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Information-driven Social and Business Innovation

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Message from the Planner

With advances in information technology (IT) and networking has come the widespread adoption of mobile devices and social media, and this in turn has led to individuals becoming the source of a wide variety of information. Also expanding is the scope of application of machine to machine (M2M) systems that connect sensors and other equipment to networks to collect information or control their operation. The quantity of data these systems produce is growing year by year.

Providing social infrastructure that allows people to live prosperous and secure lives, building a society that promotes long and healthy lives, and delivering value chain innovation and creating new business models that facilitate business growth while also reducing the load on society and the environment require an approach to using information that can transform the large amounts of different types of data generated by daily life and corporate activity into new forms of value. It is this that provides the motive force for innovation.

Hitachi’s core Social Innovation Business generates new value by fusing and integrating the infrastructure system technologies we have built up over many years with advanced IT, including cloud computing and big data utilization.

This issue of Hitachi Review focuses on advanced IT applications that drive innovation and the utilization of big data, one of the core elements of these applications.

The Overview article covers business and social infrastructure, and also discusses the big data that provides people with new value and the associated use of analytics. Subsequent articles describe platform technologies and provide examples of big data utilization in various different fields, while also explaining what Hitachi is doing to encourage smarter practices in fields like agriculture, logistics, and healthcare and the latest trends in the IT platforms and networks that support this work.

Through this issue, I hope that you can learn more about what Hitachi is doing, and that our solutions, services, and products can be of some help for innovation in your businesses or in wider society.

Planner for this issue
“Information-driven Social and Business Innovation”

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New Business Trends Created by Big Data Utilization

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NATURE AND PURPOSE OF BIG DATA

AWARENESS of the term "big data" has risen in recent years as it has become a topical subject with frequent references in the news media. Many of these references have dealt with the analysis of customer purchasing activity acquired from loyalty cards, point-of-sale (POS), or other sources of data, with the emphasis tending to be on the large quantity of data involved. This has led to a misunderstanding in some quarters by people who assume that big data is nothing to do with them because the volume of data handled by their system or business is small.

In fact, the true nature and purpose of big data is the ability to utilize information acquired from large amounts of different types of data that was ignored in the past, or other heterogeneous data. Big data and its associated analytics can be seen as a foundational technology for supporting and enhancing future business activities, social infrastructure, and lifestyles.

This article summarizes and explains the new value generated by the use of information produced by big data and its analysis.

EXPANSION IN SCOPE OF IT RESULTING FROM USE OF BIG DATA AND ITS ASSOCIATED ANALYTICS

The predominant form of information technology (IT) in the past has been the processing of forms and other business data (transaction processing). In the meantime, however, digital devices such as personal computers (PCs) and smartphones have become ubiquitous, and with this have come the availability of high-speed network connections and the generation of large quantities of different types of digital data. Unfortunately, this data is still far from being fully utilized, with its value often left unappreciated or unexploited. This is true even of information that is relevant to business, such data on people's activities or the status of production equipment or social infrastructure.

On the other hand, there do exist companies that have recognized this value and have used it to build business models. These include Amazon*1, which has developed internet sales techniques that utilize the large quantities of data collected on customer's purchasing behavior and patterns, and Google*2, which utilizes information from collecting and evaluating search keywords in applications such as internet advertising. The current situation is that new businesses or services are starting to appear that collect data, even though the quantity of data may not be that large nor its scope world-wide.

Balance of IT Costs and Benefits

Behind this interest in big data is a dramatic fall over the last decade in the cost of the IT required for data collection and computational processing. The benefits of this data collection and analysis now outweigh its costs, a situation that seems likely to continue for some time (see Fig. 1).

Increasing the amount of data being processed and analyzing it to get a better understanding of various performance indicators will help improve the efficiency of commercial activity. Similarly, measures aimed at new business processes or incremental cost savings that result from the falling cost of IT will be able to be trialed without risking expensive losses. These trials can then be used in an ongoing cycle of quantifying improvements, establishing new indicators, and implementing actions.

Data with New Possibilities for Use in IT

This raises the questions of what new data is now able to be utilized, and in what new ways. The following lists the underlying changes brought about by big data and its associated analytics.

(1) Use of previously unused data

The falling cost of IT means that data that in the past was collected but not used, or simply discarded, can now be put to use (examples include past transaction records, text-based information, and operation logs).

*1 Amazon is a trademark of Amazon.com, Inc. or its affiliates.
*2 Google is a registered trademark of Google Inc.

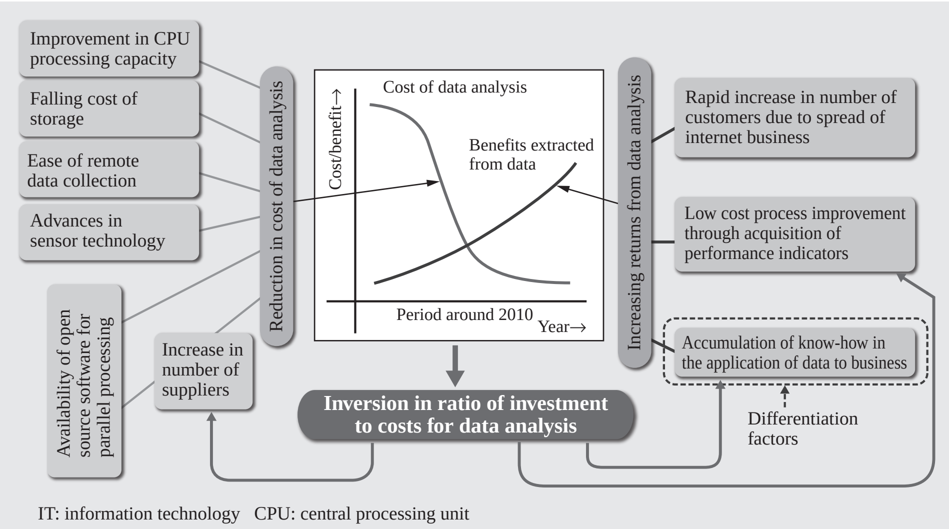

Fig. 1—Reduction in Cost of IT and Use of Data Analysis to Boost Profits.
The cost of the IT required for data analysis has fallen dramatically over the last decade. As a result, the benefits of data analysis now outweigh the costs.

(2) More things can be measured

Advances in sensor, network, and other technologies mean that phenomena that could not be measured in the past can now be captured in the form of data [examples include the operational status of machinery, worker activities, or posts on social networking services (SNSs)].

(3) Discovery of new data or knowledge

As data increases in quantity and becomes more comprehensive, it becomes possible to extract new data or knowledge by collating this data or subjecting it to more sophisticated analyses. This has been described as the process of "data begetting data" (examples include the correlation of customer profiles and their purchasing behavior, or of equipment status and faults).

Hitachi classifies the use of big data for business into five main categories based on the source of the data, and is researching and developing solutions for each of these (see Fig. 2).

The aim is to create more opportunities for applying these to business by expanding the scope of IT. Ways of doing this include developing new sensors for data acquisition or developing special-purpose data collection and analysis techniques.

NEW COMMERCIAL VALUE ADDED BY BIG DATA

This section describes the commercial value added or otherwise made possible by big data and its associated analytics. The methods and benefits of analyzing and utilizing data can be grouped under a number of different patterns (see Fig. 3).

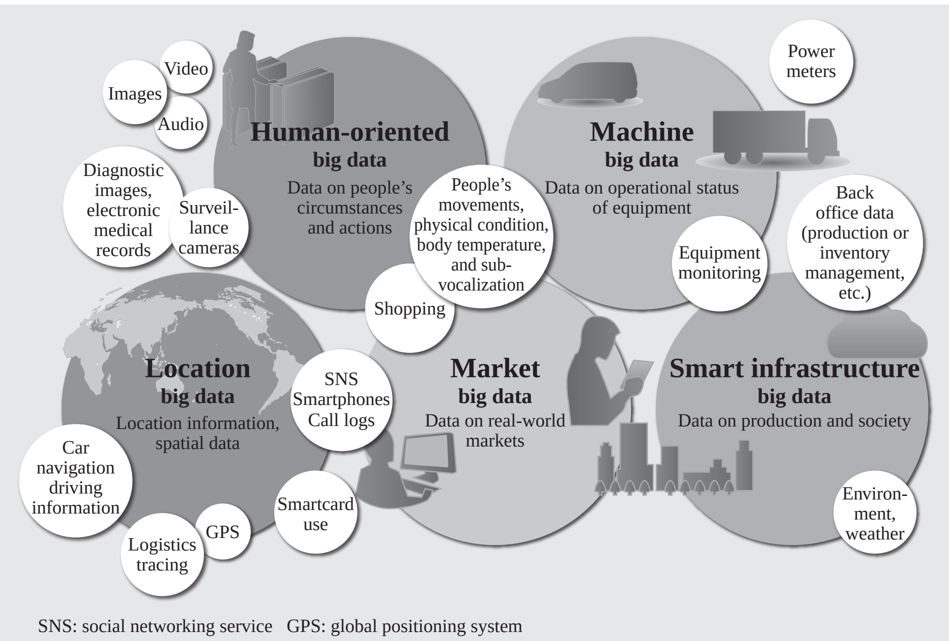

Fig. 2—Five Types of Big Data Businesses.
Data can be broadly divided into five types based on its source: human, machine, location, market, and smart infrastructure.

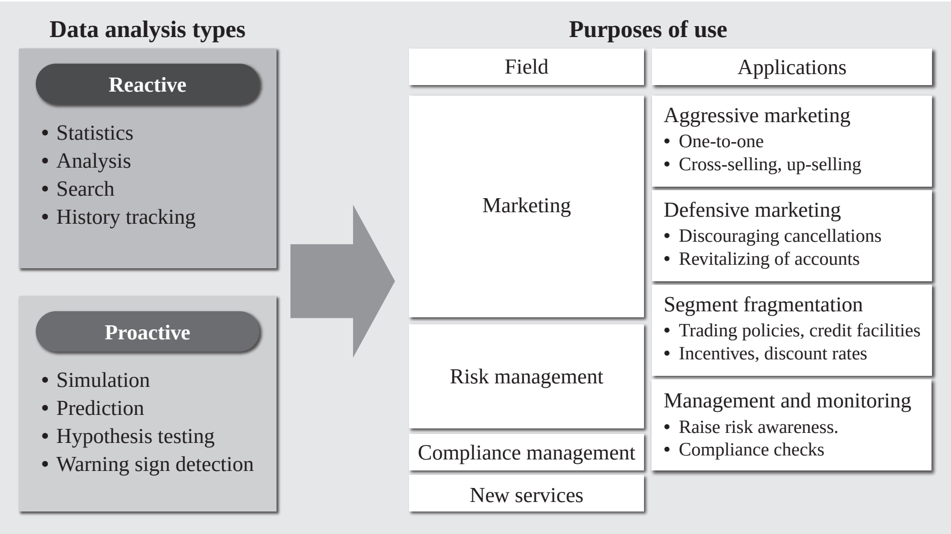

Fig. 3—Categories of Data Analysis and Purpose of Use. Data analysis can be broadly divided into reactive (reviewing and assessing) and proactive (prediction and inference). Purposes of use include marketing, risk management, compliance management, and the development of new services.

The analysis of data can be used to determine cause and effect relationships, consider new perspectives, or create new performance indicators, while the collection of real-world data from front-line systems, for example, can improve the accuracy of business management and provide more information for making decisions. Also, new business processes or businesses can be created using this information and the associated processing techniques.

The following sections consider this added business value in terms of its relationships with customer businesses, manufacturing, and social infrastructure respectively.

Relationship with Customer Businesses

Firstly, big data can be used to get a better understanding of customers, and to create new relationships or business opportunities. If knowing your customer is the basis of business, then big data has a major contribution to make.

Many companies act as if they know their customers when in fact they do not. Naturally, such companies have customer databases in their business systems and their sales staff collect information through their daily activities. However, this information often remains unused, being left dispersed and not collated together. It is also often the case that the information held by a company is not enough on its own to see more than a one-sided view of customer behaviors or profiles.

The term “personalized marketing” is used to refer to sales and marketing practices in which in-depth analysis of customer information is used to obtain a clearer and more detailed image of the customer. The basis of big data analytics lies in collecting together data from across the company, such as past sales or other transactions, communications with the customer, or use of website or other services, and using it to obtain a more personalized appreciation of customers and to analyze its correlation with sales figures or other information. The knowledge gained by this process can then be put to use in achieving more accurate sales and marketing practices. Amazon’s recommendations produced from an analysis of purchase histories and activity on the web, and the resulting impulse purchases, are examples of personalized marketing.

This exploitation of information on customer activity is beginning to move away from being the exclusive preserve of the internet, with increasing bricks and mortar applications involving the acquisition of customer information. The following are two examples of this trend.

(1) Use of sensors to track customer movements

This involves using business-card-sized sensor nodes fitted with infra-red and acceleration sensors to detect face-to-face communication between wearers, what is known as “human-oriented big data.” Infra-red laser sensors are also used to determine the location of people within an area. Technologies like these allow the creation of selling environments that can deliver higher sales by collecting and analyzing detailed and accurate data on the movement of customers around a store, for example, and then using the results to improve the store layout, displays, advertising, or other merchandising methods.

(2) Use of data from different industries

New business opportunities can also be identified by collecting and analyzing information from outside the company. One example is an insurer that uses various types of vehicle telematics information to offer pay-as-you-drive car insurance.

Relationship with Manufacturing

Just like customer relationships, there are also cases in the manufacturing industry where companies do not have good knowledge of their own products. It is not uncommon, for example, for a manufacturer to lack an overall understanding that encompasses design information, production technology, production information, and post-sales maintenance information. In fact, there are surprisingly few cases of manufacturers with a good grasp of things like how their products are used in practice and their operating status.

If correlations between technical information such as on a product's design and manufacturing and information on its operation, faults, and maintenance could be analyzed by product or by serial number, the information could then be utilized in quality or functional design. Also, the availability of information on actual operating status opens up the potential for new business processes in maintenance and inspections and after-sales and other services. These are important differentiating factors that potentially add value to the product. New products that make greater use of digital technology include large numbers of sensors, and utilizing the information these generate is a source of added value for businesses. An example is a Japanese copier manufacturer with a strong international market presence that collects information such as operational status and errors via a network and utilizes it for tasks such as maintenance and design.

This use of new processing techniques for big data is also happening in the machine-to-machine (M2M) sector. In the past, even if data could be collected from sensors, it was only able to be used for things like simple threshold-based control or fault detection. Now, however, big data processing techniques can process large quantities of sensor data concurrently and utilize more sophisticated algorithms to make accurate operational decisions. Furthermore, high-speed networks mean that this advanced monitoring and operation can now be performed remotely.

Hitachi supplies the Global e-Service on TWX-21[(a)] to support all aspects of machinery lifecycle management, and is working on strategies for using M2M to achieve smarter operation in agriculture, logistics, and mining.

(a) Global e-Service on TWX-21
A software as a service (SaaS) lifecycle support service for Japanese corporations that manufacture and sell machinery on the global market. It manages the lifecycle of machinery by collecting information on its manufacture, sale, operation, and maintenance, and by making this information available for shared use. Hitachi Construction Machinery Co., Ltd., Hitachi's construction machinery business, operates the service for the global market and delivers the functions of Global e-Service, which collates the collected business know-how, over Hitachi's TWX-21 inter-company business media service. TWX-21 is a trademark of Hitachi, Ltd.

Relationship with Social Infrastructure

Whether it be in social infrastructure or people's way of life, opportunities exist for utilizing big data and generating added value.

Social infrastructure covers a wide range and is made up of complex equipment and services. Furthermore, each form of infrastructure, such as electric power, water, or transportation, has been operated independently. Integrating IT with the operation technology (OT) systems that control the social infrastructure in order to make it more efficient and sustainable is one of the objectives of Hitachi's Social Innovation Business. The wide variety of data and information obtained from social infrastructure is a genuine contender for being treated as big data.

Adding value to the utilization of information in social infrastructure means that each type of infrastructure can be operated in the best way possible and advanced services delivered through the coordination of this infrastructure. Open data is also being used by other businesses and other organizations, where "open data" means public data held by national or local government that is made available in a form suitable for repurposing. Using optimized social infrastructure to support the lifestyles and activities of individuals is another form of added value achieved through the use of information.

Examples of optimizing the entire social infrastructure include electric power transmission and distribution systems that incorporate renewable energy, and traffic systems based on road information and data on people's movements. Other examples of supporting the lifestyles and activities of individuals can be found in the use of information in the healthcare sector.

REQUIREMENTS FOR UTILIZING BIG DATA IN BUSINESS

A number of issues need to be resolved for big data to be utilized in business, including providing the necessary personnel and environment.

Business Knowledge × Analysis × IT

Utilizing big data in business demands a higher level of knowledge and understanding of business than was required in the past. When strong correlations, points of difference, or other findings are identified by the analysis of data, it is necessary to explain their

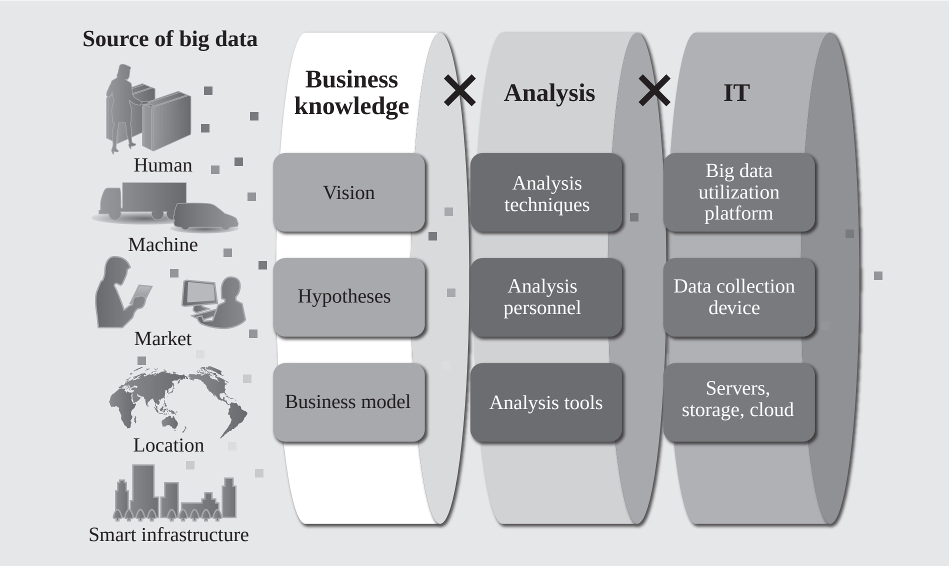

Fig. 4—Business Knowledge × Analysis × IT.
The use of big data in business requires a combination of business knowledge, analysis techniques, and IT.

meaning and to assess their impact on the business. There is also a need to plan for approaches and scenarios through which business can incorporate new knowledge acquired from analysis. What is required to achieve the utilization of big data is a combination of business knowledge, data analysis capabilities, and IT (see Fig. 4).

Hitachi defines data analytics meisters(b) as experts who draw out the customer's business knowledge and act as leaders in putting big data to use, and is working to build on these talents. Hitachi is also working on integrated platforms designed specifically for big data, including middleware and high-speed data access platforms.

New Skill Set Focused on Information Value

In contrast to past business systems designed with consideration for processes and their associated processing, systems that deal with big data focus on the value of information. Naturally, it is necessary to acquire new skill sets and have appropriate personnel in place. Although there are similarities with past skill sets in terms of the technical aspects of IT, there are also issues relating to skills acquisition and transition that will require time and effort to overcome (see Table 1).

(b) Data Analytics Meisters
These are experts at Hitachi with a high level of knowledge and skills in the utilization of big data. Data analytics meisters lead customers or other partners who are seeking to create new business value from big data through the steps up to final system installation. These include building a vision for the utilization of big data, scenario planning in which quantitative estimates are made of the targeted value, and feasibility studies that establish the data analysis techniques to use and verify factors such as the performance of the system implementation and the viability of the scenarios.

Literacy in Real-world Numbers

Business management involves deciding on important performance indicators and then working steadily through the plan, do, check, and act (PDCA) cycle to achieve them. What is important is to set quantifiable performance indicators and to measure progress toward their achievement. What cannot be measured cannot be managed. On the other hand, having a large number of things able to be measured provides more alternatives for action, and this is the only way to improve management accuracy. That is, the use of information that incorporates big data also provides more performance indicators and methods.

While a value of 1% in statistics or samples is often assumed to be error (and therefore meaningless), a 1% value measured from real-world data is a real difference of 1%. The meaning of data is changing. It is becoming increasingly important to understand data and information, and to use it as a basis for business decisions and actions.

TABLE 1. New Skill Set Focused on Information Value
The new skill set can be considered in terms of how it compares with the past.

Past skill set	New skill set
Computational and processing logic	Analytics
Program	Algorithms and mathematical models
Programmer	Data scientists
Processing speed and response	Complexity and precision
Accurate coding and standardization	Hypothesis-based reasoning and testing
User interface	Visualization and infographics
Business design	Business model design

BIG DATA AS SOURCE OF NEW BUSINESS CREATION

The use of big data technology is a means, not an end. Ultimately, all IT provides are things like scale, volume, and speed. It is people who need to provide business with its values, ideas, and insights.

Big data and its associated technologies are a genuine source of new business creation. With its philosophies and objectives, Hitachi intends to take on this challenge, and to deliver the sort of value that only Hitachi can provide.

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Hitachi Data Processing and Distribution Service for Telematics

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OVERVIEW: The rapidly advancing automotive sector is showing interest in enhancing services that use big data. Work is proceeding on how to make use of the diverse telematics data held by vehicle manufacturers and others, with growing demand for highly reliable platform services for utilizing this information that provide easy ways of working with information across different business areas. In response, Hitachi has established its data processing and distribution service for telematics. The service uses Hitachi data centers to analyze and process a variety of vehicle information acquired by vehicle manufacturers through telematics based on contracts with vehicle owners, and then distribute this information to companies that wish to use it in accordance with their contractual arrangement with the vehicle manufacturer. This provides a basis for creating new services and helps improve the overall level of convenience in society.

INTRODUCTION

WITH interest in big data from a wide range of different sectors, there are also growing moves in the telematics sector aimed at analyzing and utilizing large quantities of traffic and other information for business or public purposes. This includes information on traffic volumes and congestion, such as “probe information” (data on vehicle use) collected from vehicles. However, the service providers wanting access to this probe and other information are many and varied, including, for example, companies that provide services to car owners, suppliers of energy services such as home energy management systems (HEMSs), and tourism and other service operators. For each of these organizations to develop and implement their own systems is not practical.

Hitachi has launched its data processing and distribution service for telematics to collect, store, and process probe information received from vehicles, regardless of the vehicle model or manufacturer, and to provide information such as records of vehicle use to telematics operators.

This article describes Hitachi data processing and distribution service for telematics that performs structural analysis and processing of probe information and other data collected from vehicles to make it suitable for use by service providers such as non-life insurance companies.

HITACHI’S APPROACH TO BIG DATA SERVICES

A variety of fields are showing interest in the utilization of big data, with a number of initiatives being pursued. Based on know-how in a variety of fields and partnerships built up over time with different industries and companies, Hitachi is working on big data services that operate across a large number of different industries (see Fig. 1).

Background

Greater use is being made of information technology (IT) in machinery and business operations across all industries, with information such as sensor or customer data being utilized in business. However, because this information is collected independently by different companies or departments and applied to specific applications, business initiatives that involve combining or otherwise integrating data are difficult to implement.

Hitachi has an extensive track record of work in a wide range of different business sectors. In the energy sector, for example, Hitachi is developing energy management systems that manage distribution systems or distributed power generation, give access to information on carbon dioxide (CO_2), and coordinate demands. Similarly, for the equipment management sector, Hitachi is developing analysis services that support preventative and other maintenance. The

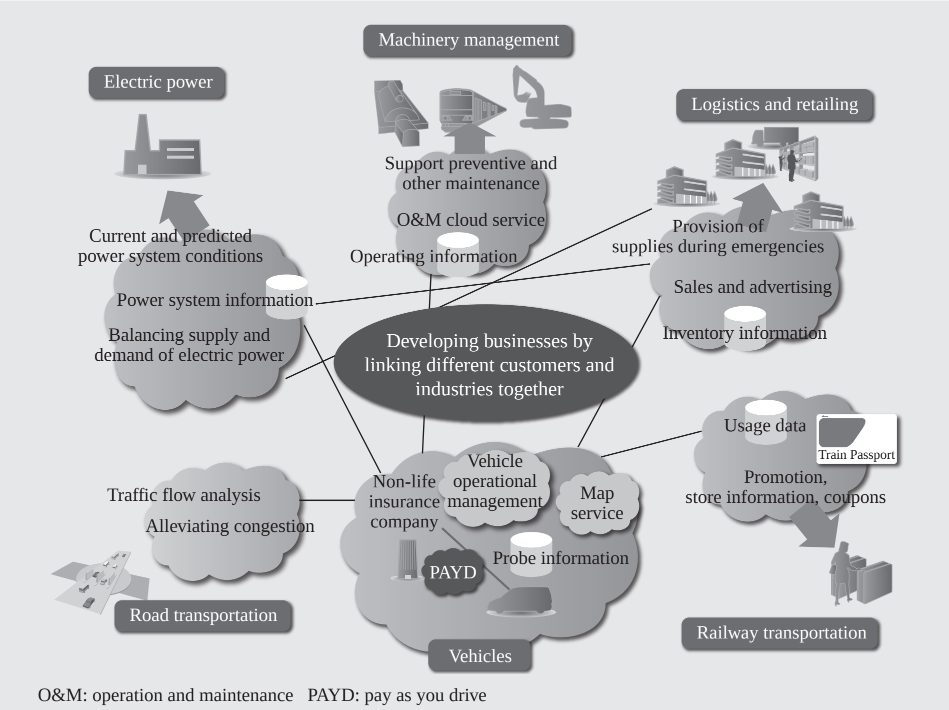

Fig. 1—Hitachi's Planned Big Data Services.
Hitachi is deploying big data services in fields such as electric power, machinery management, and marketing. It intends to create new businesses in the future by linking these data together.

objective is to add to the value that big data provides to different industries and service providers by allowing them to share and use data among themselves.

Data Services for Telematics Industry

Interest in the utilization of telematics data as a form of big data has also arisen in connection with the provision of new added-value services that complement safe and comfortable vehicle travel. However, there is a data acquisition cost associated with the collection and utilization of telematics data from vehicles. Also required are mechanisms for collecting the data. Establishing these separately for each company or service is impractical.

Hitachi is working on the development of services for appropriately hosting the telematics data held by vehicle manufacturers, and that utilize its own technology, know-how, and channels to provide efficient methods for the integrated use of this data across different applications.

HITACHI DATA PROCESSING AND DISTRIBUTION SERVICE FOR TELEMATICS

Service Overview

The data processing and distribution service for telematics launched by Hitachi is a cloud-based service that receives vehicle big data (records of vehicle use and other data collected by telematics communication units) from vehicle manufacturers, subjects it to structured analysis and other processing, and then distributes it to companies that want to use it for the development of new services (see Fig. 2).

The service has been adopted as the integration system for utilizing data collected from Nissan LEAF[*1] electric vehicles (EVs) sold by Nissan Motor Co., Ltd. in the car insurance scheme introduced by Sompo Japan Insurance Inc. in July 2013. This is a pay-as-you-drive (PAYD) scheme in which policy holders pay for insurance based on their actual distance driven. In addition to this PAYD data delivery service, other services introduced by Hitachi in October 2013 provide probe information files and a probe information application programming interface (API) (see Fig. 3).

These services centrally receive and store the probe information collected by vehicle manufacturers from different regions and types of vehicles, and then convert it to the data formats required for distribution to the participating systems and services. By storing this collected probe information in a database and providing an API for accessing it, Hitachi operates a global service that provides participating service providers with easy access to this probe information.

Service Features

The service can be provided globally through a system built in the cloud. It includes a multilingual help desk with support available in Japanese, English,

*1 Nissan LEAF is a trademark of Nissan Motor Co., Ltd.

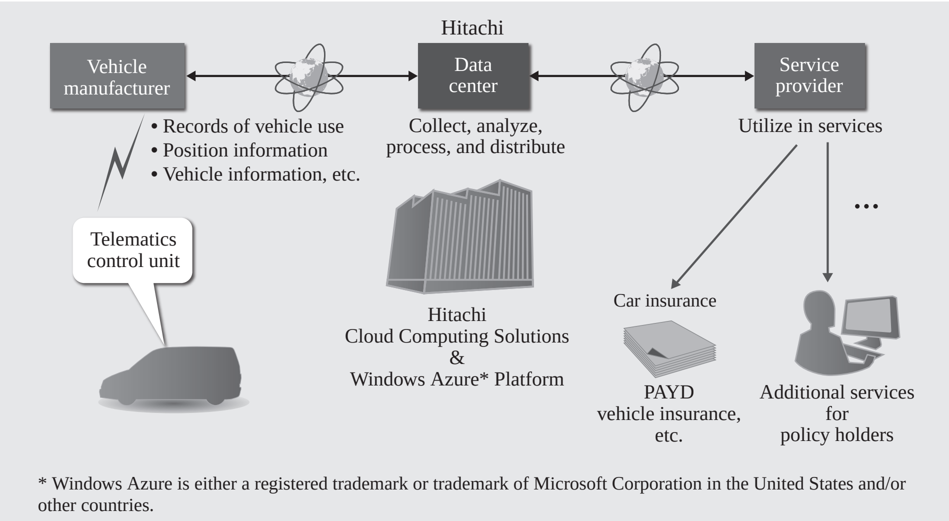

Fig. 2—Overview of Hitachi Data Processing and Distribution Service for Telematics.
This overview of how the service integrates shows the processes from collection of probe information (records of vehicle use and other information) from vehicle manufacturers through to its use by service providers.

and Chinese, is able to maintain 24-hour-a-day system operation, and can link to service providers in Japan and overseas.

The intention is to provide the following forms of added value to vehicle manufacturers, associated service providers, and others.

(1) Development of services using probe information API

An API is provided for extracting specified data based on different search criteria from the accumulated historic probe information. Service providers can use this API to operate services that use probe information.

(2) Use of probe information by vehicle manufacturer

Structural analysis is necessary for systems to use probe information. Hitachi supports the analysis of probe information by vehicle manufacturers through

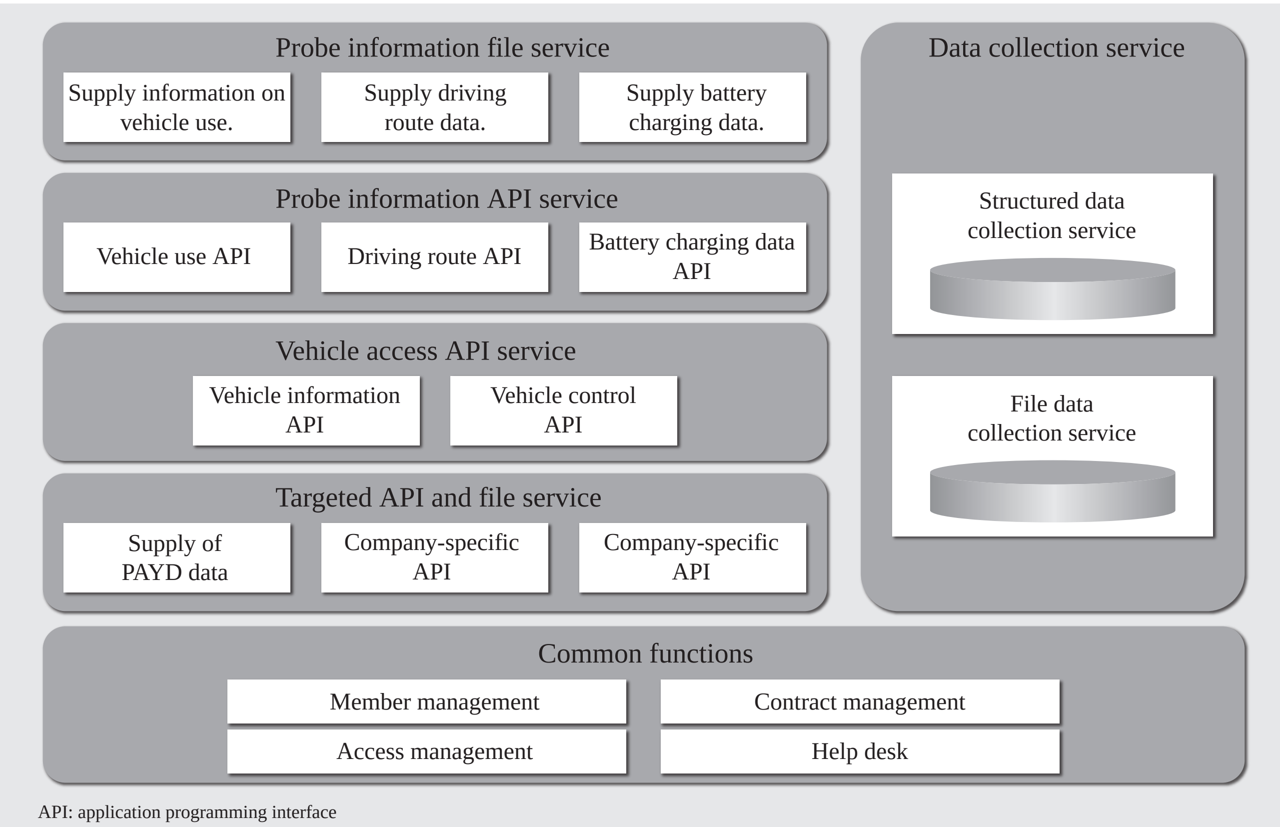

Fig. 3—Service Structure.
Hitachi data processing and distribution service for telematics has this structure.

providing file-based integrations for probe information that has undergone this structural analysis.

(3) Use of vehicle access API to improve convenience for vehicle owners

This uses an API for accessing vehicle information in realtime to provide service operators with added value such as tracking of stolen vehicles or battery charging control.

(4) Control of information supplied to each service operator

The vehicle manufacturer can control which data to make available to each service operator. It is possible to restrict each operator to only the minimum data they require, such as operators who only use speed data or charging data, for example.

(5) Storage of required data only

The service can limit collection of the various data contained in probe information to only those items used by services. This minimizes the potentially high costs of big data collection.

(6) Conditional processing of data

The service can process and deliver data based on the requirements of service providers.

IMPROVING SECURITY OF PERSONAL INFORMATION

Probe information includes the vehicle's identification number (VIN). Combined with other information, the VIN can be used to identify individuals. Although Hitachi does not keep information that could link VINs to individuals, it does treat VINs as personal information. The following functions are also provided for safeguarding personal information.

(1) Data use permission function

This ensures that only VIN data approved by the vehicle owner can be used, and only for specific applications. Data for which permission has not been obtained cannot be used.

(2) Encryption of personal information

Personal information is stored by the service in encrypted form. The data can be supplied to service providers in encrypted form.

(3) Communication encryption

Encrypted communication is used to distribute data. Data is protected by the use of secure sockets layer/transport layer security (SSL/TLS) and secure shell (SSH) when sent via the internet, and by security architecture for internet protocol (IPsec) when sent via virtual private network (VPN).

(4) Internal data storage network

Probe information and associated analysis results are collected and stored on an internal network with no direct access from outside. Hitachi has also installed intrusion detection system (IDS) for a demilitarized zone (DMZ) to monitor unauthorized access.

FUTURE SERVICE EXPANSION

Hitachi data processing and distribution service for telematics currently includes a service that supplies

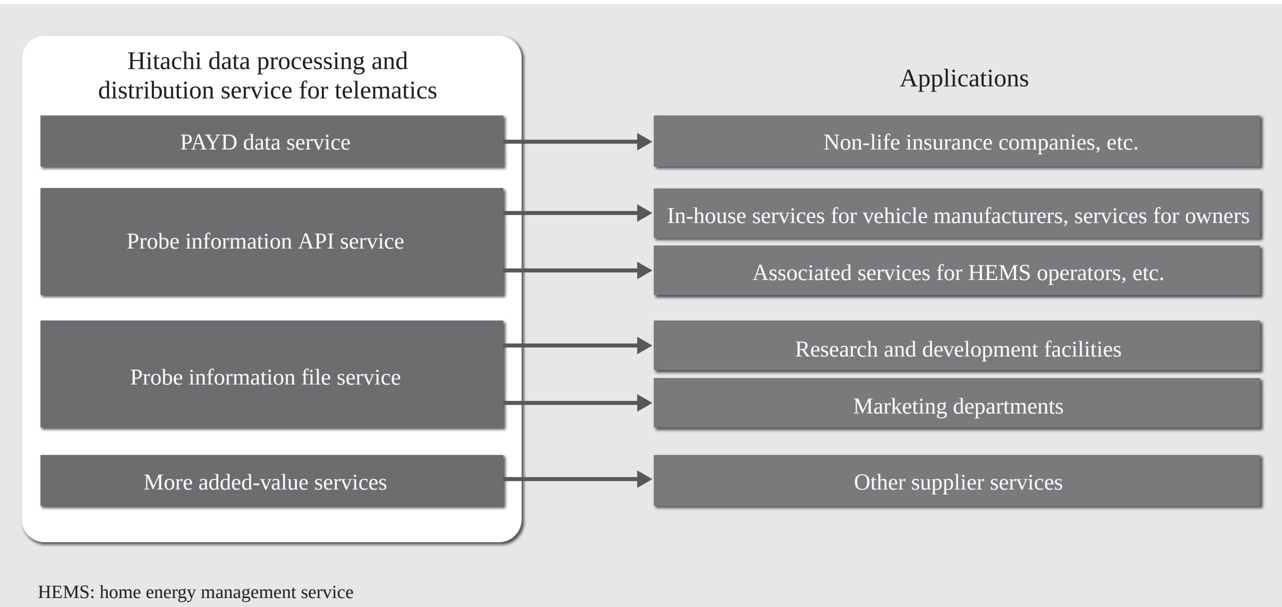

Fig. 4—Future Service Expansion.
Hitachi is considering the progressive introduction of new services, such as services for HEMS operators.

PAYD data to insurers and a service that provides the probe information API.

In the future, Hitachi intends to expand into a series of new services, such as a service for HEMS operators that integrates with HEMSs to support the use of EVs for energy storage or the use of household batteries, and a data integration service that supplies data to marketing departments or research and development facilities that use probe information in product or new business development.

In addition to the processing and distribution of probe information, Hitachi is also considering services that integrate with other services such as logistics or operational management, or new cross-domain services that work in conjunction with other industries, such as telecommunications operators (see Fig. 4).

CONCLUSIONS

This article has described Hitachi data processing and distribution service for telematics that performs structural analysis and processing of probe information and other data collected from vehicles to make it suitable for use by service providers such as car insurance companies.

Hitachi is helping to raise the overall level of convenience in society by strengthening links with vehicle manufacturers and associated service providers to create new services.

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New IT Solution Using Human-oriented Big Data Analytics

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OVERVIEW: There has been a shift in recent years toward innovation and the creation of new value being the wellspring of corporate competiveness. By working in collaboration with customers on big data analysis through its data analysis service, Hitachi is fostering creation of a series of services that extend from the discovery of new knowledge to the development of IT solutions that can put this knowledge to use in decision making in the customer's business. Hitachi is also investigating the possibilities of a new IT solution that analyzes quantitative data on human behavior (human-oriented big data) to consider unconscious behaviors and identify hidden opportunities or risks. Work is also proceeding on the use of behavior data collected from business-card-sized or wristwatch sensor nodes to support strategies in marketing or sport.

INTRODUCTION

THERE has been a shift in recent years toward innovation and the creation of new value being the wellspring of corporate competiveness, and this has drawn attention to the use of big data to uncover new value. Behind this is the ongoing collection of large quantities of different types of information in the form of digital data, a consequence of the spread of sophisticated portable devices such as smartphones or tablets and of social networking services such as Twitter* or blogs, and the extensive adoption of business management applications.

However, there are three problems in the way of turning this big data into something of benefit to companies.

The first problem is that big data is a mixture of both significant and useless information. Because there is a limit to how much data a single person can process, extracting the significant information is not easy. Instead, what is required is to define what is of value to the customer, namely the key performance indicators (KPIs), and to filter the data accordingly.

The second problem is that ad hoc attempts to take account of the knowledge obtained from data when implementing plans are insufficient. Instead, what are required are solutions that can utilize the extracted knowledge and make improvements on an ongoing and self-sustaining basis.

The third problem is that the results of analysis inevitably depend on the type of data able to be collected. To provide value to customers, it is important to keep looking for ways of unlocking fresh potential from new types of data.

Hitachi has introduced its data analysis service to deal with these problems, applying all of its strengths to the task of creating value. In the first step, a "meister" (expert) works collaboratively with the customer at an upstream process to clarify a vision before utilizing large storage systems, parallel and distributed processing techniques, and statistical analysis to extract meaningful data from big data. Next, the meister conducts analyses that consider the business system implementation. The aim is to support customer's strategy formulation and execution by providing an information technology (IT) solution that can perform continuous monitoring of the identified key indicators.

Furthermore, recognizing that more than 70% of workers in Japan are employed in service industries[(1)], Hitachi believes that extracting knowledge from multifaceted data on people is essential to improving competitiveness. Accordingly, Hitachi has been looking at the analysis of human-oriented big data (data on people's activities) and investigating its potential for developing service support solutions that take account of people's unconscious behaviors.

This article outlines the data analysis service and describes examples of human-oriented big data analysis and the potential for future IT solutions.

DATA ANALYSIS SERVICE

In its data analysis service, Hitachi has formalized the process of extracting the value inherent in big data (see Fig. 1).

* Twitter is a product name, trademark or registered trademark of Twitter, Inc.

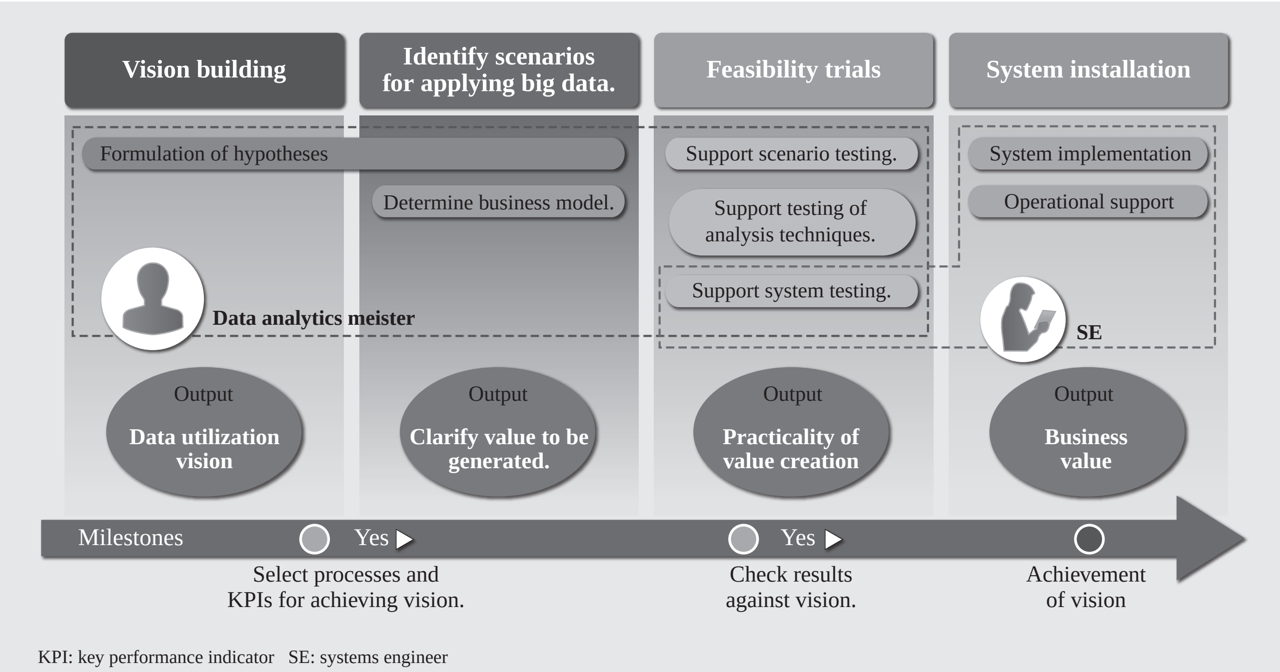

Fig. 1—Steps Handled by Data Analysis Service.
While working collaboratively with customers to propose and test hypotheses, Hitachi provides support for all steps up to system implementation and operation. The four steps are: (1) vision building, (2) identify scenarios for applying big data, (3) feasibility trials, and (4) system installation.

An important factor in the utilization of big data is to improve the efficiency of the processes leading up to and including feasibility trials that seek to demonstrate the relationship between business value and the results of data analysis. Accordingly, Hitachi seeks to help fully realize its customer's vision by employing data analytics meisters and focusing on working alongside the customer to propose and test hypotheses. Once it has been demonstrated that the vision can be realized using perspectives contained in big data, the meister and Hitachi systems engineers (SEs) work together on the system design in order to provide the customer with an IT solution. This service consists of the following four steps.

(1) Vision building

Hitachi works with the customer to clarify and agree on the vision for big data utilization. Examples include optimizing the paths taken by visitors to a website or bricks and mortar store, using the collection of comments from a customer service center or the analysis of reputation on social media to enhance customer satisfaction, or using preventive maintenance to improve the utilization of plant and equipment.

(2) Identify scenarios for applying big data

This involves formulating hypotheses on how to achieve the targets based on a thorough understanding of the customer's business. A series of hypothetical scenarios are devised, including deciding on the types of data to use as input, which data processing techniques to use, the likely results of data analysis, and how these results can be utilized in the company's activities.

(3) Feasibility trials

These are intended to verify whether the analysis of big data delivers valuable knowledge in terms of the vision. An experimental environment is established to test the hypotheses using mathematical and statistical analyses. This frequently involves obtaining data from the customer and conducting trials on Hitachi's cloud computing systems.

(4) System installation

The requirements for the customer solution are determined based on the results of the trials. This is followed by development, testing, installation, and operation, with the work being progressively handed over from the data analytics meister to the SEs responsible for system implementation.

HUMAN-ORIENTED BIG DATA AND ITS POTENTIAL

A broad definition of service industry includes not only retail workers but everyone who creates value through interaction with other people, including teachers, call center operators, medical professionals, and sportspeople. It is estimated that more than 70%

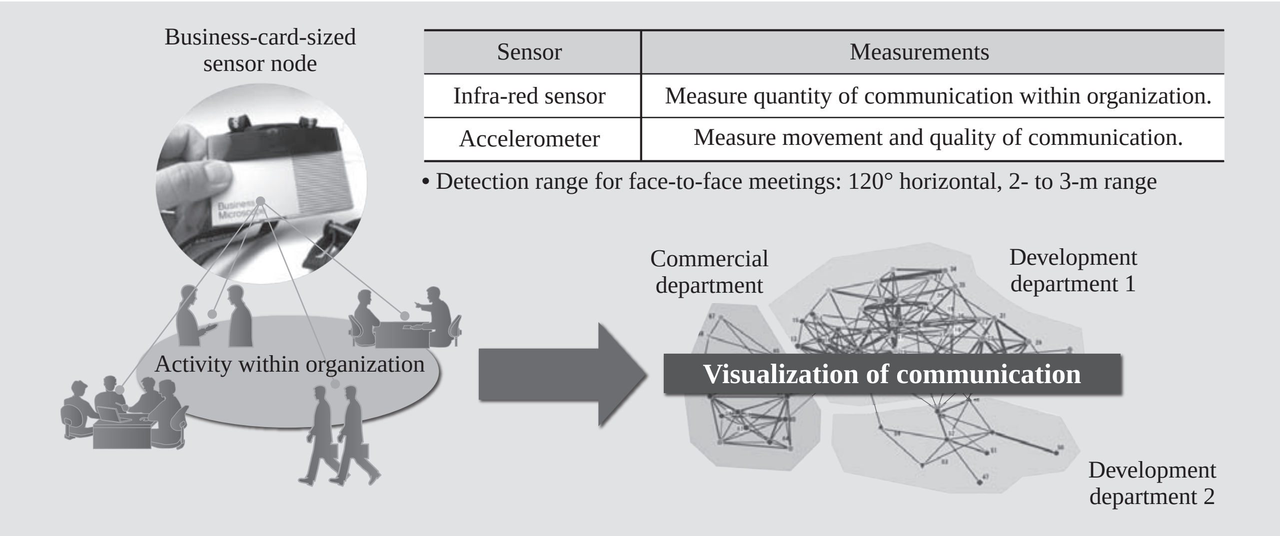

Fig. 2—Business Microscope.
This uses business-card-sized sensor nodes to obtain quantitative data on the quantity and quality of communication between wearers, and their activity patterns.

of the workforce in Japan is employed in services. Because people are both the creators and recipients of value in service industries, the extraction of knowledge and in-depth analysis of people are factors in business success.

This section uses the term human-oriented big data to refer to quantitative records of people's behavior, actions, and circumstances. While some initiatives have begun to emerge, such as analyzing the flow of information through Twitter or other social networking services and utilizing this in marketing(2), practical examples of the fully fledged use of human-oriented big data in business decision-making remain rare. In the future, the comprehensive analysis of human-oriented big data that has been collected from a variety of sources offers the potential to identify opportunities or risks inherent in services, and to do so in ways that take account of people's unconscious behaviors.

To collect this human-oriented big data, Hitachi is developing business-card-sized (business microscope) and wristwatch (wristband-based life recorder system) sensor nodes.

"Business Microscope" Business-card-sized Sensor Nodes

The "business microscope" business-card-sized sensor nodes provide a means for collecting data on the activity of a number of people(3). Incorporating infra-red and acceleration sensors, the sensor nodes are worn around the neck and can detect communication between fellow wearers and identify activity patterns (such as working at a desk, walking, or attending a meeting). In the case of communication between fellow wearers, they can collect data on who is actively engaged in the communication based on bodily movement(4) (see Fig. 2).

Wristband-based Life Recorder System

The wristband-based life recorder system provides a means for collecting 24-hour-a-day data on the wearer's activities(5). The sensor nodes are fitted with accelerometers to collect second-by-second data on activity patterns (such as walking, running, or sleeping), levels of activity [metabolic equivalents (METs)], and depth of sleep from small movements in the wearer's arm. For example, a visual representation of someone's lifestyle pattern can be presented by plotting their level of activity over the course of a day (see Fig. 3).

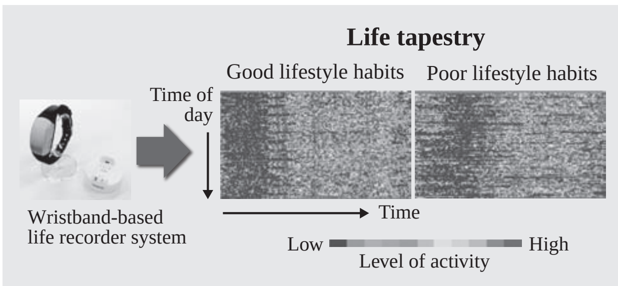

Fig. 3—Wristband-based Life Recorder System.
This uses an accelerometer to measure parameters such as actions, activity level, and depth of sleep. By collecting data over a long period, it can provide an overview of the wearer's lifestyle pattern.

SOLUTIONS FOR UTILIZING HUMAN-ORIENTED BIG DATA

IT solutions that unlock new potential in services can be implemented by utilizing human-oriented big data and applying the solution-building techniques of the data analysis service. This section shows what can be achieved by presenting actual examples in which the steps described above [(1) vision building, (2) identify scenarios for applying big data, and (3) feasibility trials] were put into practice.

Support for Marketing Strategies: Performance Evaluation of Dating Event

Shrinking and aging populations have become a major issue for outlying towns in Japan in recent years. In response, an increasing number of local governments are staging dating events to encourage couples, both from within the region and elsewhere, to meet and settle down.

This project involved working with the local government and using the business-card-sized sensor nodes to measure communication between participants. The aim was to obtain knowledge about the operation of the event in order to increase participant satisfaction and the number of successful couples that resulted. The analysis focused on the number of people engaged in conversation, who they spoke to, and whether they were speaking or listening. The results showed that conversations between people who were good talkers and attentive listeners went on the longest, and that while groups of a number of people formed naturally, there were some who were left out of the conversation.

This knowledge in turn provided ideas that helped improve the quality of the event, including recommending which participants were likely to have a good affinity and providing advice on how to increase the opportunities for conversation. It also indicated the potential for creating future solutions for supporting marketing strategies that are aimed at maximizing customer satisfaction at corporate exhibitions or inter-industry get-togethers, for example. Other similar examples include projects aimed at improving the sales performance of call centers and retail stores(6).

Support for Sports Strategies: Performance Evaluation for Football

It is becoming more common for sport to call on the capabilities of science and technology. Hitachi participated in a demonstration trial aimed at strategic team building and player development at the Kashiwa Reysol Academy, a training academy for under-18 players run by the Kashiwa Reysol team in the Japan Professional Football League.

The demonstration analyzed a week of wristband-based life recorder system data from each player to determine the relationships between their lifestyle rhythm and their training and match-day performance. In addition to energy expenditure, number of steps, and distance covered, the performance analysis also looked at the type of running, such as whether they were dashing or jogging. What it found was that the quality of activity differed depending on factors such as how the game was progressing or the player's positional role (see Fig. 4).

The analysis of lifestyle rhythm, meanwhile, considered daily sleeping and study schedules as well as the level of routine activity and the quality of sleep. It was found that performance was being affected by taking a nap before training and a lack of nighttime sleep due to having a long commute to school.

An issue for the staff of the Kashiwa Reysol Academy in the past has been that they have had no way of knowing about a player's circumstances off the field. The demonstration showed that having an understanding of the length and quality of sleep and

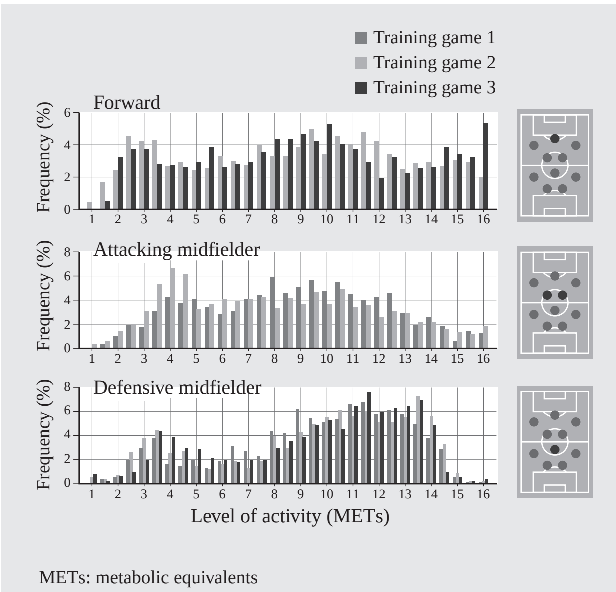

Fig. 4—Application to Under-18 Players at Kashiwa Reysol Academy.
The graphs plot the match performance of players in different positions acquired using wristband-based life recorder system. Their different characteristics are represented by the frequency of different levels of physical activity. This approach also helps with lifestyle management by analyzing lifestyle rhythms and sleep patterns over 24-hour periods.

the resulting degree of tiredness was valuable for providing lifestyle advice to these young players who are seeking to become professional footballers. By collecting data over longer periods of time to provide an insight into things like player and team growth or their cycle of peaks and troughs, this approach should also be able to help with deciding on game-day strategies.

These results show the way forward for implementing solutions for the sports and fitness sector that aid things like human resource development, condition management, and the formulation and execution of team strategy.

CONCLUSIONS

This article has outlined the data analysis service and described examples of human-oriented big data analysis and the potential for future IT solutions.

Hitachi has established the Smart Business Innovation Laboratory to facilitate the work of its data analytics meisters. The laboratory brings together the capabilities of specialists from a variety of fields, including data analytics researchers and consultants and SEs with expertise in the implementation and operation of systems in areas like business intelligence (BI) and high-volume data processing.

Hitachi's business divisions are domain experts who are deeply familiar with their specific industries. By utilizing the existing results of work by its research and development divisions, and through collaboration between these business divisions and Hitachi's customers and other partners, Hitachi is able to proceed with big data utilization in a wide variety of fields.

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Big Data Collection and Utilization for Operational Support of Smarter Social Infrastructure

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OVERVIEW: Progress is being made on the use of information-control platforms for the collection of social infrastructure data and its utilization in fields such as electric power and EV operation. In addition to the collection of social infrastructure data, information-control platforms also have a role in large-scale data analysis (big data) and as analytical databases that span different applications. They can provide a means for optimizing the operation of social infrastructure through their use as a platform for big data analysis involving the collection and analysis of information on electric power, EV use, and equipment operation. Hitachi is currently working on the use of information-control platforms for data collection in projects in Japan and elsewhere, and has plans to add additional functions for utilizing this data.

INTRODUCTION

RECENT years have seen the rise of an approach to urban development that is associated with terms such as "smart cities" or "smart communities"[1]. In addition to enhancing the convenience of existing social infrastructure for services like electric power, water, and transportation, this also includes the introduction of new social infrastructure that helps reduce greenhouse gas emissions and other loads on the environment, such as photovoltaic and wind power generation or electric vehicles (EVs). The combination of new and old infrastructure is seen as a way of making society more comfortable as well as safe and secure. It involves understanding patterns of use or consumption and making appropriate operational decisions to ensure that the many different types of social infrastructure function efficiently. To achieve this, there is a need to identify trends by using information technology (IT) to collect and analyze information on the operation and use of social infrastructure. Because of the nature of this data, its frequency of collection, and the size of activity records, its quantity is expected to be large enough to justify the term "big data."

This article describes how big data is used on an information-control platform[2, 3] (referred to below as the smart city platform) for the efficient operation of social infrastructure, with a particular emphasis on its use in power system management, transportation, and especially EV operation.

OPERATION OF SOCIAL INFRASTRUCTURE USING SMART CITY PLATFORM

The smart city platform plays an important role in understanding the changing patterns of use or consumption, and in taking account of this knowledge in the operation of the many different types of social infrastructure to ensure efficiency (see Fig. 1).

Role of Smart City Platform

The roles of the smart city platform are (1) data collection, (2) data analysis, and (3) coordination of the systems (applications) that operate social infrastructure (see Fig. 2). Given the interrelationships between different social infrastructure systems, this supports the implementation of new operational applications that take account of these interrelationships by supplying data that has been collected from these systems and analyzed.

The following sections describe data collection, data analysis, and application coordination.

Data Collection

The smart city platform includes a database function. In addition to data on equipment performance and configuration data such as the topology of links between equipment (network information), it also handles the collection and management of large quantities of other data, including data on the supply of a diverse range of social infrastructure along with details of consumption or use, and records of

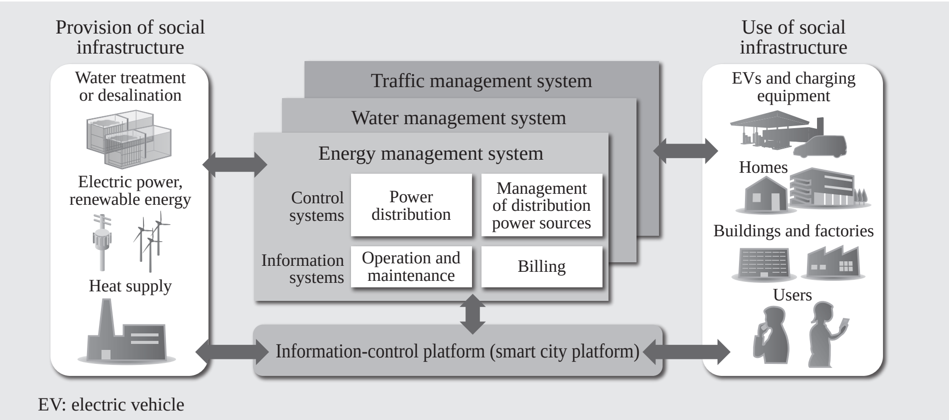

Fig. 1—Functions and Roles of Smart City Platform.
In addition to collecting data from different types of social infrastructure, the smart city platform is also used for analysis and to improve the efficiency of social infrastructure operation.

equipment operation, malfunctions, and other journal data. For example, data on the supply of electric power is collected from sensors fitted to power plants, transformers, and other equipment. Similarly, details of consumption are collected from sources such as smart meters installed in buildings, home energy management systems (HEMSs), building and energy management systems (BEMSs), and EV charging equipment. Over a wide area, this can add up to tens of millions of items of data to be collected. By collecting and managing this information in the form of historical data, it is possible to determine power use over a wide area.

The smart city platform also has a bus function[2] that is used to collect control information. The bus buffers equipment control information sent from control applications in memory before forwarding it to the destination device. The buffered data is also saved in the database. This provides a latency guarantee, meaning that the control information is forwarded on within the allocated time, without having to wait for processing by the smart city platform.

The smart city platform also collects journal data at intervals of between several seconds and several minutes, including data on equipment operation or alarms (notification of malfunction). This provides timely updates on whether equipment is operating normally or malfunctioning, and allows the extent of the flow-on effects of any malfunction to be determined with reference to the network configuration. As this journal data can also be collected and managed in the form of historical data, it can be used to detect or infer potential malfunctions.

Data Analysis

Analysis can add value to collected data. The analysis data is used for high level decisions in control and prediction applications. Accordingly, the analytics

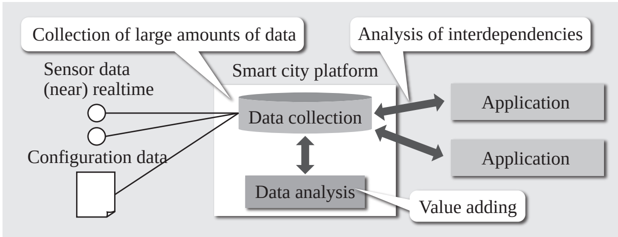

Fig. 2—Roles of Smart City Platform.
Smart city platforms enhance the value of social infrastructure data through data collection, data analysis, and application coordination.

functions on the smart city platform fall into the following two categories.

(1) Functions able to prepare data required by applications

(2) Functions able to be used by a number of different applications

The following three functions are important for data analyses used by a number of different applications.

(1) Data interpolation

This means interpolating the overall situation from collected sampling data.

Electric power data, for example, may not be able to be collected from all buildings. Instead, statistical analysis or other techniques are used to estimate power use for the entire district.

(2) Prediction

Collected data is time-stamped and stored in the database. Changes in historical data can be analyzed to identify trends. Because prediction accuracy improves as more data is collected, potential applications include situations that are continuously changing, such as determining trends in electric power or water use, or assessing conditions such as traffic congestion.

(3) Knowledge acquisition

The analysis of historical data can identify trends and extract knowledge. Information on things like electric power, water, or traffic congestion depend on the time of day, date (whether it is summer or winter, weekday, weekend or long holiday, etc.), and location (residential or commercial district, etc.). These categories can be used to determine the applicable parameters for prediction.

Application Coordination

Data collected from social infrastructure and data obtained from analysis is made available to applications and used in ways that take account of the interdependencies between different parts of the infrastructure, including control and predicting usage. Because of this interdependency between different types of social infrastructure, the smart city platform helps coordinate applications by exchanging data between them.

One example is the way in which greater use of EVs increases demand for electric power (for charging vehicle batteries). Accordingly, by collecting all information on EV use, it will be possible to determine factors such as which areas (sites at which charging equipment is located) and which times will have a high demand for electric power. Similarly, interrelationships also exist between existing grid power and renewable energy. If power use information such as times of peak demand can be obtained, it is possible to determine the times when renewable energy will be used. Also, predictions about the deterioration of facilities can be made by coordinating information about the provision and use of electric power or EVs with enterprise asset management (EAM) systems.

EXAMPLE DEPLOYMENTS OF DATA COLLECTION USING SMART CITY PLATFORM

Hitachi is currently seeking to implement data collection functions on smart city platforms and deploy them in projects involving smart cities or smart grids in Japan and elsewhere. In the future, Hitachi also plans to implement them as an analytical database by developing and deploying functions for the analysis of collected data. The system configurations used in the projects are described below.

Example projects for making social infrastructure smarter include initiatives that involve electric power management and the wider use of EVs. The system characteristics are listed below (see Fig. 3).

(1) Collection of electric power data by micro demand management system (μDMS)

Information on power use is collected from smart meters installed at buildings or other sites by systems called μDMSs that manage energy use for a district. The smart city platform collects power use data from the μDMSs and sends back control data specifying adjustments to power use that it has received from the applications.

(2) Coordination of renewable energy and existing grid power

Hitachi is building systems that manage not only existing sources of electric power such as thermal power generation, but also combine it with electric power from renewable sources such as photovoltaic and wind power. Because of its weather-dependence, use of renewable energy involves storing it in storage batteries. The storage batteries are also used to store electric power at times when tariffs are low. The smart city platform collects data on the storage and discharge of renewable energy.

(3) Coordination with EVs

EVs have a shorter range than vehicles that use an internal combustion engine. Accordingly information is collected from EVs on location, speed, steering, and remaining battery level. Information about power consumption and usage is also collected from charging equipment and used for applications such as advising drivers on where to go for charging.

DEPLOYMENT FOR BIG DATA UTILIZATION

The smart city platform delivers added value to providers and users of social infrastructure by collecting and analyzing big data, such as equipment

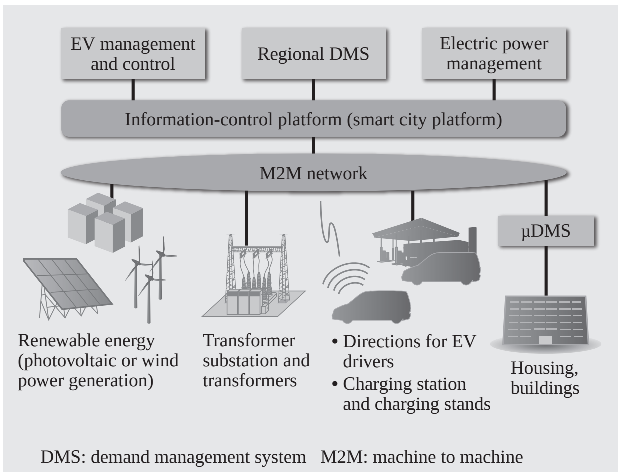

Fig. 3—Deployment of Smart City Platform for Collection of Electric Power and EV Data.
Smart city platforms are adopted and evaluated for the collection of data on electric power operation and use.

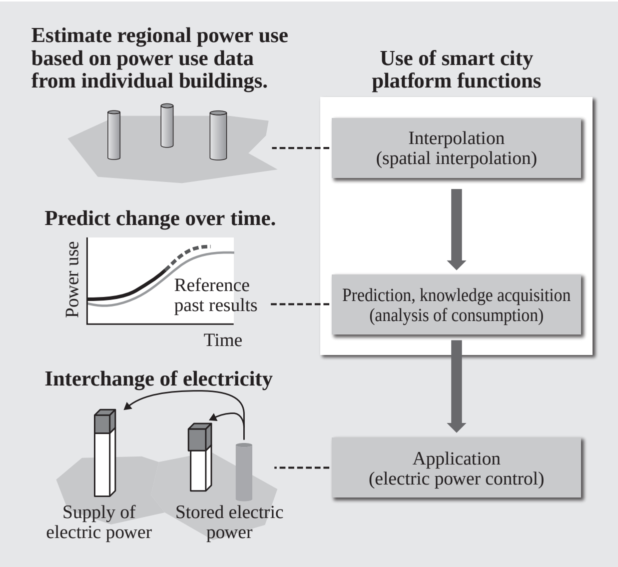

Fig. 4—Analysis of Big Data on Electric Power.
The smart city platform provides functions for prediction and the analysis of electric power data, and supports its use by applications such as electric power distribution.

journal data or information on EVs or supply and demand for electric power, and by coordinating this with applications (see Fig. 2). The following sections give an overview of future applications for big data processing(4).

Deployment in Smart Grids

Smart grids are a way supplying electric power in the best way possible and combining it with the discharging of storage batteries to shift the timing of peak demand. They are being built in conjunction with renewable energy from photovoltaic or wind power generation. Because the operation of smart grids is based on the analysis of information such as the balance of supply and demand, or supply and demand including the discharging of storage batteries, it is seen as a field with potential applications for big data processing (see Fig. 4).

(1) Identification of trends in use of electric power by district or building cluster

Residential, commercial, and industrial districts are each likely to have different patterns of power use. This means that precise assessments of trends in power use can be made by using statistical processing to detect changes in power use in specific districts or in clusters of similar buildings.

(2) Support for electric power supply decisions

The storage of electric power in storage batteries not only helps supply power to the district, interchange arrangements can also be established to supply power to other areas. The best times to discharge the batteries can be determined by analyzing how power use fluctuates. The system also works out how to discharge the batteries in situations such as when there is a risk of damage to equipment due to reverse power flows caused by voltage differences becoming reversed. When a number of households are generating photovoltaic power, this information can be used to determine the order in which batteries should be discharged and to operate the system so as to minimize equipment deterioration caused by discharging.

Deployment in EV Management and Control

When driving an EV, it is essential to monitor power consumption and take care not to run out of battery power. However, it is not ideal for the driver to be continuously having to deal with all this monitoring on their own. Instead, to ensure safety for EV users, it would be better to provide a service that notifies the driver of available charging equipment, taking account of waiting and charging times. Achieving this will likely involve management and control of EVs together with monitoring and notification functions. This means that big data processing will be an effective tool for providing information to drivers based on information on EV use (see Fig. 5).

(1) Providing directions to charging equipment

If the location of an EV is known, suitable charging equipment can be identified. Together with the collection of information from charging equipment, including its future schedule, this means that drivers can be directed to the charging equipment with the shortest waiting time when the level of charge in their EV is running low. The directions in this case are provided by the car navigation system. By applying statistical analysis and prediction functions

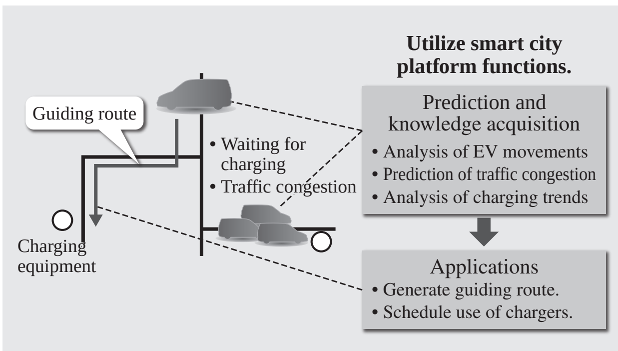

Fig. 5—Analysis of EV Big Data.
The smart city platform analyses things like traffic congestion prediction and possible guiding routes based on information from EVs such as location or remaining battery power.

to location and speed information from a large number of vehicles, it is possible to identify which roads are congested (road sections in a traffic jam) or estimate how long it will take to reach the charging equipment. Furthermore, the availability of accurate arrival time predictions improves the convenience of EV use because it allows the use of charging equipment to be scheduled and drivers to be informed of how long they will need to wait before their vehicle can start charging.

(2) Redirecting EVs in accordance with predicted charging power use

Frequent use of the charging equipment in a particular area will increase power use in that area and potentially affect other consumers. Accordingly, if the system predicts heavy use of a particular set of charging equipment, drivers will be directed elsewhere to avoid the excessive concentration of load.

Deployment in Equipment Monitoring

Collection of journal data includes data on the operational status of control, production, or communication equipment, and on faults or malfunctions. Equipment that operates autonomously requires continuous monitoring. In the case of production equipment in particular, in which malfunctions have serious consequences, large quantities of machinery big data is collected at intervals ranging from microseconds to seconds (see Fig. 6).

(1) Identify warning signs of potential malfunctions

Journal data is used for the following types of monitoring, for example.

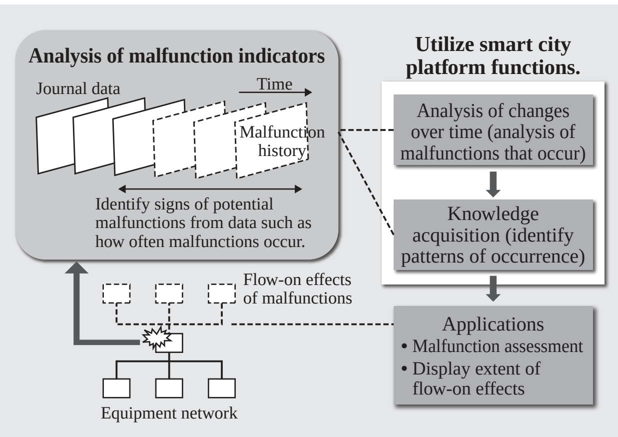

Fig. 6—Big Data Analysis of Journal Data.
The smart city platform collects and analyzes journal data comprising information on equipment operation or alarms to help respond quickly when warning signs such as malfunctions occur.

(a) Problems in equipment operation
(b) Interruptions to communications
(c) Rises in internal temperature of equipment

The following two types of monitoring can be used.

(a) Determine how often and for how long data is not received

(b) Determine how often data values exceed a threshold

When a malfunction is detected, it is not necessarily clear whether it is an equipment fault or simply a temporary malfunction. Because the smart city platform manages a large volume of historical journal data, knowledge acquisition functions can be used to analyze variations in the frequency of malfunctions and past assessment results so as to identify potential malfunctions and pass them on to an assessment application.

(2) Analysis of flow-on effects

By holding configuration information about communication networks and other systems on the smart city platform, it is possible to determine which areas will be affected by the failure of a particular communication relay device, for example.

ADVANTAGES OF SMART CITY PLATFORM USE AND VERIFICATION OF BENEFITS

This section summarizes the advantages to social infrastructure providers and users of using a smart city platform for processing big data, and the visualization techniques that can be used to present these.

Advantages of Using Smart City Platform

(1) Advantages to providers

(a) Because the smart city platform performs centralized collection and analysis of data from different social infrastructure to generate added-value data, it can be used for predicting demand and how the social infrastructure is used.

(b) Because the smart city platform can provide information on interrelationships between different forms of social infrastructure by supporting the coordination of applications, it can be utilized to operate the infrastructure in a balanced way.

(2) Advantages to users

(a) Because social infrastructure is operated in ways that seek to provide more convenience for users, residential and social activities are easier and more effective. Examples include using regional power generation to reduce user costs and trouble-free use of EVs.

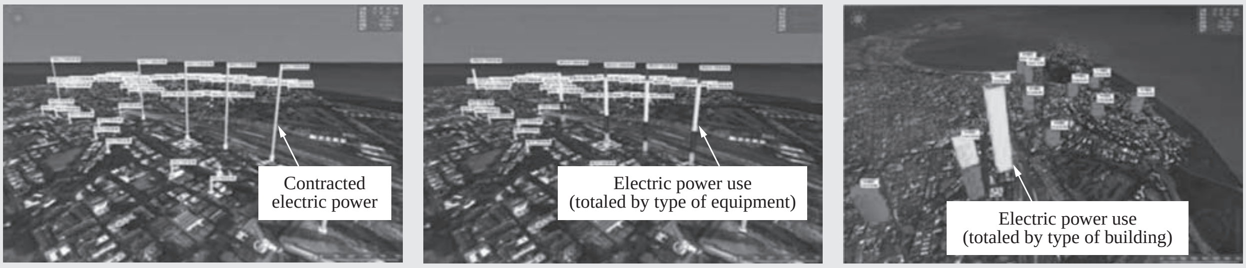

Fig. 7—Example Visualization of Electric Power Use.
The effects of control operation can be seen clearly by displaying electric power supply and demand for buildings or districts. Similarly, letting the user shift the viewpoint wherever they want allows them to take in the situation across the entire area. Fig. 7 is created using the flood simulator by Hitachi Power Solutions Co., Ltd.

(b) The smart city platform encourages users to make effective use of their assets. Expected future developments include the use of residential photovoltaic power generation and the earning of income from the sale of excess power, for example.

Visualization

The use of visualization techniques to present the results of big data processing in a geographic information system (GIS) can provide people with a clear representation of the benefits. In particular, this can be used by social infrastructure providers for tasks such as determining the user benefits of electric power supply or identifying the location of a problem that has occurred. Because the collection of control information by the smart city platform facilitates tasks such as reproducing control outputs or predicting the effects of control, it can be used to support decision-making about social infrastructure.

Fig. 7 (a) and (b) show visualization examples from a simulation. They show the changes in electric power use by individual buildings during the night and day, and the power consumption of individual devices. Fig. 7 (c) shows the case when the display has automatically been switched to show electric power use by building type to present the results for a wide area.

Location-based display techniques have the following benefits.

(1) They provide an intuitive appreciation of geographical trends in electric power supply, such as the characteristics of residential, commercial, or other districts.

(2) They show how arrangements for redirecting electric power (interchange of electricity) or the discharge of storage batteries influence the supply and demand of electric power. This also helps determine in advance the timing and benefits of discharging storage batteries based on the time-of-day, date, and location.

(3) They provide effective ways for selecting the best control methods to use in situations such as natural disasters when there is a shortage in the supply of electric power.

By using a global representation of the location of these data points, users can scroll the display to wherever they like.

CONCLUSIONS

This article has described how big data is used on a smart city platform for the efficient operation of social infrastructure, with a particular emphasis on its use in power system management, transportation, and especially EV operation.

The smart city platform acts as an analytical database for big data processing and fulfills the following roles.

(1) Collection and integrated management of data on the operation and use of social infrastructure.

(2) Analysis of collected data to determine the operation of social infrastructure, while also helping improve convenience

(3) Clarification of the relationships between different types of social infrastructure by coordinating applications, and operating social infrastructure in ways that take account of interactions between its different parts

By enhancing analytics functions, these will help identify and resolve the problems faced by social infrastructure operators and other customers in the future.

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Capturing Benefits of M2M in Manufacturing

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OVERVIEW: M2M has attracted the interest of the manufacturing industry in recent years as a means toward cutting maintenance costs and improving the added-value of after-sales services. As numerous challenges need to be overcome to take advantage of M2M, expanding its use without first dealing with these may result in diminished efficiency. Accordingly, Hitachi recommends a three-stage implementation of M2M. The Global e-Service on TWX-21 is a SaaS-based support service for equipment lifecycle management. In addition to its current services, Hitachi also plans to add an assessment service that assists with the staged implementation of M2M and a globally available M2M service.

INTRODUCTION

IN addition to the conventional business model of enhancing and selling equipment, the manufacturing industry has seen growing interest in recent years in after-sales services that have the potential to be highly profitable. With the globalization of manufacturing, there has also been more significance given to the use of machine-to-machine (M2M) technologies to cut maintenance costs and improve the added-value of after-sales services by using “machinery big data” for the remote monitoring and management of this equipment. This “machinery big data” is collected automatically from equipment operating in different parts of the world and includes operating information and location information.

This article presents Hitachi’s proposition for the introduction of M2M technology in the manufacturing industry, gives an overview of the Global e-Service on TWX-21* that uses the experience and know-how built up by Hitachi as a basis for supporting all aspects of equipment lifecycle management, and describes the planned assessment service and M2M service.

PROPOSITION FOR INTRODUCTION OF M2M IN MANUFACTURING

Typical benefits of M2M for the manufacturing industry include maintenance cost savings achieved through the availability of realtime information and the development of new businesses that utilize the collected information.

However, a number of challenges need to be overcome before these benefits can be achieved in practice. Going ahead with M2M without first dealing with these challenges may risk causing confusion in the workplace and actually diminish efficiency. Furthermore, because of the risk of failing to achieve a return on the long-term investment required, it is important to identify appropriate targets for investment based on an understanding of such factors as the product characteristics and the business environment in which the company concerned is operating. To provide greater certainty that manufacturing industry will be able to reap the benefits of M2M, Hitachi recommends a staged implementation.

The following explanation divides this process into three stages, comprising an initial stage in which the mechanisms for M2M are established, a second entrenchment stage in which the benefits of M2M are secured, and a third development stage for building on these benefits. It also explains the measures required to deploy M2M globally. Note that the explanations given here relate to the case in which the manufacturing industry supplies machinery with a long life and can be expected to create added value from the provision of after-sales services.

Initial Stage (Establishment)

In this initial stage, only a small number of machines will be fitted with M2M systems and therefore most equipment on the market will not have an M2M capability. Accordingly, the benefits of M2M will still be small in quantitative terms and it will be difficult to generate income from M2M on its own. This may tend to diminish the incentive to adopt new business processes that take advantage of equipment with an M2M capability.

This makes it important to accompany the initial introduction of M2M with the establishment of new

* TWX-21 is a trademark of Hitachi, Ltd.

business processes that allow for its greater use in the future, and to reduce support costs by adopting practices that also apply to equipment without an M2M capability. Specifically, in addition to establishing an equipment management regime that can be relied on to manage machines individually, this involves using this equipment management as a basis for providing access to business information and undertaking organizational reforms to standardize and support the activities of service engineers based in different parts of the world.

Second Stage (Entrenchment)

During the second stage, greater adoption of M2M means that equipment with an M2M capability makes up a larger proportion of the market. It is at this point that the benefits of M2M start to grow. Along with the changes to existing business processes implemented during the initial stage, the entrenchment stage is also characterized by growing integration of M2M into existing business processes.

Furthermore, an important factor in entrenching the benefits of M2M is to establish maintenance services that utilize M2M and take steps to increase service income. This means improving services by applying the plan, do, check and act (PDCA) cycle to dealings with customers, utilizing “machinery big data” (the location and other operating data on individual machines collected via M2M), and machine-specific maintenance records and other business information. This requires that service improvements be made by establishing and measuring quantitative and qualitative key performance indicators (KPIs), and then monitoring how they trend over time. KPI examples include the service income generated per machine, order ratios, and work times for service engineers.

Third Stage (Development)

In the third stage, equipment with an M2M capability has a high market share and the benefits from M2M exceed the investment. Also, with business process standardization now well established, a large amount of location and other machine-specific operating information is being collected along with associated business information.

To build further on the benefits of M2M, it can also be used as a catalyst for business innovation by performing analyses that combine business information with large amounts of machinery big data. Possible examples include analyzing machinery big data to perform “failure diagnosis” and make quality improvements for equipment, using machinery big data and information on service engineers to determine the best times to make service calls at customer sites, using machinery big data and production management to determine optimal inventory levels, and using machinery big data and sales information to improve marketing.

Global Deployment

In addition to the staged implementation described above, the global deployment of M2M also requires the resolution of issues specific to particular countries or regions, including regulatory requirements, different languages, communication unit certification, choice of communication protocol, and telecommunication costs. Because expanding coverage to more countries and regions makes the standardized collection of machinery big data more difficult, there is a need to establish international standards for machinery big data as well as for its collection and delivery processes, and to have these widely adopted. As M2M is extended to cover more equipment across more countries and regions, management tasks such as handling inquiries and the administration of equipment and users also become more complex. While it is necessary to perform equipment management in ways that are independent of country or region, a highly centralized approach becomes impractical when the number of machines being supported reaches the tens of thousands. Rather, a distributed and hierarchical management regime needs to be established.

The resolution of issues specific to particular countries or regions and the establishment of standards for information collection are both important considerations in the initial establishment stage. Similarly, establishing a distributed and hierarchical management regime is important during the second entrenchment stage. These challenges are associated with global deployment, and ways of dealing with their complexities include consulting and the adoption of existing best practice.

FUTURE PROSPECTS FOR GLOBAL E-SERVICE ON TWX-21

Hitachi supplies Global e-Service on TWX-21 to utilize the experience and know-how it has built up to support equipment over its entire lifecycle. To support the adoption of measures described above that provide greater certainty regarding the benefits of M2M to the manufacturing industry, Hitachi intends to include an assessment service and M2M service in Global e-Service on TWX-21.

This section gives an overview of Global e-Service on TWX-21 and describes the planned assessment service and M2M service.

Global e-Service on TWX-21

Global e-Service on TWX-21 is based on the Global e-Service, an international service provided by Hitachi Construction Machinery Group that collates business know-how and has been in operation collecting various types of information for 12 years. Through the centralized management and visualization of equipment lifecycle information, it helps improve the efficiency of maintenance work, the proportion of customers who enter into service contracts, and customer satisfaction (see Fig. 1). TWX-21, meanwhile, is the largest business-to-business media service in Japan. Using the TWX-21 platform to deliver the service ensures high reliability while reducing operating costs.

Assessment Service

Because of the increased risk of failing to earn a return on the long-term investment required to reap the benefits of M2M, it is necessary to consider which business areas warrant preferential reform based on an understanding of the company's characteristics and circumstances. Accordingly, as part of Global e-Service on TWX-21, Hitachi plans to provide an assessment service for equipment lifecycle management that will take account of the staged implementation of M2M and include consideration of business reforms. By developing an understanding of the business's current and future circumstances in the manufacturing industry, taking account of equipment lifecycles, the service will identify the areas that need to be worked on at each stage in order to use M2M to achieve the best possible equipment lifecycle management. If necessary, the service can also assist with measuring the effectiveness of business process

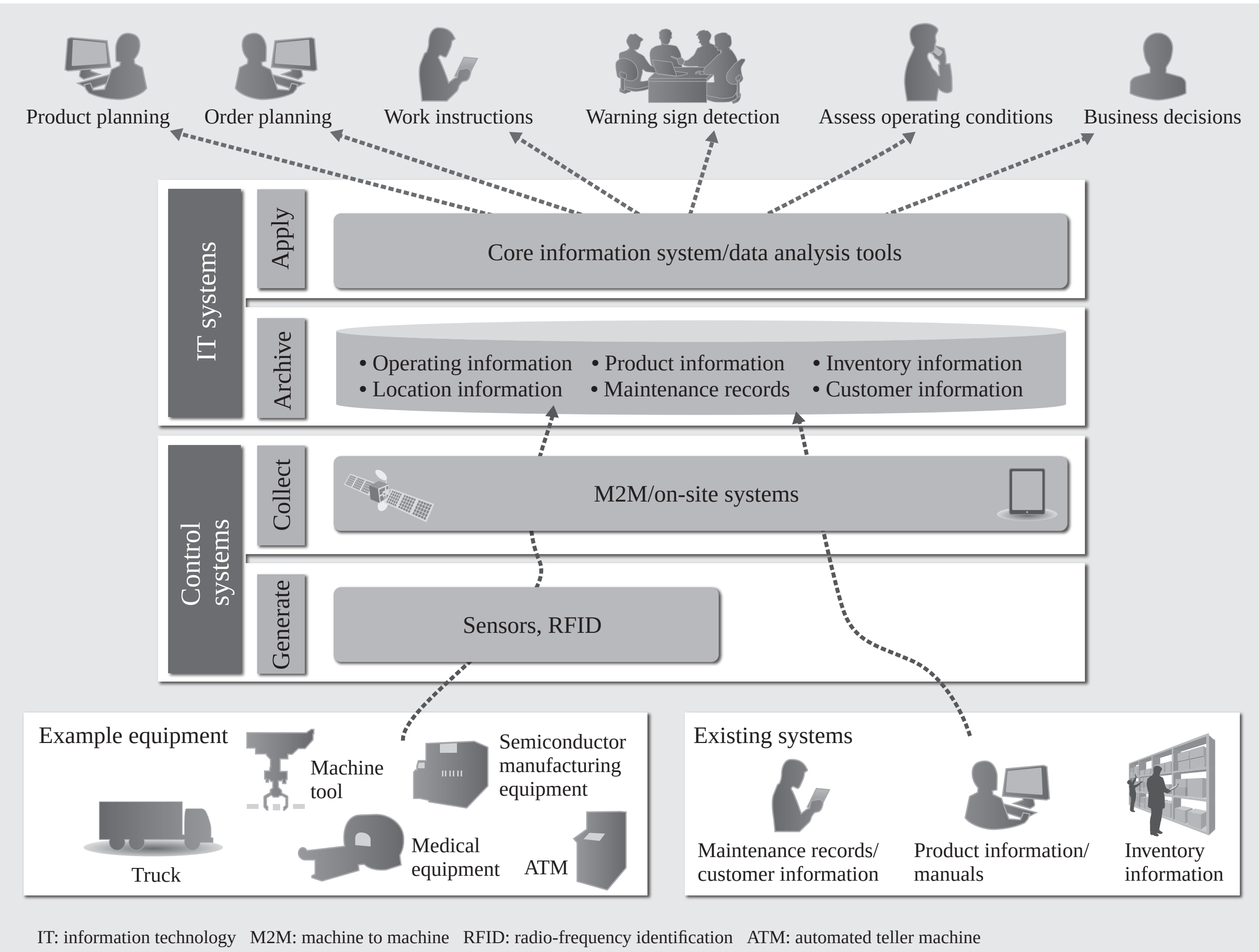

Fig. 1—Overview of Global e-Service on TWX-21.
Global e-Service on TWX-21 helps improve the efficiency of maintenance work, the proportion of customers who enter into service contracts, and customer satisfaction through the centralized management and visualization of equipment lifecycle information.

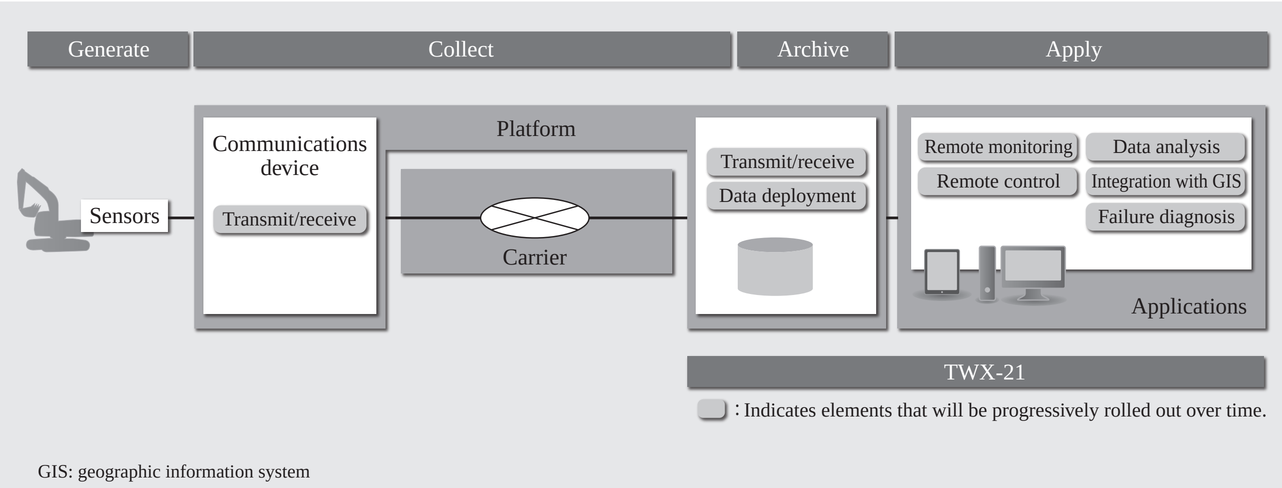

Fig. 2—Overview of M2M Service.
The M2M service will provide automatic collection of machinery big data, including location information obtained using the global positioning system (GPS) and other operating information, and also remote monitoring and control. This will allow the use of machinery big data incorporating machinery management functions to support sales and maintenance activities, and the analysis of machinery big data to improve quality or aid product development.

reengineering (BPR) or other business reforms in ways that are compatible with the adoption of M2M.

M2M Service

To assist the international operations of the manufacturing industry, Hitachi plans to include an M2M service in Global e-Service on TWX-21 that will be supported globally. The M2M service will be able to be used for the automatic collection of machinery big data (location and other equipment operating information), and for remote monitoring and control. This will allow the use of machinery big data incorporating machinery management functions to support sales and maintenance activities, and the analysis of machinery big data to improve quality or aid product development.

As part of the M2M service, Hitachi plans to progressively introduce the following elements (see Fig. 2).

(1) Applications

Remote monitoring, remote control, and functions such as geographic information systems (GIS), failure diagnosis, scheduling of service engineer visits, and inventory management that utilize machinery big data.

(2) Platform

Automatic collection of machinery big data required by applications, command transmission

(3) Devices

The issuing of operation commands or information collection requests to equipment

(4) Carrier

Communication links provided by overseas telecommunications carriers to support the international operations of the manufacturing industry

CONCLUSIONS

This article has presented Hitachi’s proposition for the introduction of M2M technology in the manufacturing industry, given an overview of the Global e-Service on TWX-21 that uses the experience and know-how built up by Hitachi as a basis for supporting all aspects of equipment lifecycle management, and described the planned assessment service and M2M service.

The Global e-Service on TWX-21 draws on the experience and know-how within Hitachi to help customers improve their equipment lifecycle practices. The operation and maintenance (O&M) business can progress by continuing to provide the functions that customers need for business reform.

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New Bricks and Mortar Marketing Technique Based on Human Behavior Measurement

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Naohiro Suzuki

OVERVIEW: In recent years, internet companies have used big data on people's behavior on the web to conduct behavioral marketing in which they rapidly work through the PDCA cycle. Accompanying this, there have also been moves to apply these same marketing techniques in the physical "bricks and mortar" world. Techniques and know-how on the measurement of human behavior and its quantitative representation developed over time by Hitachi are suitable for deployment in new marketing techniques like these that are applicable to bricks and mortar environments, and Hitachi is currently working on developing them into solutions.

INTRODUCTION

MEASURES aimed at taking advantage of advances in information technology to utilize big data and apply it to the sources of companies' competitive strengths are becoming increasingly common. Internet companies like Amazon[*1] and Rakuten[*2], for example, are making considerable use of these techniques and have successfully applied them to boost competitiveness, particularly in marketing.

Underpinning the successes of these companies are advances in big data technologies that support the collection and analysis of records of purchasing behavior by ordinary consumers. These technologies allow internet companies to apply the plan, do, check, and act (PDCA) cycle of progress by trial and error to a variety of marketing activities, and to work through the cycle rapidly. One possible example would be to experiment with two different forms of web advertising and then to analyze the access logs for customers who view these ads. This can provide feedback to new marketing activities. For example, the company could assess the actions of customers before and after viewing the ads to determine which of the two forms is more effective, and then proceed with a full-scale campaign using the more effective option, all within the same day.

Coupled with this ability to work through the PDCA cycle more quickly, these advances in marketing techniques based around the internet provide internet companies with significant competitive advantages. For the bricks and mortar retailers who operate the physical stores that accounted for the bulk of purchasing activity in the past, this entry of new players has brought intense competition. An example of this new purchasing behavior is the customers who use a bricks and mortar store to try and choose what they want to buy, and then make their purchase online after shopping around internet retailers to find the lowest price. As a result, bricks and mortar retailers are looking for new approaches to marketing that can counter their internet competitors.

This article describes behavioral marketing techniques that utilize a variety of technologies to assess customers' state of mind in physical settings, something that was not amenable to machine measurement in the past.

POTENTIAL OF BEHAVIORAL MARKETING

This section describes the potential for using behavioral marketing to make quantitative assessments of human behavior in physical settings and to determine the customer's state of mind, the critical factor from a marketing perspective.

Understanding Customers in Bricks and Mortar Stores

While the term "marketing" covers a variety of different factors, the key focus in the current context is on understanding customers.

The following describes techniques currently used to understand customers in bricks and mortar stores.

Traditionally, these have fallen into three main categories.

(1) Analysis of sales information collected at the point of sale (POS)

(2) Use of points-based and other loyalty cards to analyze the purchasing history of individual customers

*1 Amazon is a trademark of Amazon.com, Inc. or its affiliates.
*2 Rakuten is a trademark or registered trademark of Rakuten, Inc.

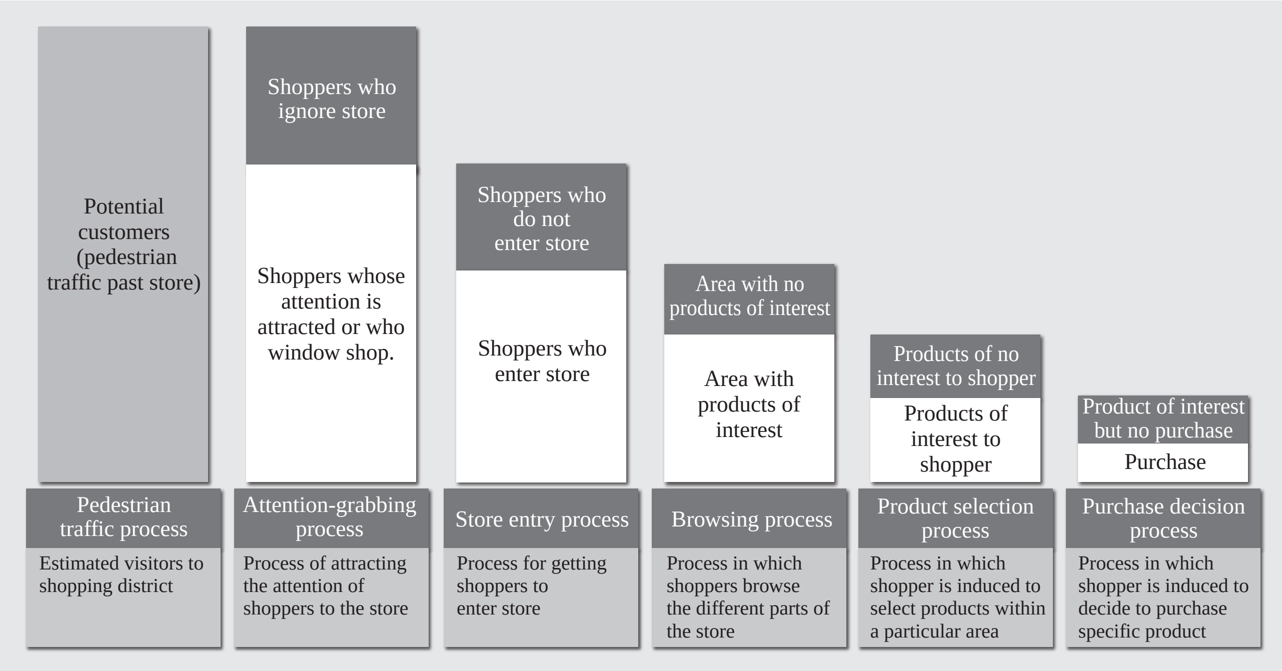

Fig. 1—In-store Purchasing Behavior Model.
Appropriate measures can be adopted for each process leading up to a sale by quantitatively assessing the processes to understand the factors involved.

(3) In-store questionnaires and other studies of customer behavior

These methods were first introduced decades ago, and have remained in use ever since because they provide effective ways for learning about customer purchasing behavior. Sales information collected at the point of sale, for example, can be used to determine what sorts of products customers are buying and when. Similarly points-based and other loyalty cards can be used to obtain time-series purchase history data for individual customers. The most effective means of all for learning about customer behavior has been in-store questionnaires.

However, while POS or loyalty card data can be used to determine what products customers have purchased, they provide no insights into what these customers were thinking or feeling when they were in the store. In-store questionnaires, meanwhile, are time-consuming, and because samples sizes are limited, they do not necessarily capture the full diversity of customer thinking.

Determining Customer State of Mind

This section looks at what is needed for bricks and mortar stores to implement marketing practices that can rival those of their internet competitors.

The first requirement is to find better ways of determining not only customer purchasing behavior, but also their reasons for not making a purchase. In other words, their state of mind. For example, customers peruse a variety of products in the store and only make a purchase if they find what they want. That is, customers' actions and states of mind are influenced by a variety of processes on the way to making a purchasing decision (see Fig. 1). Therefore, it should be possible to boost total sales by understanding the actions and state of mind of the customer in each process, and then using this as a basis for taking appropriate steps. In other words, instead of what customers purchase when they visit the store, what is important is to understand their state of mind (what they are thinking and feeling).

Next is the time taken to determine the state of mind of customers. The ability to work through the PDCA cycle rapidly is an important factor in the competitiveness of internet companies described above. Being able to revise the measures they use for marketing to customers within the same day is an example of this. Consider the case when point of purchase (POP) advertising is used. If it is possible to ascertain customer reactions on the same day as it is put up, then stores can use this information to experiment with better ways of presenting the advertising on the following day. By using these techniques to obtain prompt, quantitative feedback on customer reactions, bricks and mortar stores can also achieve the rapid application of the PDCA cycle to their marketing practices. By dramatically speeding up the process of trial and error, this can result in even greater improvements to marketing practices in a bricks and mortar environment.

The aim of behavioral marketing is to use a variety of techniques to determine the physical-world behavior of customers up to the point of making a purchase in order to provide an insight into their actions and states of mind. This allows bricks and mortar store to work rapidly through the PDCA cycle for their marketing.

HITACHI'S TECHNOLOGIES AND ACTIVITIES

Behavioral marketing requires the use of a variety of techniques to determine the physical-world behavior of customers (see Fig. 2). Also required are ways of determining the state of mind of customers by analyzing changes in their in-store behavior and representing these quantitatively.

While there is no technological way of measuring customers' states of mind directly, they can be inferred by utilizing the know-how that Hitachi has built up in the quantitative representation of behavior. By calculating indicators representing such factors as the influence that POP advertising has on customers, the degree of interest that products invoke when inspected by customers, and indecision when looking at products, it is possible to evaluate these quantitatively.

Technologies for Capturing Customer State of Mind

Hitachi has been working on research and development of techniques for using behavioral indicators to infer the states of mind of customers since 2003. Over that time, they have accumulated know-how by analyzing one million days' worth of data on people's behavior (10 trillion data points). Hitachi has also spent many years on a variety of research and development involving human behavior measurement.

These techniques are categorized into "flows," "relationships," and "demographics," with different techniques being used depending on the application, sensor characteristics, or other circumstances to provide a fine-grained response to customer needs.

(1) Capturing "flows"

Laser sensing is a technique that can be used to determine the flow of people through a site. This involves using laser sensors to detect the location of people in an area and to record their movements as a trace. To date, Hitachi has built up know-how in how

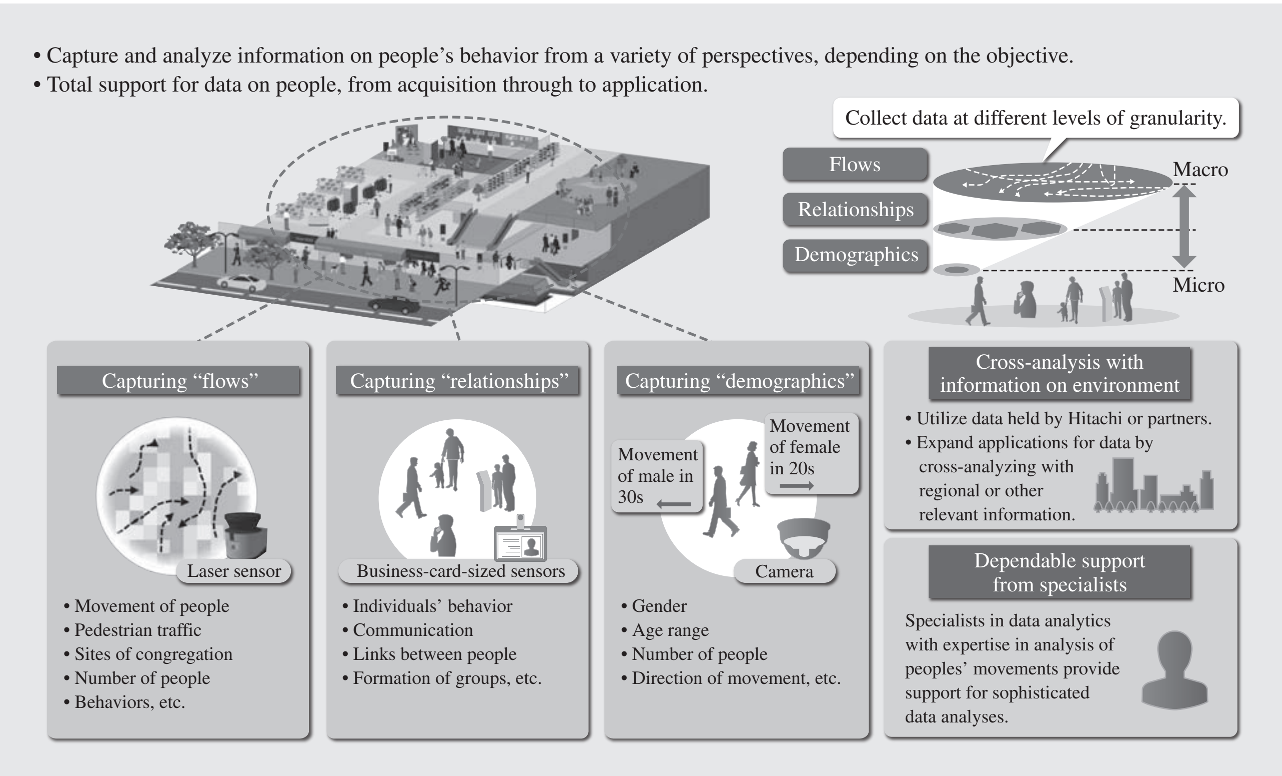

Fig. 2—Technologies Used in Behavioral Marketing.
Customers' states of mind can be inferred by utilizing and combining Hitachi's know-how in the quantitative representation of human behavior and techniques for capturing the "flows," "relationships," and "demographics" of people.

to detect intrusions, including by people attempting to enter an area by tailgating someone else.

This technology and accumulated know-how can be used to determine both the areas within a space where people congregate and the areas where nobody goes, for example. It can also be used to detect indecision when a person is simply wandering around a particular area.

(2) Capturing “relationships”

Communication measurement and analysis is a technique that can be used to identify relationships. It uses business-card-sized sensors and infra-red beacons to measure where people are and how they are communicating (face-to-face time, acceleration, etc.), and to calculate indicators such as their level of activity, constructiveness, and concentration time. Hitachi has built up know-how from its use in applications such as improving workplace productivity.

By applying this technology and know-how to estimating face-to-face times for people and objects, and their circumstances during these times, it is possible to provide insights into the relationships between people and between people and objects. It allows the use of indicators such as the amount of time staff spend face-to-face with customers and how constructively they are using this time, for example.

(3) Capturing “demographics”

Facial recognition is a technique that can be used to identify the demographics of people at a site. That is, it can be used to obtain head counts, ages, genders, and other information about the customers at the site.

Hitachi has built up know-how in the use of facial recognition in combination with digital signage to measure advertising effectiveness by detecting people in the vicinity of the signage.

This technology can be used to determine the demographics of the people at the site.

Application at Large Shopping Center

This section describes the use of behavioral analysis at a large shopping center.

The use of laser sensors to measure people’s movements at a particular site found that there existed both places where the flow of people was congested and other places that remained largely empty with few people passing through. To make more effective use of space, stores have now been opened at the locations of these empty spaces (see Fig. 3).

Work is ongoing on measuring the value of different locations in this way so that action can be taken to increase this value.

Application at Large Retail Store

This section describes the use of behavioral analysis at a large retail store.

Measurements were made at a large retail store to identify what relationships were emerging, such as determining the attributes of customers being served and actions being performed on objects, and also to obtain information on shoppers’ movements such as the proportion of people passing through each aisle. Correlations between sales and the placement of staff and products were found in the resulting data, and these were used as a basis for measures to increase sales, such as rearranging the staff and product layout.

This is an example of how even bricks and mortar stores can achieve a rapid PDCA cycle based on people’s behavior.

BEHAVIORAL MARKETING SOLUTIONS

Hitachi makes possible a rapid PDCA cycle for marketing at bricks and mortar spaces by combining the technologies described above to infer the states of mind of customers at retail facilities and then to present this information in the form of numeric indicators.

Solution for Assessing Value of Different Spaces

This solution for assessing the value of different spaces is aimed at use in large retail facilities such as shopping malls. It can be used to ascertain the states of mind of shoppers (how they think and act) and to decide on how best to manage the overall site and implement measures for improving sales.

Examples include assessing the ability of specific locations at the site, such as stores or event spaces, to attract people, and determining the power of events to bring in customers by monitoring where in the

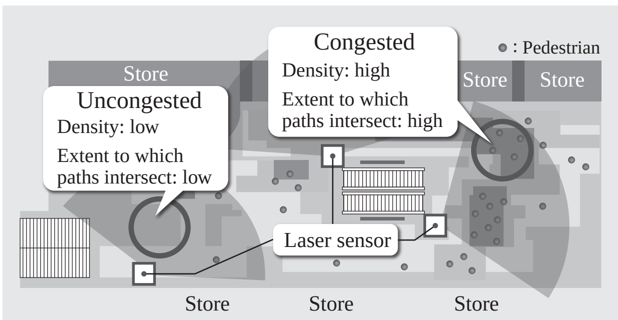

Fig. 3—Overview of “Flow” Measurement.
This involves measuring the “flow” of people and calculating parameters such as density or the extent to which paths intersect. The dark and light regions represent congested and uncongested areas respectively.

site people who have gathered for a particular event subsequently go. This can identify stores that, even if their own sales are not particularly high, have a positive effect on the overall site by attracting customers who subsequently visit other stores, something that was not possible using sales data alone (which was all that was available in the past). It can also be used to make quantitative assessments of the value of events. In other words, it facilitates a rapid PDCA cycle for improving subsequent measures at the site.

Purchasing Behavior Analysis Solution

This solution is intended for assessing the purchasing behavior of customers in apparel and other similar stores. It provides insights into aspects of the customers' states of mind, such as their purpose for visiting the store, whether they are uncertain about a purchase, and reasons for making a purchase. It can also make quantitative assessments of the effectiveness of the store's merchandising practices, such as the use of in-store advertising or the layout of products in the store. It raises sales by providing the means to experiment with better merchandising.

For example, it can be used to identify changes in customer behavior (state of mind) in response to factors such as how they are served by staff and the layout of products in the store. This can be used as a basis for initiatives such as creating a more inviting atmosphere for customers, placing products in ways that better catch the eye, and having staff serve customers in ways that encourage purchase decisions.

CONCLUSIONS

This article has described behavioral marketing techniques that utilize a variety of technologies to assess customers' states of mind in physical settings, something that was not amenable to machine measurement in the past.

Privacy concerns are an important consideration when implementing the marketing techniques described in this article. Hitachi is strengthening the privacy protections it has established in its big data utilization business to ensure that its customers and partners can utilize data without concern for privacy intrusions, and is incorporating these into its services and solutions. Hitachi is also working with partners from outside the group to offer products to customers that combine analysis with ways of making improvements in their bricks and mortar operations.

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Use of Smart Information Systems in New Markets

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OVERVIEW: Together with technological advances in communications, sensors, and other fields, the falling cost of hardware means that IT is now being used to improve business activities in areas or industries where extensive use of IT was less viable in the past. Smart information systems differ from past information businesses in that they include things like the collection of sensor data by M2M networks or the analysis of big data. This smart information can be applied in areas such as providing safety and security or efficiency improvement. Hitachi is utilizing its existing cloud technologies to commercialize the services of its information businesses and supply them globally, thereby extending its services to new industries around the world, such as agriculture, logistics, and mining.

INTRODUCTION

RAPID advances in hardware and in communications and sensor technology have reduced per-bit and communication costs. As a result, industries such as agriculture or logistics that have struggled in the past to deliver benefits from the direct use of information technology (IT) are now making progress on the use of IT for business innovation and smarter operations.

To date, the pace of adoption of IT in different industries has been dictated by the extent to which the benefits of IT to those industries have impacted directly on corporate profitability. The finance industry, for example, has been using IT since the 1960s, with financial institutions achieving great progress as they competed to build online systems. The mainframe-based IT resources that predominated in those days were expensive and cumbersome compared to current systems. Nevertheless, they were adopted because the benefits of IT outweighed the costs. The costs of IT were subsequently cut through downsizing, with one example being the adoption of point-of-sale (POS) systems by the retail industry. Throughout this process, there was a close correlation between the extent of advances and cost reductions in IT and the areas where it was able to be deployed. Recent years have seen further advances and cost reductions, leading to interest in the use of IT for business improvement and smarter operations in industries where it had not previously been widely used (see Fig. 1).

This article describes Hitachi’s strategies for achieving smarter operation in industries such as agriculture, logistics, and mining.

AGRICULTURE

Given its dependence on the weather, conventional agriculture (particularly field cropping) is without doubt an unreliable form of commercial activity. Also, because it is underpinned to a considerable degree by the experience and intuition of farmers, agriculture in Japan finds it difficult to attract young people into the industry. This is posing a problem for the nation because the increase in land left uncultivated as a result of the shrinking and aging of the farming

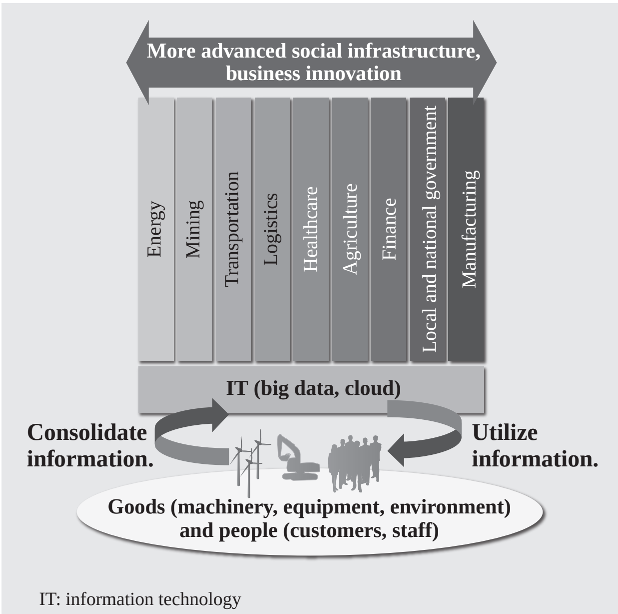

Fig. 1—Applications for Smart Information.
A shift is underway from traditional information businesses toward the commercialization of smart information systems that use IT to support the infrastructure of society.

population is diminishing food self-sufficiency. The following section describes how smarter agricultural practices offer one way of overcoming this problem.

Achieving Smarter Agricultural Practices

Based on discussion with agribusinesses, Hitachi believes that capturing the empirical knowledge of current farmers in the form of data will make farming more reliable and aid new entrants to the industry.

Consequently, Hitachi is planning the release of a cloud service for supporting vegetable production. Rather than field crops, which are exposed to the outdoor environment, this service will utilize information technologies such as sensor networks or cloud computing to support the production of agricultural goods from factory farms where managing the environment is comparatively easier. In doing so, it will provide the following three forms of "visualization."

(1) Visualization of the environment: This involves using sensors to measure variables such as temperature, humidity, or carbon dioxide concentration and periodically transmit them via a network to a monitoring center. (The development of this technology is allowing for the potential use of environmental control in the future as the number of factory farms being monitored increases.)

(2) Visualization of crop growth: This analyzes data on the growing environment that has been collected by the monitoring center to predict what effect changes in this environment will have on future crop growth and harvests.

(3) Visualization of production and sales: This is concerned with factors such as the volume and timing of agricultural production, and also market prices.

Cloud Service for Supporting Vegetable Production

This service supports the production and management of agribusinesses, and assists the entry of young people into the industry.

The following examples describe the two main ways it is envisaged for the service to be used.

(1) In the case of a poor harvest, the reasons can be identified by analyzing historical data on the growing environment and this knowledge put to use in cultivation of future crops.

(2) New entrants to the industry can obtain information about current conditions at the factory farm and make changes to the environment to bring it closer to optimal conditions.

In the case of lettuce grown at a factory farm, a rapid feedback cycle is possible because crops are harvested after approximately 30 days (see Fig. 2).

Advances in Smarter Agricultural Practices

Agriculture is seeing an accelerating trend toward big data analysis involving rational decision-making based on data rather than on experience and intuition as in the past.

In operating its services in the future, Hitachi intends to use feedback to improve its services while also seeking to identify which information is essential for farmers.

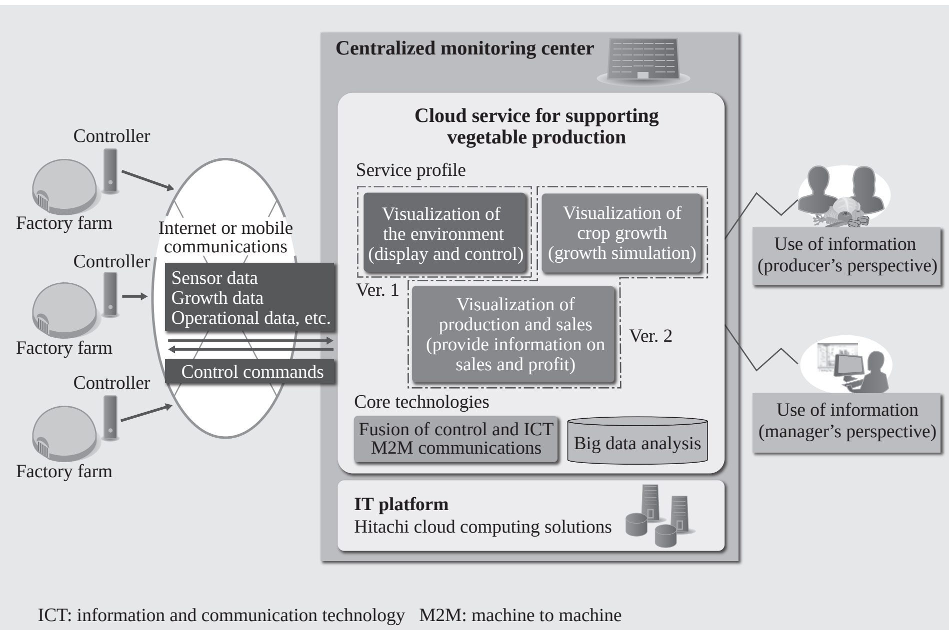

Fig. 2—Cloud Service for Supporting Vegetable Production.
This service supports production and management activities of farmers by managing the conditions at factory farms from a centralized monitoring center in the cloud.

LOGISTICS

Logistics in the future will need to deal with challenges such as global supply chains, changing social structures, the information society, and environmental problems, with growing opportunities for adopting smarter practices. The following sections describe the background to these various challenges, which markets and issues offer opportunities for adopting smarter practices, and how to go about establishing the best business models for logistics.

Background to Growing Globalization

Factors such as growing demand in emerging economies and the relocation of production sites overseas have been driving growing globalization in recent years. As a result, the question of how best to improve and strengthen logistics has become an even more important management issue than it was in the past. This has made it necessary to develop further the logistics that enhance the efficiency and sustainability of supply chains and help provide a safe and secure way of life by extending the scope of system-wide optimization based on a rigorous approach to overall management in companies.

The present era of big data is making it easier to extract and collate the large quantities of data collected from logistics operations, including procurement, production, sales, distribution, and the recycling or disposal of goods. This in turn is recognized as making it more important that this data be utilized in future decision-making aimed at improving corporate profitability.

Markets and Issues Where Opportunities Exist

The global logistics market is currently growing at an annual rate of 8%, with growth in the emerging economies of Asia running at an even higher 18%. In China in particular, which features both a large market and rapid growth, the market is forecast to reach $US 2 trillion in 2015. Despite this, inefficiency remains an issue in the Chinese market where logistics accounts for 17 to 18% of gross domestic product (GDP), a higher proportion than in Japan and other developed countries. Limited logistics assets need to cope with rising freight volumes, higher expectations, increasing labor costs, and compliance with environmental regulations.

Management overheads make up a high 13% of the cost of logistics in China, suggesting that issues exist at the operational level. Possible reasons for this high figure include that the systematic creation of smoothly functioning logistics systems remains inadequate in China, and problems with wasteful spending on fuel for trucks and unnecessary administration or delays.

Smarter Logistics through Combination of Operations and IT

Against this background of change, Hitachi supports better and more efficient logistics for manufacturers of transportation equipment, electrical machinery, and components in the Chinese market through a “One Hitachi” approach that integrates the operations of Hitachi group companies with the cloud platform provided by Information & Telecommunication Systems Company of Hitachi, Ltd. Hitachi also intends to establish businesses that support corporate operations by providing IT services with high added value through the repurposing of big data collected from logistics operations.

In a first practical step toward achieving these objectives, Hitachi will provide a service for improving existing logistics operations that directly addresses the issues of concern to its customers (cargo owners). This can cut logistics costs in the short term while also shortening delivery times. Subsequent steps will include expanding services that improve logistics quality by supplying information that assists with the continuous improvement of logistics operations. Finally, in its role as a corporate partner to its customers, Hitachi also intends to supply IT services with high added value that support business strategy through the use of logistics information, involving analysis and evaluation based on the utilization of big data (see Fig. 3).

MINING

Worldwide demand for minerals and other natural resources is rising in response to rapid growth in emerging economies, and this in turn is creating a need for IT-driven changes to operating practices in mining, a field that has been slow to adopt IT in the past. This section describes the background to the adoption of smarter mining practices, the areas where this is happening, and the necessity of using the cloud.

Smarter Mining Practices

While fluctuations may occur in the short term, factors such as the increasing demand associated with rapid growth in emerging economies mean that, viewed over the medium to long term, the markets for minerals and other natural resources are expanding internationally. In response, there is vigorous activity

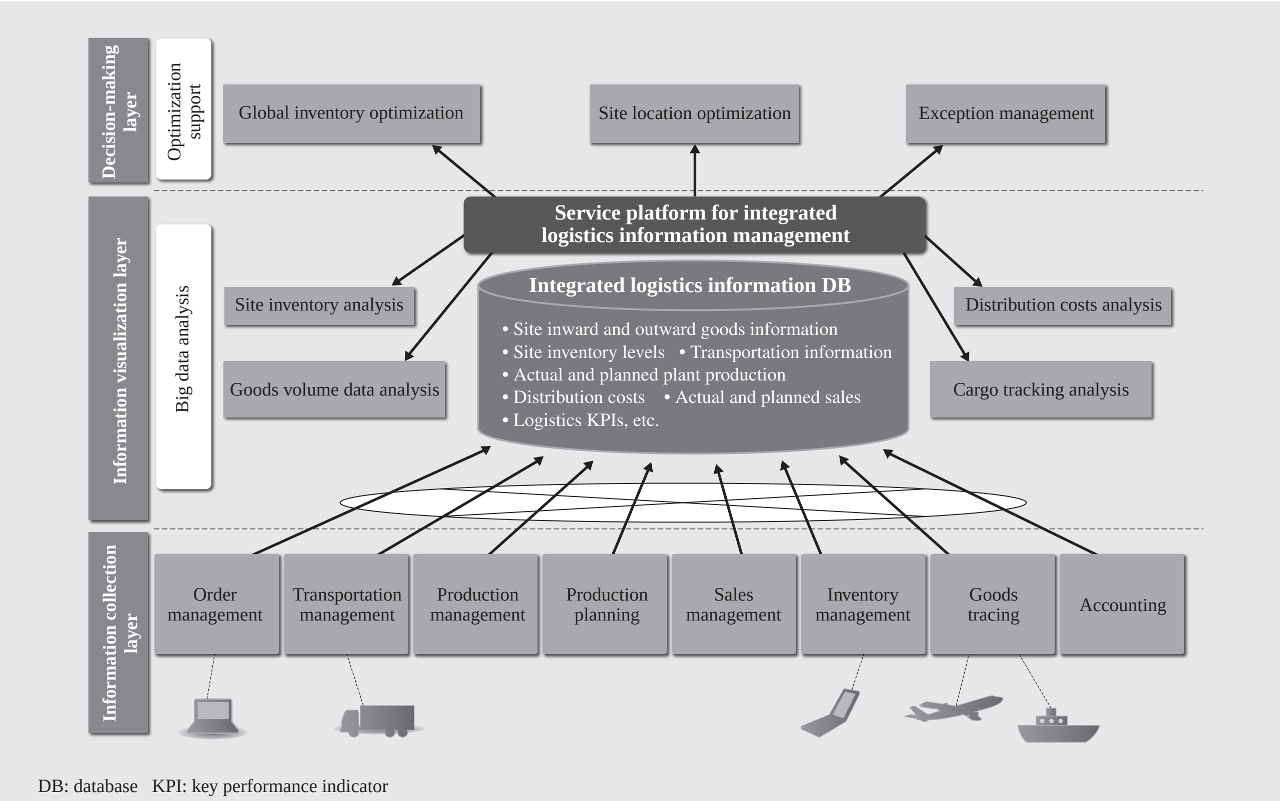

Fig. 3—Service Platform for Integrated Logistics Information Management.
The aim of the platform is to deliver services with high added value that extend from the collection of information to its application in analysis or visualization, and that support management strategies when making decisions.

in the field of mining development throughout the world. One of the challenges of the mining business is that, while the upfront and running costs of excavation, refining, and other production equipment are very high, they tend to have poor utilization and productivity compared to the plant used in other industries. Rapid mining development also puts strain on the availability of experienced technical staff, creating a need for measures for sharing know-how and dealing with rapidly rising labor costs. Also, because operating conditions at mines tend to be harsh and the machinery very large, there is a need for safety and security measures as mine site accidents can often put human lives at risk.

As a result, there is strong demand for the adoption of smarter mining practices based on IT to increase the utilization of production equipment (assets), improve productivity through initiatives such as sharing the know-how of experienced technical staff, and ensure safety and security.

Opportunities for Smarter Mining Practices

After the initial prospecting to survey the site, mining projects can remain in production for decades. The production processes extend from excavation and conveying at the mine through to crushing, grinding, separation, and refining at a processing plant close to the mine and then transportation by rail or ship (see Fig. 4).

Potential opportunities for smarter mining practices include the use of sensors, communications equipment, and other devices to improve safety and security at the mine, increase the utilization of excavation equipment, or boost productivity by coordinating the operation of the machinery used in the different processes performed at the processing plant. Other possibilities include identifying and removing bottlenecks in production or optimizing the mining supply chain through measures such as making available information on each step of the mining process.

Use of the Cloud for Smarter Mining Practices

Because mines are often located a long way from cities, use of the cloud is considered to be essential if mining is to be made smarter (see Fig. 5).

The following four points need to be considered in relation to smarter mining practices.

(1) Uncertainties about the full-scale use of IT systems due to unreliable electric power at the mine.

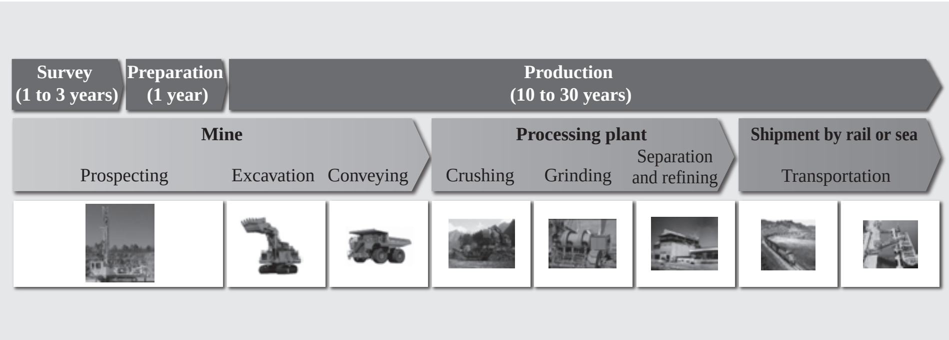

Fig. 4—Mining Processes.
This shows the processes used in mining from the mine to the transportation stage.

(2) When IT systems are installed at a mine, the difficult working conditions for IT staff compared to urban workplaces is a cause of high labor costs.
(3) Mining company headquarters are often located in the city or in another country, meaning that a network is essential for the transmission of business information.
(4) Improving the utilization of production equipment requires the establishment of maintenance arrangements with the supplier or their agent, and this in turn requires the sharing of operational and fault information.

Hitachi believes that the use of the cloud to implement IT systems able to share information with remote locations and multiple sites offers an effective way to overcome these challenges, and is proceeding on this basis.

CONCLUSIONS

This article has described Hitachi's strategies for achieving smarter operation in industries such as agriculture, logistics, and mining.

Industries that have tended to be slower to adopt IT have begun taking advantage of advances in the field to start utilizing IT for business innovation and smarter operations. By steadily pursuing the strategies for adopting smarter practices described in this article, they should contribute to progress in social infrastructure that incorporates IT.

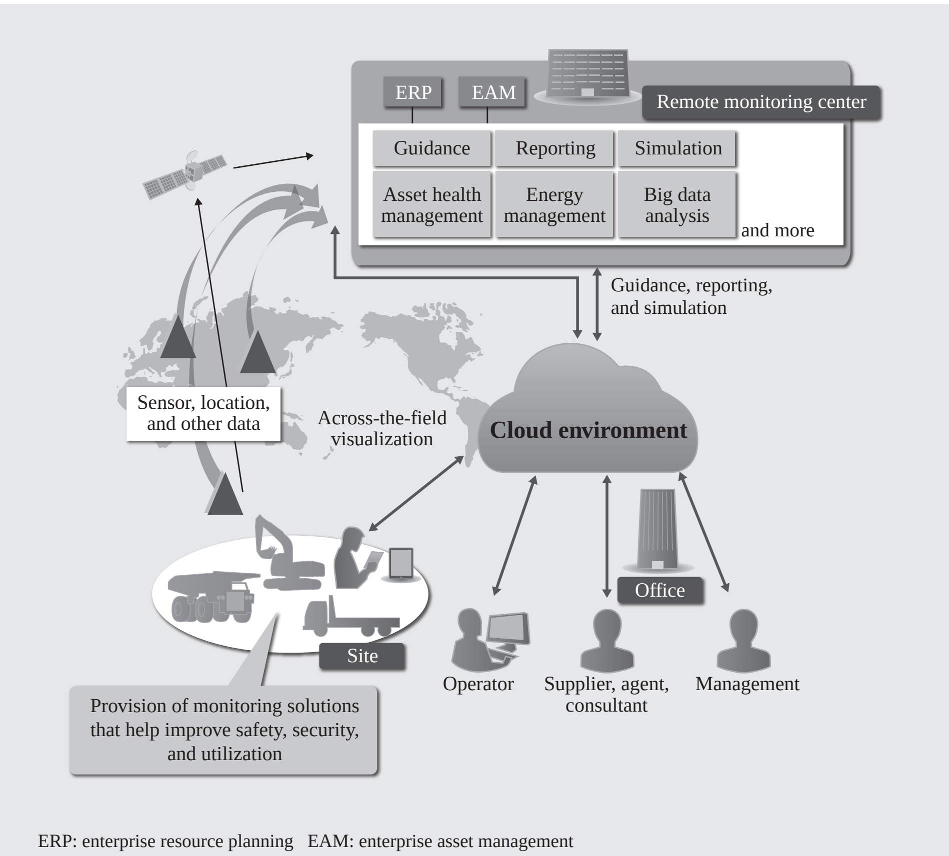

Fig. 5—Use of Cloud for Smarter Mining.
Hitachi aims to use cloud technology to provide services with high added value that support management strategies by promoting smarter practices across the full range of processes associated with mining.

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Hitachi's Plans for Healthcare IT Services

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OVERVIEW: The soaring cost of healthcare has become a problem for developed economies in recent years as their populations age. Costs are also rising fast in emerging economies where one of the side effects of better living standards is an increase in the incidence of lifestyle diseases. In Japan, meanwhile, based on programs that are unlike those found anywhere else, measures are being adopted for the various stages of healthcare, which include prevention and health management, treatment, and nursing. The measures are characterized by the highest levels of quality and the increasing use of IT. However, less progress has been made on providing cross-disciplinary services that span different programs, and on making good use of the information generated by the individual services. In response, Hitachi is working on the global deployment of healthcare IT services developed in Japan, and on looking into services that utilize various types of information.

INTRODUCTION

WHILE facing the prospect of a very large population of elderly people, Japan has also over recent years maintained its position as the nation with the longest life expectancy. It's healthcare expenditure as a proportion of gross domestic product (GDP), on the other hand, is 9.5% (in 2011), placing it 16th in the Organisation for Economic Co-operation and Development (OECD)[1]. This indicates that healthcare services are delivering a high level of cost-performance, which can be seen as a result of various preventive, health management, nursing, and other programs such as medical checkups for mothers and children and medical checkups for school children.

While the philosophy behind these healthcare services is coming to be appreciated outside Japan, various differences of approach in areas like lifestyle, education, and values mean that these programs or services have often failed to catch on when transplanted to other countries. In Japan, meanwhile, while services extend from prevention and health management to treatment and nursing, little progress has been made on integrating the operation of these services across different programs.

Recognizing this situation, Hitachi is focusing on the data generated at each stage of healthcare services and looking into new service businesses that operate by integrating this data.

This article uses the example of a healthcare information technology (IT) project in the UK to describe the services currently under consideration and the technology developments that they will require.

HITACHI PROJECT IN UK

Current Situation and Challenges Facing Healthcare in UK

Greater Manchester county, the site of Hitachi's proposed joint development project in the UK, is made up of 10 cities, including Manchester and Salford, has a population of approximately 2.6 million, and is located about 300 km north-west of London, the capital of the UK.

Like other developed economies, how to care for the increasing number of people with chronic illness is a major issue for the UK. However, it lacks any obligatory preventive measures similar to Japan's health check programs. Instead, each region runs their own voluntary programs, including Greater Manchester. Nevertheless, they share many points in common with Japan, with the questions of how to improve the overall quality of healthcare and cut costs posing major challenges.

Although the UK has the National Programme for IT (NPfIT), which is operated on a top-down basis by the National Health Service (NHS) and includes the management of appointments and the sharing of clinical information between health providers, it has been unable to deliver adequate benefits, having yet to be fully adopted in the field apart from certain functions such as the sharing of basic patient information that have entered widespread use. Recognizing these failings, work is now proceeding at the regional level on measures for the sharing of clinical information between local healthcare providers in the form of bottom-up programs that take note of the views of doctors on the ground.

Project Overview

NHS Greater Manchester (NHS GM)*1, the Manchester Academic Health Science Centre (MAHSC)*2, and NorthWest EHealth (NWEH)*3 are establishing a healthcare IT environment for Greater Manchester that is centered in Salford and based around a secure medical data sharing system that is designed to ensure privacy. Hitachi has been involved in this project since April 2013 and is participating in studies.

Salford already has a network for the sharing of medical data between general practitioners (GPs). The connection of the above medical data sharing system to this existing network makes it possible to control access to data based on patient consent and other factors. This function for sharing highly confidential medical data between healthcare providers is vital if healthcare professionals are to be able to use the system with confidence. In addition to allowing for the future expansion of data sharing through the connection of other existing networks outside Greater Manchester, potential applications for the system extend beyond providing coordination between healthcare providers, and include such areas as medical research.

The medical data sharing system also has potential for providing even greater value by adding functions for the repurposing of data within a secure and privacy-protecting environment and by allowing for the addition of applications that deliver a variety of different services. Hitachi believes that it can make a significant contribution to the project by drawing on the healthcare know-how and core technologies it has built up through its past experience, primarily in Japan, and by taking responsibility for developing these additional functions.

Hitachi's Involvement

Hitachi is currently involved in the following three areas.

(1) Use of IT in measures to prevent or manage lifestyle diseases such as diabetes.

(2) Development of primary functions based on use cases that are directly relevant to the needs of healthcare workplaces that use the medical data sharing system.

(3) Improvements across all healthcare processes aimed at cutting costs while maintaining the quality of healthcare delivery.

While these objectives are currently being pursued independently, the aim is to combine (1) and (3) by implementing them together on the medical data sharing system being developed through (2).

Project Goals

Unlike past solution services that introduced IT to deal with immediate requirements, a major feature of this project is its objective of establishing and operating new services while also identifying needs in collaboration with partnerships between industry, government, and academia that have a leading role in local healthcare.

In addition to developing services for the residents of Greater Manchester, the aim for the future is also to take the service model and technologies created in Greater Manchester and deploy them not only elsewhere in the UK, but also in Japan and other countries.

RESEARCH AND DEVELOPMENT OF TECHNOLOGIES THAT UNDERPIN SERVICES

Value to Customers of New Businesses

The businesses currently under consideration by Hitachi, such as the UK project described above, supply new value to users at each system layer, namely (1) data collection, (2) use of collected data, and (3) services that use this data (see Fig. 1).

Specifically, the objectives for each layer are to provide, (1) a safe, secure, privacy-protecting and reliable data collection platform, (2) functions for extracting, analyzing, and correlating that simplify the use of complex healthcare data, and (3) disease prevention services that both improve quality of life (QOL) and control costs and services of use to product development by pharmaceutical or food companies.

To deliver this value, Information & Telecommunication Systems Company of Hitachi, Ltd. is working jointly with its Central Research Laboratory and Yokohama Research Laboratory on the research and development of the required technologies.

The following sections describe some of the technologies that Hitachi is considering using in these services.

*1 The UK's NHS aims to provide everyone with a uniform level of healthcare services. NHS GM is the coordinating body for the 10 clinical commissioning groups in Greater Manchester.

*2 A consortium made up of The University of Manchester and healthcare providers in Greater Manchester. Plays a leading role in healthcare research in the region.

*3 A non-profit organization (NPO) set up by The University of Manchester and healthcare providers in Greater Manchester. Handles the development and operation of software for Greater Manchester.

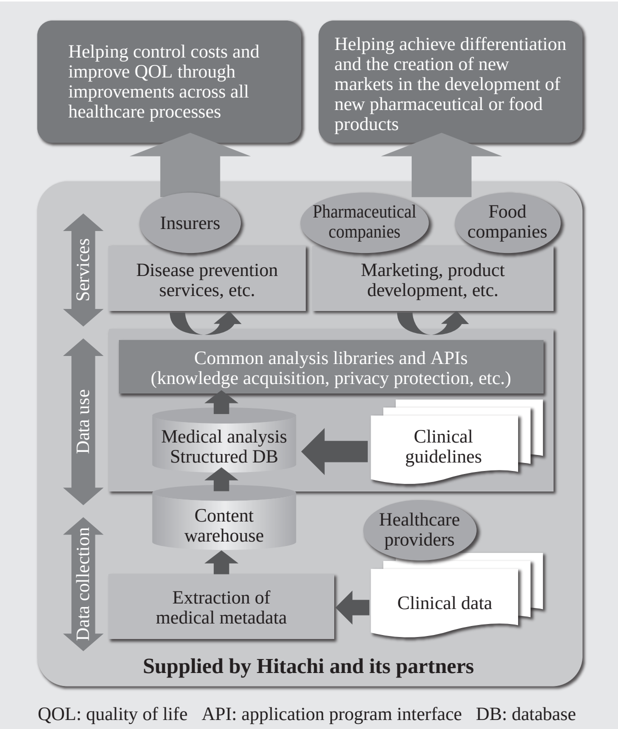

Fig. 1—Three-layer Model of Healthcare IT Services.
Hitachi supplies the new value required by the healthcare sector through the layers of, (1) data collection, (2) data use, and (3) services.

k-anonymization

In a variety of fields, collected data is coming into use for secondary purposes such as analysis. This data repurposing requires data to be anonymized so that individuals cannot be identified to protect privacy. Normally this is done using simple anonymization techniques such as the deletion of information that could be used to identify someone, such as their name and address, or the replacement of these fields with random numbers or text. However, because healthcare data may include details of rare health conditions, for example, the combination of a small number of data fields can still potentially be enough to identify people, even from data that has been subject to this simple anonymization. To deal with this problem, interest has turned to a technology called "k-anonymization" that modifies data such that, when a conditional search is performed based on a number of fields, the result always returns at least a minimum number (k) of matches.

The k-anonymization technique being developed at the Yokohama Research Laboratory has the following characteristics[2].

(1) Reduced information loss through application of data compression theory

(2) Configuration based on distributed anonymization to support scaling out

Because it requires the introduction of a degree of vagueness to the data, this loss of data accuracy is a downside of k-anonymization. However, the above reduction in information loss acts to counter this problem. The other characteristic of good scalability means that system configurations can cope flexibly with different quantities of data.

Graph-based Clinical Repository

Because clinical data has a large number of different fields, with factors such as tests and symptoms varying from patient to patient, the data sets tend to be sparse with many missing values. Furthermore, even when patients have the same disease, the potential presence of underlying conditions or complications for each case is different. In addition to these characteristics of clinical data, because many case analyses need to be performed in ways that take account of the time sequence patterns for complex medical practices, the analysis of clinical data has traditionally required a lot of time and effort.

To make the analysis of clinical data more efficient, Hitachi's Central Research Laboratory is currently developing a technology to construct graph-based clinical repository. Its features are as follows.

(1) Clinical data is represented using graphs.

(2) Clinical semantic relations between medical conditions and diagnosis or treatment are added based on medical knowledge.

A graph is a way of representing data as nodes and edges, where the edges link the nodes together. In this case, the nodes represent clinical events (such as diagnosis or treatment) and the edges represent the time relationships (elapse of the time) between events. Expressing complex clinical data in this way simplifies the analysis of time sequence patterns. Also, because automatically adding semantic relations between medical conditions and diagnostic or treatment actions allows interpolation of any parts of the data that are missing, it is possible to automate the task of preparing data for analysis, something that in the past needed to be done manually by someone with medical knowledge.

Disease Prevention Support Technologies

Central Research Laboratory of Hitachi, Ltd. has developed an IT system to support Hitachi's own diet program, which is operated by the Hitachi Health Care Center and boasts a high success rate. In 2009,

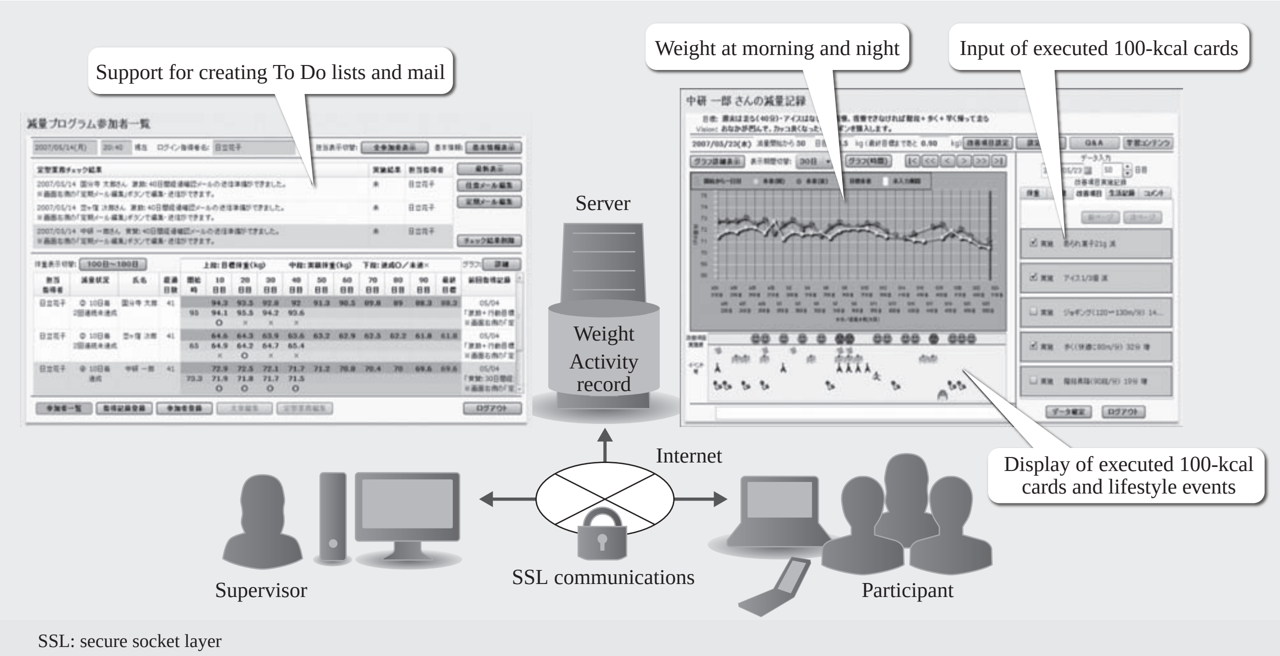

Fig. 2—Structure of Hitachi’s Cloud-based Healthcare Support Service.
The diet program sets targets for reducing calorie intake in 100-kcal increments. The system records daily progress and weight, and helps public health nurses provide guidance.

Information & Telecommunication Systems Company of Hitachi, Ltd. launched a cloud-based healthcare support service that uses this IT system (see Fig. 2).

Further research was then conducted on utilizing the diet program for the prevention of diabetes and its effectiveness confirmed. As diabetes is one of the reasons for ballooning healthcare costs in developed economies, Hitachi believes that diabetes prevention is an example of the sort of much-needed service that can keep these costs down.

CHALLENGES AND FUTURE PLANS

International Initiatives for Repurposing of Medical Data

To facilitate the repurposing of medical data, countries are establishing regulations for the protection of privacy and adopting measures that encourage the use of this data.

In the case of electronic health records (EHRs), different countries are proceeding differently depending on their circumstances, with the two main approaches being the establishment of decentralized EHRs at the level of states or healthcare groups, as in North America, and the centralized, government-driven approach to establishing EHRs being adopted in Europe. Similarly, the adoption of national or medical identifications (IDs) for identifying individual citizens is also proceeding differently in different countries. Name-matching and other similar technologies are required in cases where these IDs are not present.

US System for Handling Medical Data

In the USA, stipulations for the handling of medical data are contained in the Health Insurance Portability and Accountability Act of 1996 (HIPAA). The HIPAA permits the use and disclosure of medical data for purposes such as sales and marketing if it has been anonymized.

The requirements for anonymization are specified in detail, with the following two criteria stipulated for assessing anonymization.

(1) Whether, in the judgment of an expert in statistics, the risk of identifying an individual is very low.

(2) Whether the specified 18 attributes have been masked (information that could be used to identify individuals).

In addition to data anonymization, as in the case of anonymized information, use and disclosure without the permission of the person concerned is permitted in the case of data sets in which the available data is restricted, but in this case the data can only be used for the purposes of research, public health, or healthcare operation. Although recent amendments to HIPAA indicate moves toward making restrictions on data handling more severe, such as restricting the use of medical information in areas like sales and marketing, overall the general trend is expected to be toward encouraging the utilization of data.

While countries outside USA, such as Japan or the UK, do not currently specify rules to the same level of detail as the HIPAA does for things like how to perform anonymization, it is anticipated that each country will enact their own requirements as more use is made of medical data in the future.

CONCLUSIONS

This article has used the example of a healthcare information technology (IT) project in the UK to describe the services currently under consideration and the technology developments that they will require.

Delivering the services described in this article will require safe, secure, privacy-protecting, and reliable healthcare cloud platforms that comply with the rules on handling medical data that apply in each country. Hitachi is seeking to establish services for things like disease prevention, process improvement, and support for drug development that can be delivered on these platforms.

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IT Platforms for Utilization of Big Data

Yasutomo Yamamoto

OVERVIEW: The growing momentum behind the utilization of big data in social and corporate activity has created a demand for the IT platform that has secure and reliable collection and archiving of large amounts of different types of data, fast and simple means for its extraction and analysis, high levels of reliability and expandability, and advanced techniques for automating its management. Having set out its "One Platform for All Data" vision for its IT platform business, Hitachi is preemptively developing technologies that will be needed in the future, while also supplying products and services that support its customers' business operations.

INTRODUCTION

THE era of big data has ushered in a major trend toward the utilization of the large amounts of data held in corporate systems or on the internet, and the diverse variety of information produced by real-world companies, people, and other elements of society.

Hitachi has set out its vision of "One Platform for All Data" as the basis for its information technology (IT) platform business that supports both social innovation and this utilization of big data (see Fig. 1).

This vision involves the collection and archiving of large amounts of different types of data on Hitachi's integrated platforms that utilize servers, storage, networks, and open middleware. Through search, statistics, and analysis, this information can be utilized in applications such as social infrastructure and corporate information systems that in turn generate new data. Hitachi envisages this data cycle on a single highly reliable platform that supports integrated management and incorporates advanced functions such as high-speed data processing and virtualization.

This article describes IT platform solutions that support social innovation and the utilization of big data.

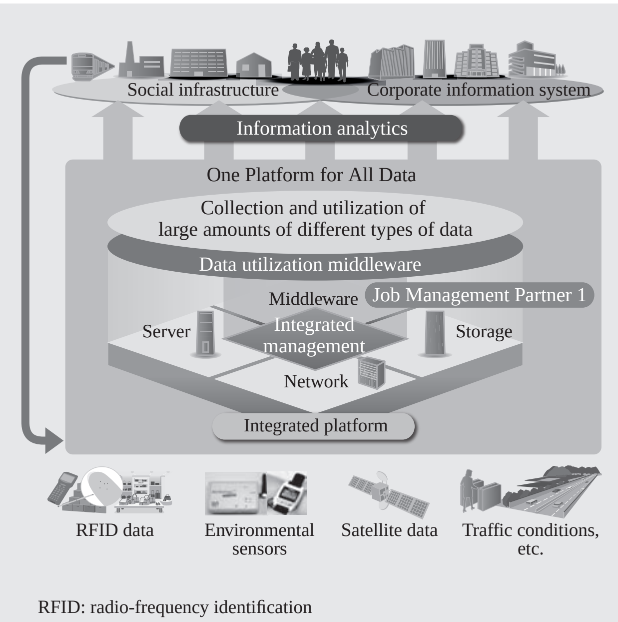

Fig. 1—"One Platform for All Data," Hitachi's IT Platform Business Vision.
A variety of data can be collected and archived on an integrated platform based on Hitachi hardware, and then the same platform can be used to retrieve, analyze, and utilize this data.

MIDDLEWARE FOR UTILIZATION OF BIG DATA

Critical to the utilization of big data is the collection, archiving, and distribution of large amounts of real-world data, followed by its utilization in specific applications.

Here, "collection" means the gathering of large amounts of different types of data for realtime monitoring and immediate processing, "archiving" means the efficient storage of these large amounts of collected data, and "distribution" means providing fast and simple ways of extracting and forwarding required data. The "utilization" of this "distributed" data then requires quick and easy ways of applying it, including through statistical and other analyses. Meanwhile, new forms of innovation are made possible by providing realtime feedback of the knowledge or other findings extracted from the results of statistics and analysis to corporate or public applications.

Hitachi has developed a suite of open middleware products that implement technologies for overcoming the challenges presented by the utilization of field data (see Fig. 2).

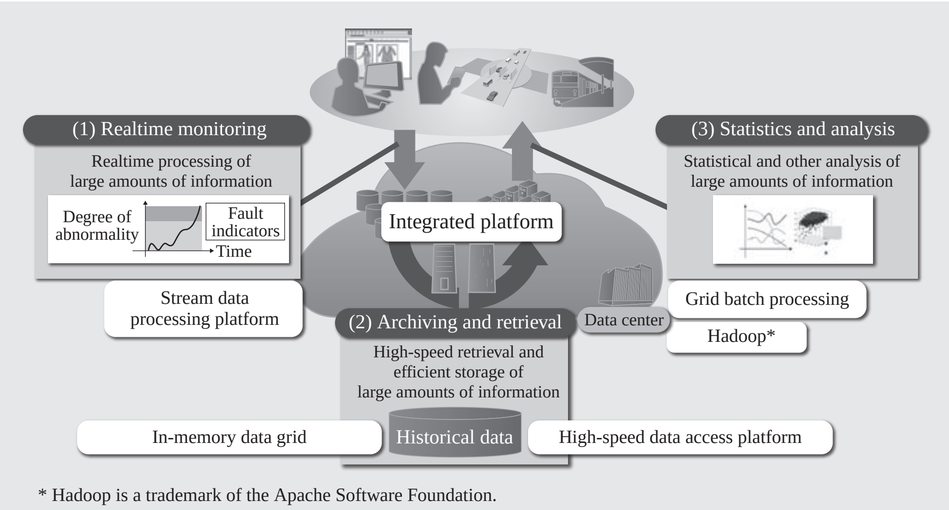

Fig. 2—Open Middleware for Utilization of Big Data.
This suite of open middleware supports the requirements of big data utilization.

To meet the requirements for data collection, Hitachi supplies a platform for processing data streams and in-memory data grids that can process large amounts of data at high speed. Similarly, a high-speed data access platform*1 meets the needs of archiving and distribution, and Hitachi also supplies grid batch processing that accelerates the execution of existing batch programs to meet data utilization requirements.

High-speed Data Access Platforms

Hitachi is working with The University of Tokyo on the joint development of an ultrafast database engine that can maximize hardware performance. Technology produced by this work has already been incorporated into Hitachi products.

The ultrafast database engine uses an out-of-order execution principle*2 (the asynchronous processing of data without regard for the order in which input and output requests occur) that achieves highly parallelized execution by automatically splitting database retrieval into blocks able to execute in parallel. This makes full use of the available server and storage capacity and delivers retrieval speeds that are 100 times faster than previous Hitachi systems.

This high-speed data retrieval performance allows applications such as the analysis of corporate data archived at a data warehouse to be performed ad hoc, without needing to set up a data mart, for example. This reduces the cost of batch processing and facilitates data utilization by providing the flexibility to analyze it in different ways (see Fig. 3).

*1 Utilizes the results of "Development of the Fastest Database Engine for the Era of Very Large Database and Experiment and Evaluation of Strategic Social Services Enabled by the Database Engine" (Principal Investigator: Prof. Masaru Kitsuregawa, The University of Tokyo/Director General, National Institute of Informatics), which was supported by the Japanese Cabinet Office's FIRST Program (Funding Program for World-Leading Innovative R&D on Science and Technology).

*2 A principle devised by Masaru Kitsuregawa, Professor at The University of Tokyo and Director of the National Institute of Informatics, and Kazuo Goda, Project Associate Professor at The University of Tokyo.

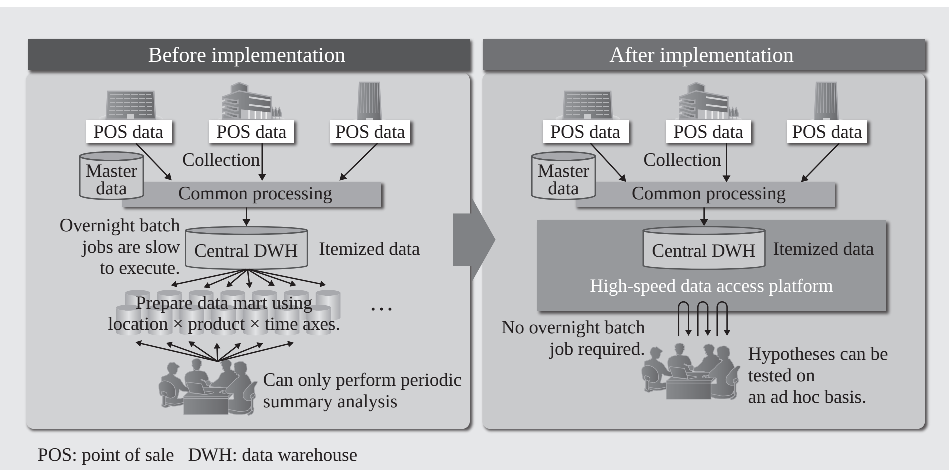

Fig. 3—Example Application of High-speed Data Access Platform.
The platform allows data to be analyzed ad hoc, without creating a data mart. This reduces the cost of overnight batch jobs and provides the flexibility to add different axes to the analysis.

The initial version of the high-speed data access platform was released in June 2012. This combined the ultrafast database engine with the Hitachi Compute Rack series and Hitachi storage systems that incorporate solid state drives (SSDs) and feature a high level of data access performance.

The second product, released in June 2013, was the DaTa SuperExpress[*3], a business intelligence (BI) appliance developed jointly with DTS Corporation. DaTa SuperExpress integrates DTS's BI NavigationStudio[*4], a BI tool featuring excellent ease-of-use, with the high-speed data access platform to create a data warehouse platform with ultra-high speed and large capacity, providing quick and simple support for the strategic analysis and utilization of big data.

In addition to working with customers and partners to work out best-practice models through measures such as conducting proof-of-concept (PoC) demonstrations of data utilization based on these high-speed data access platforms, Hitachi's future plans also include the supply of solutions and services targeted at overcoming specific business issues, such as a logistics analysis solution, for example.

New Integrated Data Platform

In the era of big data, the key to business development lies in the utilization of big data based on the collection, archiving, and distribution of large amounts of different types of data in ways that keep pace with changes in the business. Having up-to-date data is important for keeping up with what is currently happening in different corporate or public situations, and for providing timely feedback to business operations. However, the productivity of activities like analysis and extraction that generate new value from big data is low, with time and effort being required for tasks such as re-modeling of the data being analyzed, redesign of data conversion, or revision of the data mart whenever the data needs to be analyzed from a different perspective. Similarly, collection of data from diverse sources inside and outside the company requires system reconfiguration work such as application software development or the installation of new hardware and software to handle specific data. As a result, making data more up-to-date is a problem.

Hitachi has provided a platform for the execution and management of collection, archiving, and distribution operations. Also planned for the future is the provision of products such as Global e-Service on TWX-21[*5] in the form of a platform as a service (PaaS) that supports software as a service (SaaS).

This platform for the execution and management of collection, archiving, and distribution operations utilizes a high-speed data access platform for centralized management of data collected in a variety of formats, including structured, unstructured, semi-structured, non-realtime, and near-realtime. This provides fast and simple handling of sequentially generated data, together with planning that takes full account of what is happening in the field and the reliable transmission of these plans (see Fig. 4).

INTEGRATED PLATFORM FOR BIG DATA

Companies and other organizations hold data in diverse forms, such as databases, e-mail, images, and sensor data. The quantity of this data is growing explosively, currently in the petabyte (PB) and exabyte

*3 DaTa SuperExpress is a product name, trademark or registered trademark of DTS Corporation.
*4 BI NavigationStudio is a product name, trademark or registered trademark of DTS Corporation.
*5 TWX-21 is a trademark of Hitachi, Ltd.

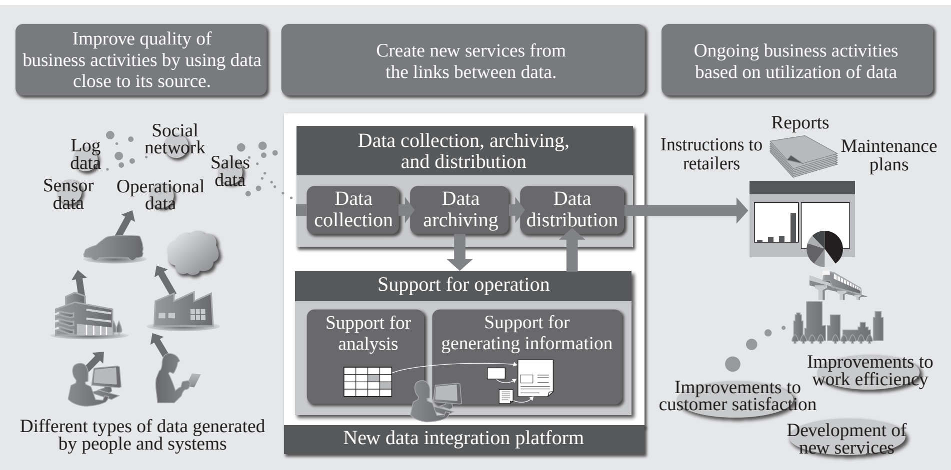

Fig. 4—New Data Integration Platform.
Hitachi supplies platforms that handle different types of data and support everything from collection to distribution.

(EB) range, and expected to reach the zettabyte (ZB) range in the future. Meanwhile, with corporate IT budgets remaining tight, there is a need to maximize customers' return on their IT investment by boosting their business operations through the use of high-performance IT platforms with advanced functions and low total cost of ownership (TCO) that can efficiently process these large amounts of different types of data.

Hardware Solutions for High-speed Processing

This growth in the quantity of data is driving demand for product enhancements, including improvements in the processing performance of server and storage products, larger memory sizes, and better energy efficiency.

In the case of servers, Hitachi is quick to release new products that take advantage of the latest processors, operating systems, and other technologies to support the high-speed processing of large amounts of data and the use of server virtualization for the large-scale consolidation of applications. This has included the development of a new Hitachi compute blade series (released in November 2012) that supports the latest Windows Server[*6] 2012 operating system (OS) and features higher processing performance and memory capacity, and Hitachi Compute Rack series of personal computer (PC) servers (released in July 2013) that incorporate the latest Intel[*7] Xeon[*7] processor and deliver approximately 1.1 times the performance of previous models.

In the case of storage, Hitachi has expanded its range of products that use flash memory media, a form of storage that is recognized for its potential in the high-speed processing of large amounts of data.

*6 Windows Server is a registered trademark of Microsoft Corporation in the United Satates and other countries.
*7 Intel and Xeon are trademarks of Intel Corporation in the U.S. and/or other countries.

In August 2012, Hitachi added a flash acceleration function to its Hitachi Virtual Storage Platform (high-end storage). By upgrading the operation of the storage controller to suit data processing on flash memory, the function achieves data reading rates of more than one million input/output operations per second (IOPS).

Meanwhile, Hitachi Accelerated Flash (HAF), a flash module developed using proprietary Hitachi technology that combines low cost and high performance, was released worldwide in November 2012. Thanks to a flash memory controller developed by Hitachi, HAF achieves approximately twice the data processing speed of previous models with an installation cost that is roughly 30% lower (see Fig. 5). With the release in July 2013 of a version of HAF intended for use with Hitachi Unified Storage VM, Hitachi has also started supplying new models that support an all-flash configuration.

Content Cloud Solutions

The data used within companies exists in a variety of forms, including structured data such as databases and unstructured data such as e-mail and documents. This data is spread across different sites and departments, and on systems such as staff PCs and mobile devices, and is continually increasing in volume. Hitachi supplies content cloud solutions that provide centralized management and easy access to content and other files in various different formats.

Hitachi Data Ingestor installed at an operational site or department acts as an on-ramp to the cloud, allowing for automatic consolidation and centralized management of site data on a Hitachi Content Platform storage system located at a data center. Users can access data without concern for whether it is held at their own site or at a remote data center. This reduces TCO and improves return on investment (ROI) by overcoming the problem of needing to administer

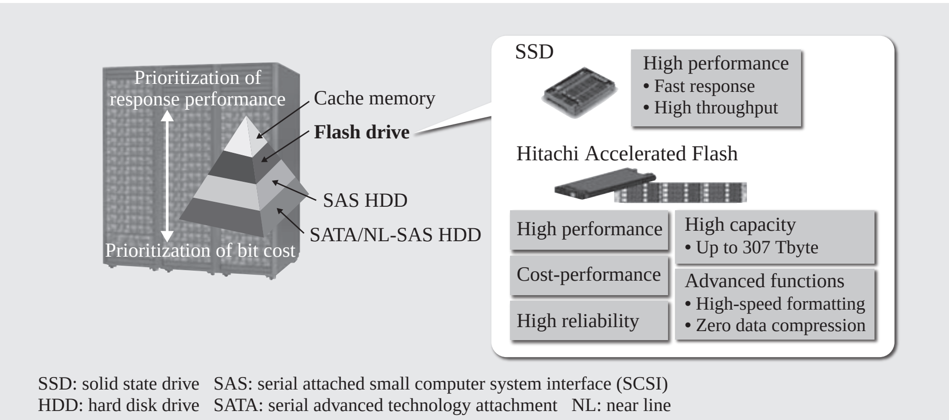

Fig. 5—High-speed Solution Using Flash Memory.
This platform achieves high-speed data processing through use of Hitachi Accelerated Flash, a flash module based on proprietary Hitachi technology.

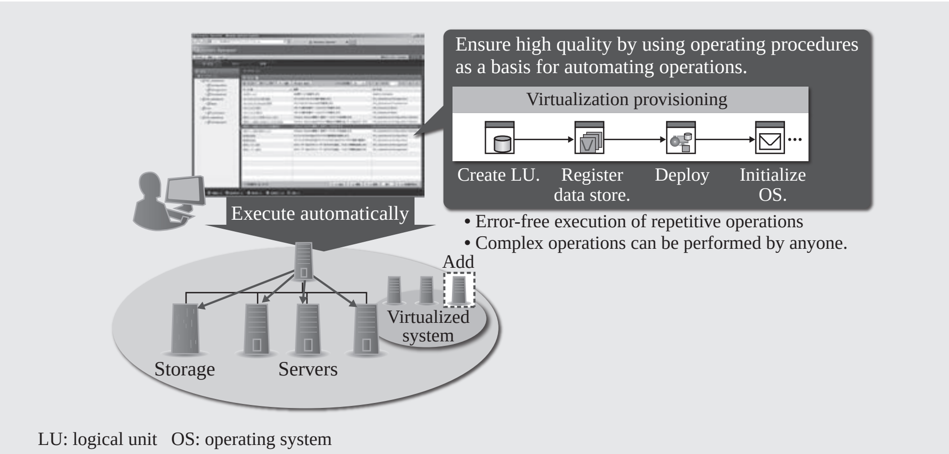

Fig. 6—Job Management Partner 1/Automatic Operation Product for Automating IT Operations.
Job Management Partner 1/Automatic Operation reduces administrator workloads by executing IT operations automatically in accordance with operating procedures.

data separately at each site, and also the challenges of data management and capacity enlargement for the complex storage hardware required to cope with larger data volumes.

Outside Japan, Hitachi Data Systems Corporation released Hitachi Content Platform Anywhere in May 2013. Aimed at corporate users, this secure file synchronization and sharing solution for mobile devices makes it easy to share files between registered devices, enhances device security and reliability, and helps provide a better IT experience for staff.

Integrated System Management for More Efficient Administration

Urgent challenges faced by corporate IT departments include the growth in the size of information systems, their increasingly complex administration, expanding operational workloads, and tighter IT budgets.

Hitachi supplies a range of solutions for reducing the cost of IT system administration through its Job Management Partner 1 Version 10 integrated system management products. These include Job Management Partner 1/Automatic Operation for automating IT operation, the Job Management Partner 1 system monitoring service that incorporates system management technology and know-how developed through Job Management Partner 1, and the Job Management Partner 1 smart device management service that provides a SaaS application for handling security and asset management of a company's smart devices (see Fig. 6).

To reduce installation costs for IT systems, Hitachi supplies the Hitachi Unified Compute Platform, an all-in-one package that combines administration middleware with proven server, storage, and network hardware. The proven performance of these products shortens the time taken from installation until users are able to start using them (the "service-in time"). The management software bundled with the platform also reduces operating costs by helping simplify and automate the operation of virtualization.

Furthermore, to provide for the quick and easy configuration of server virtualization on small and medium-sized systems, Hitachi released a simple virtualization model for the Hitachi Unified Compute Platform in July 2013 that incorporates server virtualization software.

In the future, Hitachi intends to help reduce the cost of IT systems for a wide range of customers by providing a greater diversity of configurations that combine software and hardware to suit specific end uses.

CONCLUSIONS

This article has described IT platform solutions that support social innovation and the utilization of big data.

The aims of these solutions are to use IT to process real-world data in order to determine the current and past situation on the ground, to enhance people's creativity, and to provide a view of the future. Through the accurate processing of data collected from the field, and by using it to provide feedback to the processes of public and corporate activity, it will be possible to create new forms of value.

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Traffic Management Solutions for Social Innovation Business

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Yusuke Shomura, Dr. Eng.
Hirofumi Masukawa
Yukiko Takeda

OVERVIEW: The spread of smartphones in recent years has led to explosive growth in the volume of data communications traffic. The ways in which networks are being used are also becoming increasingly diverse, with not only conventional use by people but also growing machine-to-machine traffic. Meanwhile, network businesses are emerging that generate high added value by representing and analyzing these heavier and more diverse traffic volumes, and by controlling and utilizing them in the best possible ways. Drawing on its know-how and customer base that extend across both telecommunications and IT, Hitachi is supplying solutions that provide its customers with business innovations and optimized capital investment, and is working on traffic management solutions that support its Social Innovation Business, including in fields like smart information and the utilization of big data.

INTRODUCTION

WITH greater use of smartphones driving rapid growth in the use of rich content such as video, it is anticipated that data communications traffic on mobile networks will grow fifty-fold over the next five years. Traffic characteristics are also becoming more diverse, with applications for mobile networks expanding from use by people to also encompass machine-to-machine (M2M) communications. Given these heavier and more diverse traffic volumes consisting mainly of mobile data, there is a need for appropriate ways of managing and controlling this communication.

This article describes Hitachi's work on traffic management solutions (TMSs) based around the collection, analysis, and control of traffic data.

HITACHI'S TMS CONCEPT

Information and communication technology (ICT) covers both information technology (IT) and telecommunications. In terms of its role in managing the rapidly growing volumes of data communications traffic, ICT is being called on to satisfy the following two requirements.

(1) Optimization of investment: expanding data communications traffic and data storage capacity at low cost.

(2) Innovation: promoting business innovation and helping establish and expand new businesses.

A TMS is a solution for collecting information on the traffic between people, machines, and systems, and for performing analysis and control based on specific objectives. With the TMS playing a core role, Hitachi uses ICT solutions that incorporate a variety of technologies to implement features such as network virtualization, and to deliver innovation and optimize investment in user ICT systems belonging to telecommunications operators or to transportation, distribution, local government, or other service providers. These technologies include software-defined networks (SDN), network functions virtualization (NFV), and M2M (see Fig. 1).

In the case of telecommunications operators, for example, for whom dealing with the growth in traffic volumes is an urgent issue, Hitachi can optimize investment in telecommunications equipment by using a TMS to provide fine-grained and realtime bandwidth control for each user, and techniques for making effective use of available bandwidth, such as data offloading and data compression. Hitachi also brings innovations to telecommunications operators' ICT systems by, for example, helping them identify changes in user needs, provide new services, and establish new business models through the analysis of realtime traffic data along with their customer and other stored data.

ICT SOLUTION BUSINESS WITH CORE ROLE FOR TMS

This section describes how Hitachi is working on an ICT solution business in which TMSs play a core role, supporting its Social Innovation Business in fields such as smart information and the utilization of big data.

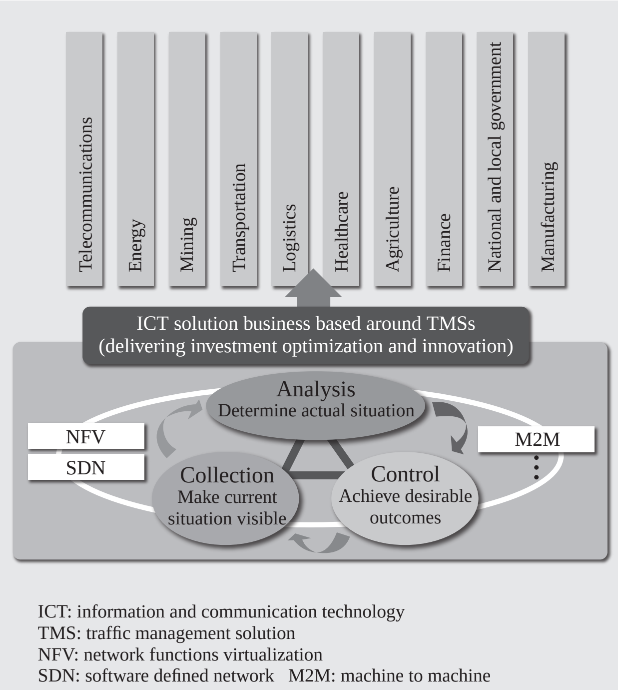


Fig. 1—ICT Solution Based around TMS.
The TMS collects a variety of traffic status data and then performs analysis and control based on specific objectives. ICT solutions based around TMSs deliver investment optimization and innovation.

Utilization of Big Data

(1) TMSs

In the past, users of telecommunications services have experienced stress in data communications such as the intermittent degradation of communication quality due to bursts in traffic. Meanwhile, telecommunications operators have needed to make sufficient capital investment to ensure that they have the base stations and other network equipment required to cope with peak traffic volumes.

Hitachi’s solutions provide reliable and trouble-free telecommunications by detecting and controlling the time and location of traffic bursts in realtime. They also optimize investment in communication equipment by utilizing techniques that absorb and minimize bursts of peak traffic. Specifically, this optimization of investment in communication equipment is achieved through realtime data collection using deep packet inspection (DPI), high-speed analysis on Hitachi’s stream processing platform, and realtime bandwidth and compression control based on policy control techniques (see Fig. 2).

(2) Network functions virtualization solution (TMS × NFV)

Mobile telecommunications operators currently use equipment configurations in which a key role is played by the special-purpose hardware that handles the evolved packet core (EPC) control function in Long Term Evolution (LTE) mobile communications. Operators also have a growing need for flexible equipment that can quickly implement changes such as network upgrades or the addition of new functions to handle increasing user numbers and a greater diversity of services.

Hitachi’s solutions combine the TMS with NFV technology to determine traffic volumes and service usage so that resources can be allocated accordingly. Specifically, by drawing on its past experience in the development of conventional EPCs, Hitachi is seeking to ensure scalability and agility together with significantly shorter lead times for new and upgrade installations. This is achieved by implementing the EPC function on a virtualization platform on standard servers, and by using the resource monitoring, analysis, and control functions of the TMS (see Fig. 3).

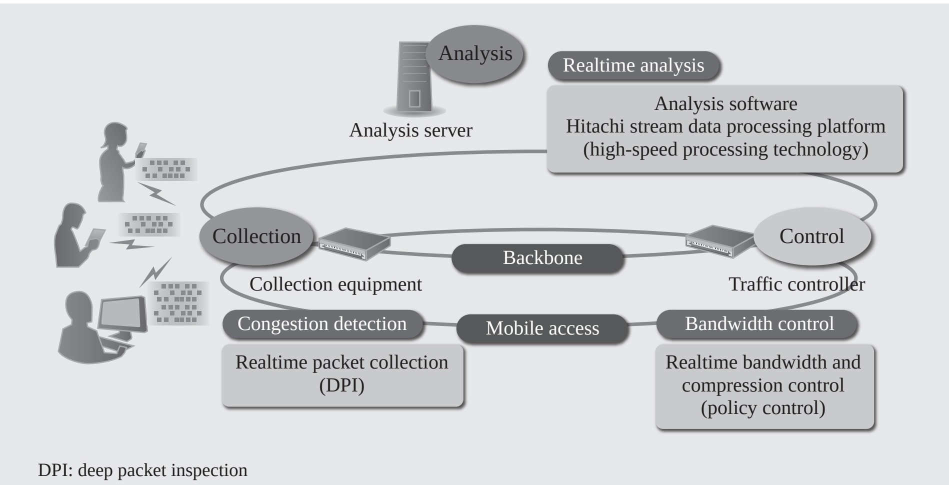


Fig. 2—Solution for Optimizing Capital Investment.
The investment in communication equipment is optimized through realtime collection using DPI, high-speed analysis using Hitachi’s stream processing platform, and realtime bandwidth and compression control based on policy control techniques.

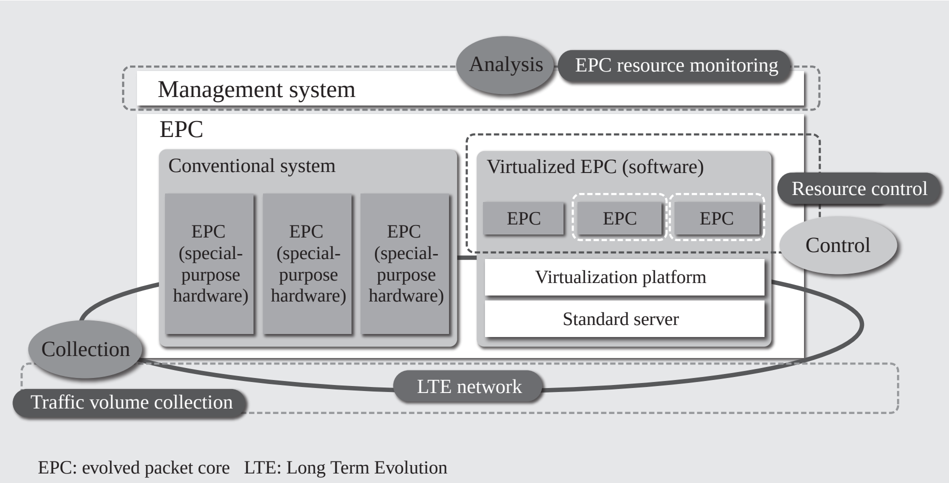


Fig. 3—NFV.
NFV ensures scalability and agility and significantly reduces the lead time for new and upgrade installations by hosting the EPC function for an LTE network on a virtualization platform running on standard servers, and using the resource monitoring, analysis, and control functions of the TMS.

Smart Information

(1) M2M traffic solution (TMS × M2M)

One application for M2M networks is in the management and maintenance of equipment used in social infrastructure, such as roads, electric power, and water. Hitachi is working on optimizing traffic management on M2M networks.

M2M networks differ from general network traffic in a variety of ways, including being characterized by large numbers of often small packets, and by the sources of this traffic being spread over a wide geographical area. While it has typically been difficult to provide an end-to-end guarantee of communication quality for M2M traffic, by collecting and analyzing network traffic, Hitachi is seeking to control it in ways that suit its characteristics (large numbers of small packets).

The monitoring of tunnels and bridges, for example, has traditionally required staff to make costly and time-consuming visits to the site to make an assessment based on sensor data. By combining a TMS with technologies for sensor nodes, highly reliable wireless communications, and sensor node platforms developed through trials conducted with social infrastructure operators and other customers, Hitachi's M2M traffic solution aims to allow remote inspections to be conducted via high-definition video, for example, by dynamically reallocating network bandwidth when status changes occur. Hitachi also intends to integrate the solution's control functions with road traffic systems, and to include a function for sending emergency notifications to users' digital devices to inform them when an abnormal situation arises (see Fig. 4). In the future, Hitachi intends to combine TMSs with know-how built up through its social infrastructure businesses to control the flow of utilities such as water or electric power.

Similarly, Hitachi also intends to help improve the efficiency of equipment management and maintenance by supplying M2M traffic solutions to a wide range of service providers in social infrastructure and other fields.

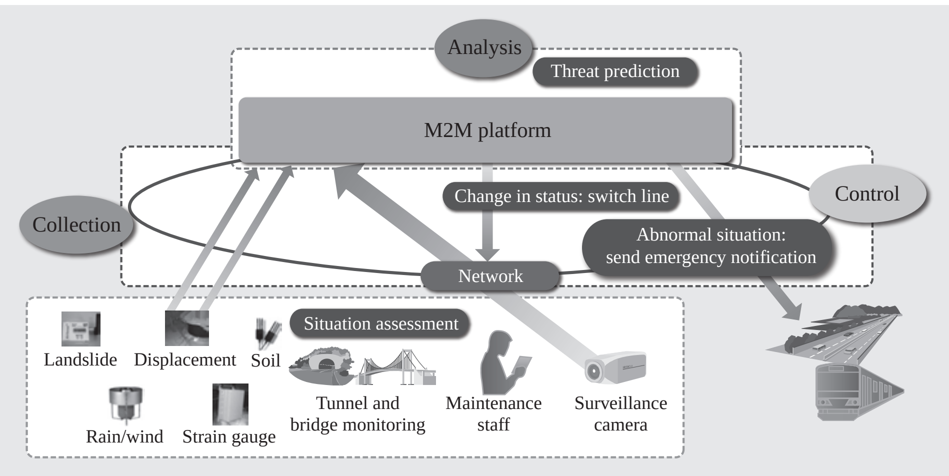


Fig. 4—M2M Network Solution.
In addition to dynamically reallocating network bandwidth when status changes occur to allow remote inspections to be conducted via high-definition video, for example, the intention is also to integrate the solution's control functions with road traffic systems so that emergency notifications can be sent to users' digital devices to inform them when an abnormal situation arises.

RESEARCH AND DEVELOPMENT WORK UNDERPINNING TMS BUSINESS

This section describes the research and development associated with Hitachi's work on TMSs.

There currently exists a demand from social infrastructure such as transportation and finance for telecommunications systems that incorporate critical infrastructure protection to ensure stable and reliable operation. Recognizing this, Hitachi is undertaking research and development work aimed at optimizing investment in communication equipment and delivering innovations that will encourage better business practices (see Fig. 5). Hitachi is providing highly reliable communication platforms that utilize NFV technology based on dependable hardware technologies built up over time, and then using these as a basis for implementing TMSs. The technologies required by TMSs include user and business management, traffic management, network management, coordination with data centers and service providers, and security and reliability enhancements.

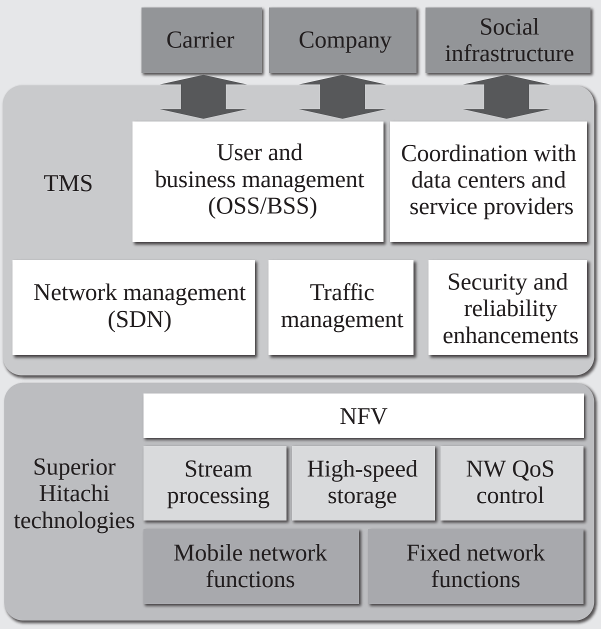
The following sections describe work on technologies for traffic management and coordination with data centers and service providers.

Traffic Management

In addition to the use of traffic management technologies to improve quality of experience (QoE) and optimize investment in equipment through the collection, analysis, and control of traffic, this also includes treating traffic information as big data and using it to improve investment efficiency. This improvement in investment efficiency is achieved by analyzing traffic information collected by DPI equipment to detect any degradation in service quality, and also by analyzing the causes of this quality degradation to determine ways of improving the network.

Specifically, this involves measuring device response delays to detect any loss of communication quality on the radio access network. The analysis of instances of quality degradation in terms of devices, areas, and time periods can then be used to infer the cause of this degradation. Identifying the causes of quality degradation allows countermeasures such as modifying the area design or optimizing system parameters to be implemented efficiently (see Fig. 6).

Network architecture



TMS technology

Technologies	Description
User and business management (OSS/BSS)	User and business workflow management
Traffic management	Make network more robust Collection, analysis, and control
Network management (SDN)	Multi-layer network management Setting up of highly reliable paths
Coordination with data centers and service providers	Handle requests from data centers and companies. Setting up of high-quality communication paths
Security and reliability enhancements	Countermeasures against DoS attacks Advance system verification

OSS: operation support system BSS: business support system NW: network QoS: quality of service DoS: denial of services

Fig. 5—TMS Application Architecture.
Hitachi is seeking to build networks that incorporate critical infrastructure protection to ensure stable and reliable operation and satisfy the varying communication quality requirements of different users.

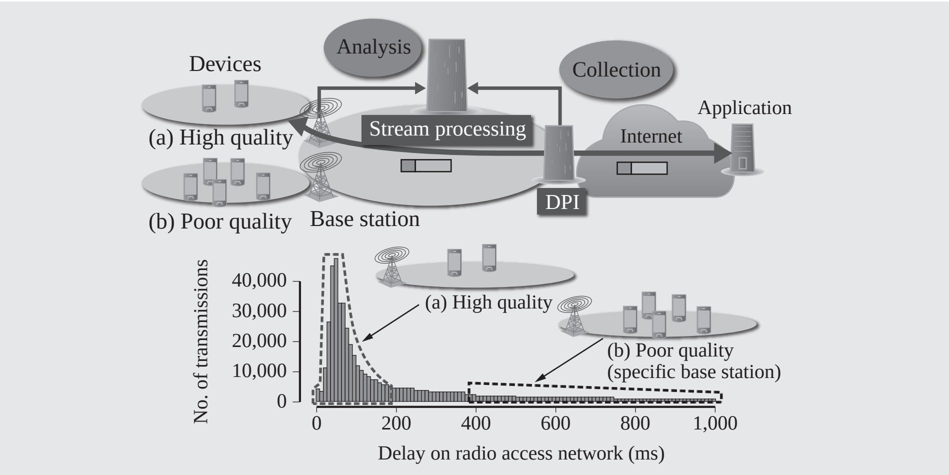


Fig. 6—Detection of Quality Degradation and Analysis of Causes.
This involves using response delays on the radio access network to detect degradation in communication quality, and analyzing the reasons for longer delays.

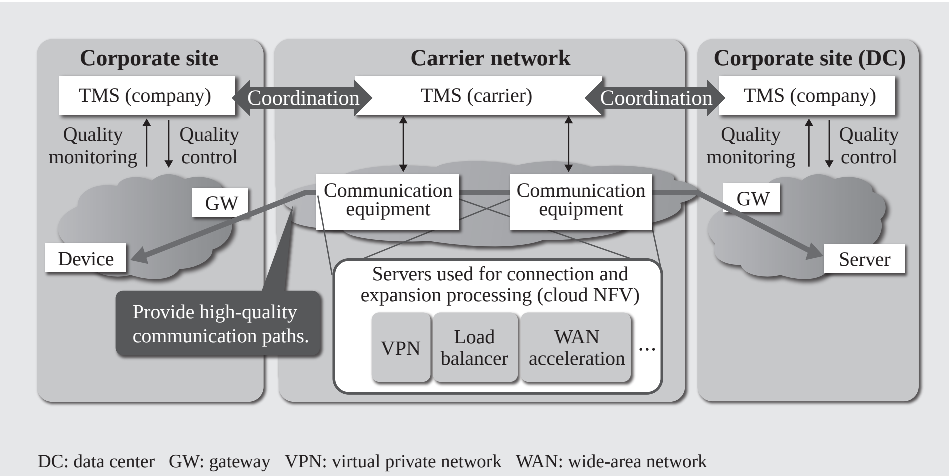


Fig. 7—Coordination with Data Center Networks.
High-quality communication paths are established by dynamically incorporating virtualized functions in response to requests from data center networks.

Coordination with Data Centers and Service Providers

Coordination with data centers and service providers can be used to implement highly reliable end-to-end networks through the coordinated control of both highly reliable carrier networks that use TMSs to support diverse communication quality requirements and unified cloud networks that span across multiple data centers (see Fig. 7).

Specifically, high-quality communication paths can be configured dynamically by incorporating virtualized functions on the carrier network based on the requirements of the cloud network. In the case of corporate applications that place a priority on communication bandwidth, for example, high-quality communication paths that are independent of the communication methods used by the application can be provided by dynamically incorporating acceleration on the wide area network (WAN) that provides the communication guarantee. WAN acceleration can provide high throughput even when the round trip time (RTT) is very long, such as when communicating between physically distant sites (see Fig. 8).

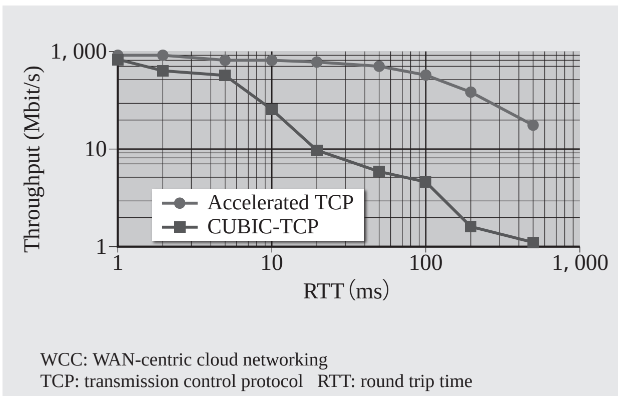


Fig. 8—Benefits of Using WCC.
The graph plots the improvement in TCP performance achieved by using WAN acceleration. High throughput can be achieved even on network with a long RTT.

CONCLUSIONS

This article has described Hitachi's work on TMSs based around the collection, analysis, and control of traffic data.

In the future, in addition to marketing its TMSs to customers in Japan and elsewhere, Hitachi intends to supply solutions that support its Social Innovation Business, including the utilization of big data and smart information.

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