Information & Control Technology Platform for Public Infrastructure

Yoshihiro Mizuno
Kojin Yano
Kazuya Okochi
Yuichi Mashita

OVERVIEW: To achieve a well-balanced relationship between people and the Earth that can deliver a comfortable way of life in a low-carbon society, future public infrastructure will need to adapt to changes in the relationships between suppliers and consumers through new business models and by using information in ways it has not been used in the past. This will require new ways of using information; support for devices, applications, and other elements that have proliferated with the growing diversity of service providers; and that the systems underpinning public infrastructure are reliable and able to provide trouble-free operation over the long term. To achieve this, Hitachi is developing the common IT platforms needed by the systems that support the public infrastructure.

INTRODUCTION

RECENT years have seen cities taking on new forms, including new approaches to urban development. Examples include the use of regional energy management to ensure the efficient local production and consumption of energy, including the widespread adoption of technologies such as renewable energy and EVs (electric vehicles) to help realize a low-carbon society, and making trains, buses, and other urban transportation services easier to use from a commuter's perspective in ways that transcend the boundaries between different operators.

Against this background, Hitachi is involved in the development and implementation of smart cities and other forms of public infrastructure based on its vision of a well-balanced relationship between people and the Earth.

This article describes the form taken by the IT (information technology) platforms that underpin public infrastructure systems, along with the functions required for their realization.

REQUIREMENTS FOR PUBLIC INFRASTRUCTURE SUPPORT SYSTEMS

Coping with Diversity

In conventional public infrastructures, energy is supplied by electric or gas companies, and transportation is provided by railway, bus, or taxi companies. With the advent of wind, photovoltaic, and other forms of renewable energy generation in recent years, however, there has also been a move toward consumers generating power for their own consumption or for use within the community. Beyond electric power, moves have also been made toward coordinating regional energy production and making it more efficient by centralizing the supply of heat, such as in the form of district heating and cooling systems. In the mobility sector, meanwhile, some auto manufacturers are entering service businesses such as car sharing as the consumer focus shifts from vehicle ownership to vehicle use. It is anticipated that future cities will see changes in the relationships between supply and demand, with the involvement of a wide

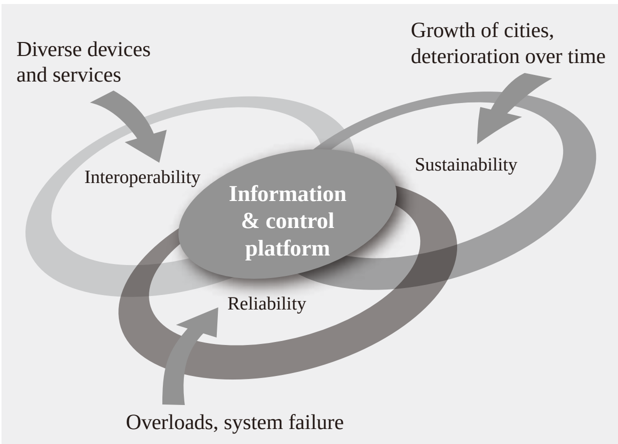

Fig. 1—IT Platform Concept for Public Infrastructure.
The IT (information technology) platform for public infrastructures handles the increasing diversity of devices and services, problems such as processing overloads, and the growth of cities and their deterioration over time.

range of different suppliers and consumers, including service providers entering new businesses and the emergence of new players. It is essential that systems are able to cope with this diversity.

Satisfying Demand for Reliability

Public infrastructure requires stable operation and security of supply. Accordingly, the systems that support public infrastructure must be sufficiently reliable that they can be accessed when and as required. In the past, the reliable and safe provision of public infrastructure services was ensured by keeping the devices and systems (including the networks that linked systems together) isolated from systems with open access. In the future, a wide variety of devices and applications will be incorporated into the public infrastructure via a range of different networks. Given this expectation, systems will need to function in a fashion that ensures that they can be built or extended in ways consistent with the scale of the city or region they serve, including both at the design stage and during operation. For those unforeseen situations when it is difficult to deliver a full range of services, it is necessary to give priority to supplying those functions that are most important to the public infrastructure if no other alternatives are available.

Coping with Growth of Cities and Long-term Sustainability

The growth of cities can take the form of both increases in size and advances in function. Recent years have seen a world-wide tendency for populations to concentrate in urban areas, and for urban consolidation and reorganization. These trends are expected to continue, making it necessary to build systems that match the size of the city and are capable of ongoing expansion. On the other hand, advances in function require advances in the applications, algorithms, and other practices for achieving more comfortable and efficient operation of public infrastructure functions. One possibility would be to measure and predict the changes in the flow of people through a city and then adjust train and bus schedules accordingly. Public infrastructures also need to deliver functions reliably over the long term. This makes it important that public infrastructure has the capacity to regenerate, and it is essential that the provision of public infrastructure functions be maintainable even in the event of an accident or when undertaking partial upgrades of functions that have become obsolete.

CONCEPT BEHIND IT PLATFORM FOR PUBLIC INFRASTRUCTURE

IT has become essential for the provision of public infrastructure. Given the increasing technical innovation and diversification of IT, Hitachi is proposing "smart city platform," which consolidates these technologies and connects together the various devices, networks, applications, and other components involved in public infrastructures (see Fig. 1).

Interoperability

The involvement of a wide range of different service providers means a growing diversity of applications and devices that need to be handled. Requirements such as data formats, data range, timings, communication protocols, and data security policies vary between the interconnecting participants. In such an environment, connectivity is achieved by managing the information collected from applications and equipment under a general-purpose data model, and also by providing standard interfaces.

Meanwhile, there is also a need for security to ensure that the device information handled within the public infrastructure is only visible to those service providers for whom it is appropriate and only to the extent needed. This involves authenticating that the people, applications, or devices that access systems are legitimate, and that they can only access the system in accordance with the authorities they have been granted. Also, data encryption is used for information sent over networks to prevent leaks due to eavesdropping by third parties.

Reliability

Ensuring the reliability of public infrastructure systems requires the prevention of system emergencies or malfunctions due to server or network failures or processing overloads. Here, the role of the platform is to maintain reliability by monitoring the current status of devices, networks, and applications, and by detecting potential emergencies or malfunctions before they happen so that operation can switch over to a different network or to backup servers if necessary.

In the case of a serious emergency, on the other hand, it is essential that the most important public infrastructure functions continue to be supplied. If a malfunction occurs due to a serious processing overload or network failure, making it difficult to continue supplying all functions, the platform selects the most important information from the large and diverse quantity of data exchanged between devices and applications so that it can be prioritized to ensure that supply of the most important public infrastructure functions is not interrupted.

Sustainability

To ensure the long-term support of a growing city, the platform ensures that systems can cope with the size of the city by allowing them to be “scaled out” (expanded) as the city grows in size. The platform also provides common functions for applications such as the visualization and analysis of data from throughout the city as functions become more advanced.

To ensure reliability over the long term, the platform improves the efficiency of things like spare parts management and maintenance staff scheduling by making it possible to monitor the many devices scattered around the city and predict when and where maintenance will be required. Equipment maintenance is also made more efficient by handling version management for the programs, firmware, and other software used in these devices, including distributing updates when programs need to be upgraded. Also, in the normal course of events, devices require replacement over time. To do this for all devices in the city at the same time, however, would be very difficult. The platform supports long-term reliability by allowing maintenance to be performed in stages, by allowing systems to continue operating even when a number of different generations of device coexist in the city at the same time, and by keeping on-site functions to a minimum with all other functions managed centrally.

OVERVIEW OF SMART CITY PLATFORM

System Architecture

Public infrastructure systems consist of devices, applications, and other components connected in a hub and spoke configuration centered on the smart city platform. In this way, the different devices and applications in each system can interoperate as well as undertake modifications or upgrades and establish connections autonomously (see Fig. 2).

The management systems for public infrastructure have a cluster configuration in which each system acts as an autonomous unit. Linking these clusters together allows interoperation between power management and transportation management systems as well as between power management systems from different regions (see Fig. 3). Examples of what this makes possible include the directing of EVs to charge stations with spare capacity based on the electric power supply and demand balance, or advanced management practices such as arranging accommodations between different regions to supply each other with electric power.

Main Functions of Smart City Platform

Applications that run on public infrastructure include some that utilize stored records from devices such as electric power demand forecasting and traffic

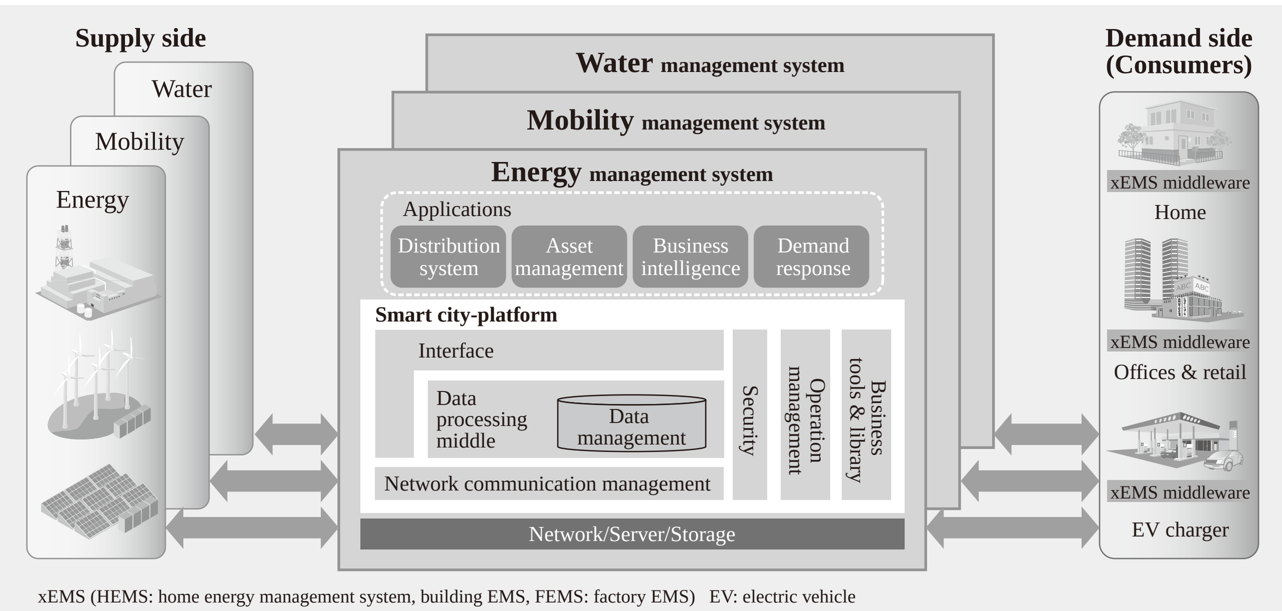

Fig. 2—System Architecture.
Public infrastructure systems connect devices, applications, and other components in a hub and spoke configuration centered on the smart city platform.

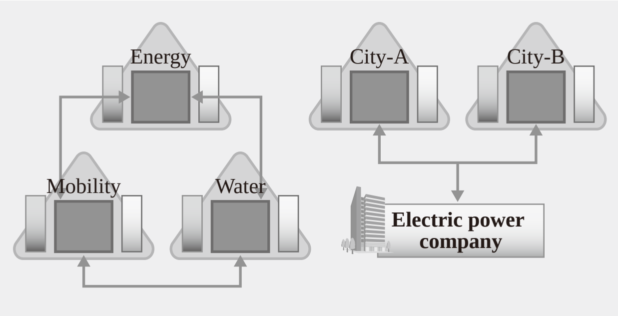

Fig. 3—Model of Links between Clusters.
Interlinking between clusters allows interoperation between different parts of the public infrastructure.

flow prediction, and some that utilize real-time equipment status information such as automation of electric power distribution and traffic management. A key challenge for the former is how to facilitate the collection, storage, and distribution of information from a diverse range of devices, while in the latter case the issue is how to ensure the rapid transmission of information between the devices and applications. The smart city platform uses its data management function to manage information from large numbers of devices and applications of many different types, and its data collection and distribution function to provide rapid delivery of device status information to applications. Table 1 lists the main functions of the smart city platform.

While the role of the smart city platform, as described above, is to provide effective interconnections between the devices, applications, and other components of the public infrastructure, its system architecture, functions, and other features can also be applied outside this realm. For example, it is also suitable for use as an IT platform for service infrastructure such as medical equipment and systems, alarms and home security systems, healthcare, education, administration, and finance. Also possible is its use as an IT platform for the urban management infrastructure that interconnects public and service infrastructure.

CONCLUSIONS

This article has described the form taken by the IT platforms that underpin public infrastructure systems, along with the individual technologies used in such platforms.

IT is making rapid progress and the next generation of public infrastructure will be supported by this advanced technology. Hitachi believes that this next generation of public infrastructure can be realized by undertaking a comprehensive redesign of the electric power, mobility, water, and other public infrastructure that in the past has evolved independently, and by sustaining coordination between each infrastructure while also maintaining autonomous and stable operation.

Hitachi intends to continue contributing to progress in public infrastructure by using the IT capabilities it has built up through its extensive experience to deliver comfort, safety, and peace of mind, without placing a burden on people and others with a stake in the public infrastructure.

TABLE 1. Main Functions of Smart City Platform
These are the main functions of the smart city platform.

Components	Description
Interface	• Collect information from a wide range of devices and supply required information to business applications and other services. • Provide interfaces that comply with IEC and other industrial standards. • Provide high-speed transmission of control information. • Provide xEMS middleware for authentication, communication control, encryption, operational management, and so on.
Data processing	• Convert between data formats used by different devices and applications. • Use stream data processing to handle device data, such as alarms.
Data management	• Use a general-purpose data model suitable for energy, water, mobility, and other public infrastructures to manage device configuration and operational (status and logs) information.
Network communication management	• Measure and monitor communication performance for exchange of information between devices, applications, and other components. • Benchmark communication performance.
Security	• Control authentication of devices, services, and users, and access to information. • Provide encryption techniques that comply with the encryption standards and authentication practices required in different countries in a swappable module configuration.
Operation & maintenance	• Monitor operational status of devices, applications, etc. • Handle version management and upgrades for firmware.
Business tool & library	• Provide unified management of the devices, users, and applications that connect to service systems. • Generate and collect billing logs based on use. • Maintain library for integration with analysis tools, GIS, and other software.

IEC: International Electrotechnical Commission GIS: geometric information system

REFERENCES

(1) Y. Yoshikawa et al., “New Social System ‘CEMS’ Concerting Supply and Demand toward a Low Carbon Society,” Hitachi Hyoron **92**, pp. 592–595, (Aug. 2010) in Japanese.

(2) Y. Yoshikawa et al., “Actions for Realizing Next-generation Smart Cities—Working both to Protect Global Environment and Achieve Prosperous Urban Lifestyles that are Secure and Convenient—,” Hitachi Review **60**, pp. 291–296, (Oct. 2011).

(3) H. Tadokoro et al., “Information and Control Systems Contributing to Reliable, Secure, and Sustainable Waterworks / Sewerage Systems,” Hitachi Hyoron **93**, pp. 606–611, (Sep. 2011) in Japanese.

ABOUT THE AUTHORS

Yoshihiro Mizuno

Joined Hitachi, Ltd. in 1991, and now works at the Business Planning Department, Smart Information Systems Division, Information & Telecommunication Systems Company. He is currently engaged in strategic planning and the design of ICT-platforms.

Kojin Yano

Joined Hitachi, Ltd. in 1996, and now works at the Social Infrastructure Systems Research Department, Yokohama Research Laboratory. He is currently engaged in research and development of ICT-platforms. Mr. Yano is a member of the Information Processing Society of Japan (IPSJ) and The Operations Research Society of Japan.

Kazuya Okochi

Joined Hitachi, Ltd. in 1999, and now works at the Enterprise Systems Research Department, Yokohama Research Laboratory. He is currently engaged in research and development of security for smart city systems. Mr. Okochi is a member of the IPSJ.

Yuichi Mashita

Joined Hitachi, Ltd. in 1991, and now works at the Smart System Middleware Solutions Department, Smart Information Systems Division, Information & Telecommunication Systems Company. He is currently engaged in the development of ICT-platforms for smart cities.