number of kilometers, companies are looking at using

status monitoring and predictive diagnosis as a way to reduce costs. I have been involved in the railway business outside Japan. In the UK, we have built our first overseas plant for maintaining rolling stock to establish the capabilities to handle everything from production to maintenance. Taking advantage of this business environment, we have implemented an online monitoring solution that provides continuous remote monitoring of the fleet status at any location by utilizing sensors and other techniques. Currently, we are collecting and analyzing data with the aim of establishing predictive diagnostic techniques. This work has attracted the interest of railway companies because of its potential for cutting costs while also maintaining reliability and safety.

Meanwhile, people around the world are working on the concept of electric trains driven by on-board rechargeable batteries. Hitachi has already commercialized hybrid rolling stock, and this interoperation and fusion of transportation and electric power systems will become even more important in the future. I believe that accurate and precise control of both electric power generation and usage, including the components that make up these systems, will make possible infrastructure systems that maximize energy efficiency.

Fusion of Information and Control Technologies Key to Innovation

Hotta: At Hitachi, we are striving to provide three "values" that we see as being essential for future social infrastructure systems. These values are: making systems "smart & smooth" by eliminating inefficiencies, ensuring that they can maintain "sustainable growth," and providing them with "security & resiliency." Making systems "smart & smooth" involves using information technology (IT) to control infrastructure efficiently, reducing social costs through measures such as improving energy efficiency or minimizing congestion, and seeking to optimize total lifecycle costs by providing operations, maintenance, and other services. Please tell us about the specific initiatives you have embarked on to achieve these.

Akatsu: "Smart & smooth" can also be thought of as an initiative aimed at combining IT and operations technology (OT) to deliver innovations in social infrastructure. A key point in this context is the use of big data. Our aim is to combine big data analysis techniques with practical business know-how so that we can deliver unique solutions that draw on the distinctive aspects of Hitachi to deliver new value. Specifically, by analyzing sensor and other operational data collected from control systems in sectors such as railway and electric power, we can determine what is happening in the field, predict what will happen next, and identify the best actions to take. The aim is to optimize activities by supplying this as feedback to operations.

For example, in January 2014, we embarked on a demonstration project of a cloud-based operation management system for mining machinery in partnership with Wenco International Mining Systems Ltd. of Canada. In addition to the future full-scale rollout of mining industry systems based on cloud services, we also intend to help make customer operations more sophisticated and cost-competitive by deploying services that run on cloud platforms supplied by Hitachi, and that incorporate industry know-how in infrastructure and in the industries that underpin society.

Ide: There is also scope for use of IT in relation to technologies for optimizing grids and making them more stable. I believe we can further improve performance by collecting and using realtime data.

Kurokawa: While the use of big data for operations and maintenance (O&M) is clearly important, there are even greater expectations for its potential to create new value through cross-industry applications that allow collected

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data to be utilized in other industries. I feel Hitachi is expected to act as a facilitator for this value creation.

Ohashi: What has become important in recent years has been to work with a diverse range of partners to resolve societal problems, and to establish the frameworks and architectures needed to achieve this. My division has been developing and supplying equipment such as control servers, networks, controllers, protection relays for power systems, and the operating systems that run on these devices. We also undertake development work to create new value with our partners, developing control platforms that can be used to introduce new services and integrate with information systems. Taking on the role of linking customers' businesses together, what we call "with HITACHI," is also one of the important aspects of achieving society-wide optimization.

Achieving Flexible and Sustainable Growth of Social Infrastructure Systems

Hotta: Because social infrastructure systems need to remain in service for decades or more, they require the flexibility, expandability, and ease of upgrading to cope with changes in society that cannot be anticipated when the systems are installed. They also need to provide a platform that can grow along with the development of the city in which they are located. This is what we mean by "sustainable growth," the second of the values described above.

Ohashi: The hardware used in control system components typically uses a lot of semiconductor devices. Since the life cycle of semiconductor devices has become shorter and more rapid these days than that of the era of mainframe computers, the rapid obsolescence of hardware is an issue for infrastructure systems that, by their nature, need to operate continuously for long periods of time. To solve this, we have adopted virtualization, the technology pioneered in the IT sector, to provide realtime virtualization for information and control servers. By extending this technology, we believe we can manage the hardware upgrade cycle effectively and protect customer assets such as their proven application software.

Seiji: Ensuring that system migrations proceed smoothly without having to make modifications to applications that need to remain unchanged is essential to maintaining long-term reliability. With uninterrupted operation being one of the prerequisites of social infrastructure systems, even more important in the future will be techniques and other know-how for making upgrades without requiring a system shutdown, just as we are able to do with railway traffic management systems.

Akatsu: Hitachi has proposed a new approach to social infrastructure systems it calls the "symbiosis-autonomous decentralized systems concept," a development of the existing idea of autonomous decentralized systems. The flexibility and high levels of extensibility of sub-systems in past autonomous decentralized systems have contributed to the provision of social infrastructure that can grow sustainably. The objective of the symbiosis-autonomous decentralized systems concept is to develop this further by getting autonomous systems that fulfill different purposes to coexist flexibly and operate harmoniously. We want to build systems that help each other, such as an arrangement between electric power and railway systems for managing energy whereby railway services are trimmed during times of peak electricity demand. Since infrastructure systems are designed autonomously to optimize operation under their own particular circumstances, having them take account of each other's requirements requires such things as a common language and the solution of complex and sophisticated computational problems. We want to turn this concept for providing sustainable social infrastructure systems into reality by utilizing Hitachi's strengths in

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diverse infrastructure system technologies for services such as electric power, railways, and water.

Building Stronger Social Infrastructure Systems

Hotta: The third value of "security & resiliency" seeks to ensure the reliability to operate continuously 365 days a year, to maintain security and privacy, and to recover rapidly from major damage caused by a terrorist attack or other disaster while continuing to deliver essential functions.

Seiji: Since data on someone's use of utilities, such as electric power and gas, provides an indication of their way of life, the protection of security and privacy will also be essential in control systems as more use is made of smart meters in the future.

Akatsu: Because control systems have been making greater use of networking and general-purpose operating systems in recent times, they need to be equipped to deal with the same sort of attacks as those faced by information systems. Also, control security must cope with more stringent performance requirements than those for information systems. Key ways of achieving this include lightweight encryption techniques and the use of whitelist methods such as only permitting access by or execution of authorized software.

With new threats appearing all the time, another approach that has been adopted, this time from the defense sector, is the "observe, orient, decide, act" (OODA) loop for ensuring that an immediate response can be mounted to a cyberattack in the event that security is breached. This seeks to minimize damage and expedite recovery by quickly observing and analyzing the situation, and then deciding on and implementing the response.

Privacy protection measures are essential to the use of big data. We are working on the development of a privacy-preserving analysis technique that can analyze encrypted data without decryption. Hitachi has succeeded in performing operations such as exact-match searches, collation of frequency statistics, and analysis of correlation rules without compromising privacy and with realistic computing times. Because the data remains encrypted at all steps, this reduces the risk of information leaks due to data being eavesdropped or stolen by the agency performing the analysis.

Since data analysis does not necessarily require raw data, anonymizing techniques are also useful. Simply anonymizing people's names is not enough to prevent them from being identified from other data. For this purpose, Hitachi uses the k-anonymization technique, which deletes or generalizes data to ensure that a minimum of *k* records with the same data exist. We have developed algorithms that reduce the amount of information lost by anonymization to utilize big data in ways that take account of privacy.

Ohashi: The CSSC (Control System Security Center) was established as a joint industry-academia-government initiative. Hitachi has worked with the CSSC since its inception, including involvement in security training and joint research into control system security. Since the control system security field, both here and overseas, is going through a period in which compliance with certification systems and other standards is becoming more widespread, I believe awareness is growing.

Hotta: What about improving resilience against disasters and accidents?

Ohashi: Management functions are essential for maintaining "lifelines" such as the use of distributed power sources during emergencies. Since enhancements are also needed for individual components, Hitachi provides not only security functions but also functional safety mechanisms into its controller products, both comply

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with international standards. Moreover, Hitachi supports maintaining control functions in a safe manner during a fault which allows control to be performed safely and flexibly.

Ide: In the future, large numbers of wind, photovoltaic, and other forms of electric power generation with fluctuating output will be connected to distribution grids. Also, the existence of power electronics equipment with the intelligence to perform active control will allow operations to be performed with response times that have never been seen on power grids before. This represents a major change. Since Hitachi has built up expertise in power electronics equipment and power system control over many years, I believe we are well placed to contribute through the fusion of these technologies.

Seiji: Power electronics equipment plays an important role in the power system infrastructure. Arrangements for sharing electric power between regions are important, not only during disasters but also in applications such as smart cities. Converters that use power electronics are a key component of such systems. I believe that possessing the core component, control, and information technologies will be a major strength for us in providing effective support for these foundations.

Kurokawa: Even globally, there are very few companies that combine all of these capabilities. Our mission is to utilize these strengths to enhance further the value of social infrastructure systems.

Hotta: To fulfill our duty to provide ongoing support for social infrastructure systems, I hope we can continue striving to develop and supply technologies that create new value.