NICT NEWS

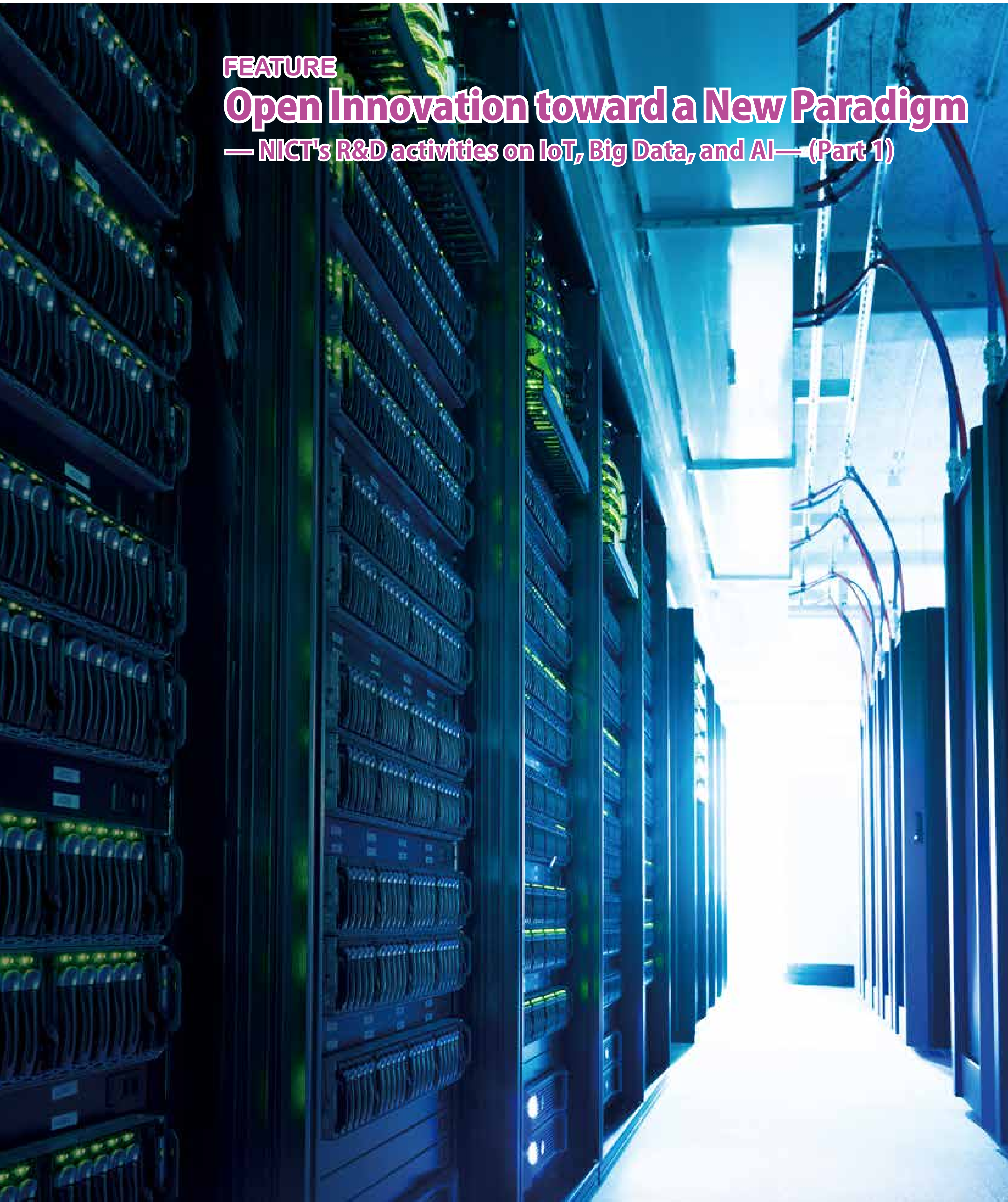
NICT National Institute of Information and Communications Technology

No.461 JAN 2017

FEATURE

Open Innovation toward a New Paradigm

— NICT's R&D activities on IoT, Big Data, and AI — (Part 1)



NICT NEWS No.461 JAN 2017
National Institute of Information and Communications Technology

CONTENTS

〈Cover description〉

StarBED as an IoT Testbed

To build a verification platform for the IoT era, which will allow all people and things to connect to the network, the Hokuriku StarBED Technology Center conducts R&D on operating platforms for all familiar devices such as PCs, mobile phones, and sensors, integrating related aspects such as temperature field and electromagnetic field into the experimental environments. It also provides access to the testbed to help accelerate development of next-generation products.

The following are some expected research topics:

- Flexible support for new devices and protocols
- R&D lifecycle support
- Emulation of the space surrounding the IoT environments
- Linking with external simulators and emulators

See the following for details regarding equipment configuration and operation.
http://starbed.nict.go.jp/ (only in Japanese)

(Cover photo: Hokuriku StarBED Technology Center Experimental node clusters. Photo: Shingo YASUDA)

This year is one second longer than a common year!

On January 1, 2017, a leap-second was added (at 8:59:60 am)

Visitors watching at the instant the leap second was added

As the sole institution maintaining and distributing Japan Standard Time, the National Institute of Information and Communications Technology (NICT) added a leap second (8:59:60 am) between January 1, 2017, 8:59:59 am and 9:00:00 am. This was an infrequent event that had not occurred in about a year and a half, and approximately 400 people came to see it on the clock in front of NICT headquarters in Koganei City.

For those who came, NICT held a briefing by NICT Vice President, Dr. Mizuhiko HOSOKAWA, and Director General, Applied Electromagnetic Research Institute, Dr. Kazumasa TAIRA.

Video of this event can be found in the Video Library section of the NICT Website.

http://www.nict.go.jp/video/leap-second.html

Briefing to the visitors

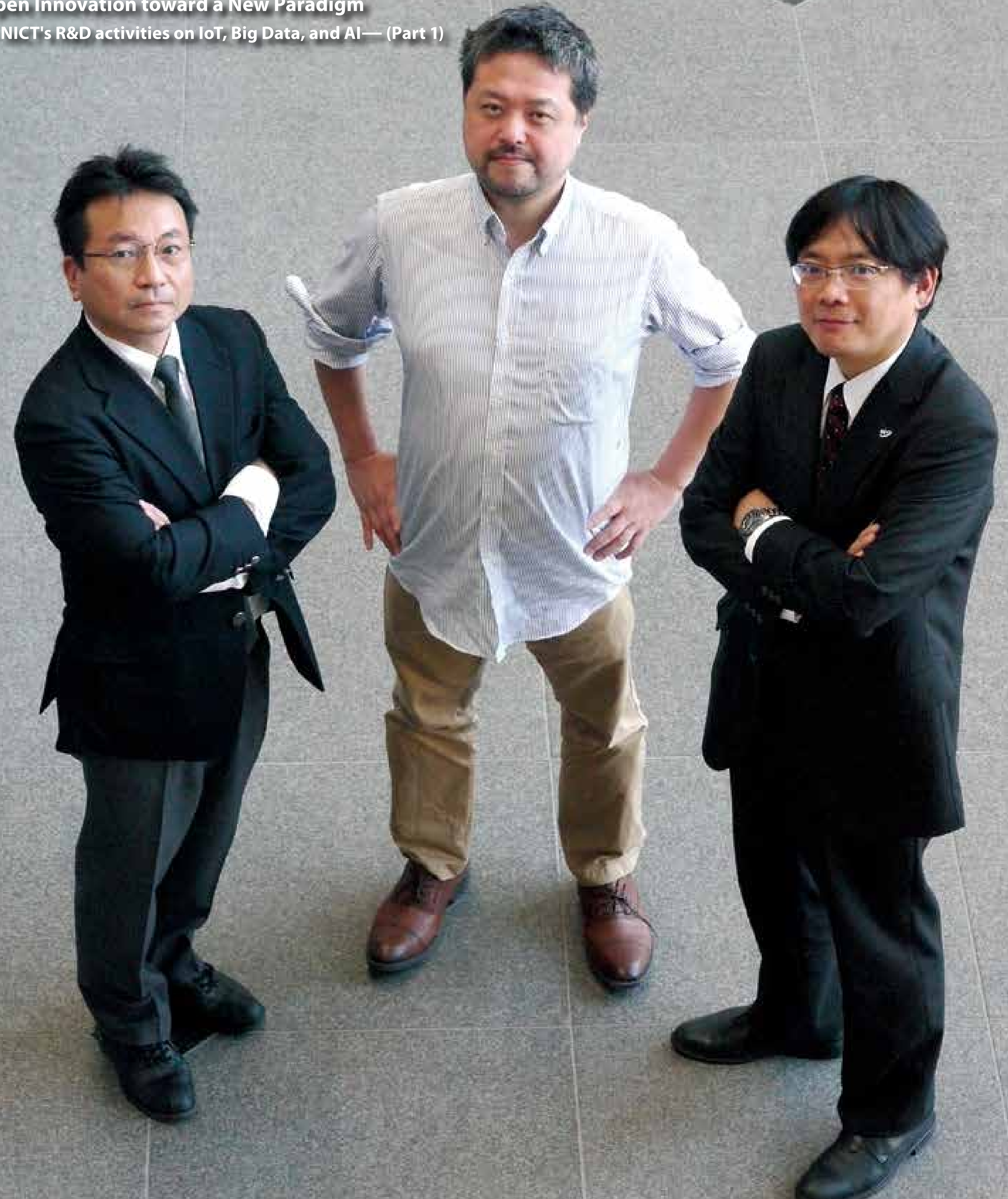
Visitors interviewed by TV station staff

Standard time display at the instant the leap second was added

FEATURE

Open Innovation toward a New Paradigm

— NICT's R&D activities on IoT, Big Data, and AI— (Part 1)



Motoaki YASUI
Executive Director of Unit, Social Innovation Unit/ Managing Director of Office, Strategic Program Produce Office, Social Innovation Unit

Joined the Communications Research Laboratory (currently NICT) in 1996. Later, was Deputy Director of the Ministry of Internal Affairs and Communications (MIC) Technology Policy Division, NICT Remote Sensing Fundamentals Laboratory Director, and NICT Strategic Planning Department Managing Director before his current position. Ph.D. (Science)

Junichi SHIMADA
Managing Director, Strategic Planning Department / Managing Director, Open Innovation Promotion Secretariat, Open Innovation Promotion Headquarters / Research Executive Director, Social Innovation Unit / Managing Director, Wireless Networks Research Center

Joined the Ministry of Posts and Telecommunications (currently MIC) in 1993. Later, worked as Deputy Director of the MIC Technology Policy Division, the Electromagnetic Environment Division, and the Standardization Division, as Specially Appointed Professor at the Japan Advanced Institute of Science and Technology, and as Senior Planning Officer of the MIC Global ICT Strategy Bureau before his current position. Ph.D. (Information Engineering)

Yutaka KIDAWARA
Director General, Universal Communication Research Institute / Director, UCRI Information Services Platform Laboratory / Director General, Advanced Speech Translation Research and Development Promotion Center/ Director General, Social Innovation Unit Big Data Integration Research Center

Joined the Communications Research Laboratory (currently NICT) in 2001. Engaged in R&D on universal communications technology based on multilingual translation, speech translation, information analysis, information utilization, and ultra-realism technologies. Ph.D. (Engineering)

Recently the terms, Internet of Things (IoT), Big Data, and Artificial Intelligence (AI) are heard more and more often. The Internet of Things refers to a society in which a wide range of objects are connected to the Internet, and their data are accumulated, exchanged, and combined in cyberspace (the virtual world on the Internet) in a timely fashion and in useful ways for diverse purposes, to create a range of new value.

IoT Initiatives

The concepts of IoT, Big Data, and AI grew out of the ubiquitous computing concept in the 1990s, so as the Internet spread and technologies related to sensors, knowledge processing, and data visualization advanced quickly, we entered a time when technology R&D activity advanced, closely linked with activity to create value and services using those technologies. These developments signified the first step into a future to be realized by cyber-physical systems, with mastery over both cyberspace and physical space (the real world). When this future is realized, it will bring changes comparable to the industrial revolution, and many countries are intensifying R&D and implementation activity with collaboration among industry, academia, and government, as with the Industry 4.0 initiative in Germany.

Promotion of IoT in Japan

In this environment, Japan also established the IoT Acceleration Consortium in 2015 (inaugural meeting Oct. 23, 2015), and the Smart IoT Acceleration Forum was established within the consortium. This was the start of concrete activities to accelerate R&D and implementation of IoT, Big Data, and AI technologies, promoting collaboration among industry, academia, and government. More comprehensive promotion to increase competitiveness in AI research, data utilization, and human-resource development in Japan also began in 2015, including collaboration on AI R&D among the Ministry of Internal Affairs and Communications (MIC), the Ministry of Education, Culture, Sports, Science and Technology (MEXT), and the Ministry of Economy, Trade and Industry (METI).

Initiatives at NICT so far

In multilingual speech translation technology, MIC announced in April 2014 the Global Communication plan (hereinafter, GC plan) to realize a society that overcomes language barriers, and has been promoting it since then.

This is one part of realizing effective cyber-physical systems to improve society and human life in it, by linking information from cyberspace and physical space according to specific purposes, and it is an important direction for ICT in the future. NICT is pursuing R&D to increase our lead in sensor technologies for collecting information, network and cloud technologies that store and distribute information, technologies that use data to create new value, and on linking these technologies organically in selected important fields. As a core facility promoting the GC plan, NICT is also promoting projects on specific themes such as multilingual speech translation, for which there is a particular need for rapid implementation, big-data utilization, which is also a focus of the AI Technology Strategy Council, knowledge processing (WISDOM X), which NICT is developing and implementing, and sensor network technology using Wi-SUN.

NICT R&D in IoT and AI

To implement IoT and AI technologies, it will be very important to be able to use the huge amounts of information circulating and accumulating in cyberspace effectively according to various purposes. As such, technologies in fields such as knowledge processing will be essential for implementing the intellect that will control IoT society in the future. Some NICT technologies that promise to play a central role in AI technology R&D are starting to be realized, such as the DISAster-information ANAlyzer (DISAANA). Often discussed elemental AI technologies such as deep learning are also being implemented in technologies that are starting to become common, such as multilingual speech translation, and are advancing daily. NICT will continue utilizing such technologies, which we have cultivated over many years from the stage of basic research, and also continue R&D to advance them further.

Realizing an "IoT Society"

IoT, Big Data, and AI are closely interrelated and essential for implementing an IoT society (or a society built on cyber-physical systems) in the future, so it will be important to take an overarching perspective on them while advancing R&D. Even more important will be to integrate R&D activity with activity to create value and services using these technologies (i.e. the activities of players in various fields). This assumes an approach promoting open innovation. To enhance the effects of open innovation requires a platform for verifying technologies, not only from a technical perspective, but also from a perspective of implementation in society.

Conventionally in ICT fields such as advanced networks, a test platform has been used to demonstrate technologies ahead of their time (demonstration using a testbed), but to verify the utility of new ICT technologies in the IoT era, a platform with a network testbed and also a virtual IoT society built inside computers is needed. NICT is also conducting R&D on testbeds using emulation to realize this.

We are also emphasizing data related R&D and business around the concept of data utilization, which will be an important key for an information-based society. For example, one aspect of this is running the administration of the World Data System (WDS), which is an international framework for handling scientific data, as a contribution to both international competitiveness and to international cooperation.

In this and the following edition of NICT NEWS, we will introduce the current state and future prospects for NICT R&D initiatives in IoT, Big Data, and AI.

IoT Testbed Research and Development

Technologies to realize next-generation IoT environments

Eiji KAWAI
Research Manager,
Network Science and Convergence Device Technology Laboratory
Network System Research Institute/
Research Manager,
Applications Laboratory
Resilient ICT Research Center
Social Innovation Unit

After receiving a Ph.D. degree in engineering in 2001 and working at universities, Eiji Kawai joined NICT in 2009. Currently he is working on IoT testbed technologies.

In ICT research and development, work on testing is very important in the process of implementing the R&D results practically. Environments used to perform this testing are called testbeds. NICT conducts R&D on testbed technologies, and builds actual testbed platforms to support such testing. We are focusing on IoT technologies, and studying how to implement testbeds for these technologies.

Testbed work at NICT

There are two types of testbeds that we are working on: large-scale real platform testbeds and large-scale emulated platform testbeds.

For a large-scale real platform testbed, an environment modeled after the presumed user environment is actually built with the technology being tested. Operating in this environment both tests the technology and promotes spread of the technology. Examples include JGN, which is a testbed for ultra-high-speed trunk networking technology, RISE, which is a testbed for wide-area SDN technology, and JOSE, which is a testbed for distributed sensor applications. By bringing in R&D results and actually operating them, these testbeds can be used to verify technologies for practical application, to improve compatibility with existing peripheral technologies, and to establish real operational processes.

On the other hand, with large-scale emulated platform testbeds, the usage environment is simulated (emulated) on a computer cluster and the technology is tested while running in that environment. StarBED is a concrete example of this, and with it, a large number of machines can be used for testing, including scalability testing. The configuration of the test environment can also be changed easily to test in a variety of environments.

Edge computing as an IoT testbed function

We are currently focusing on IoT technology as a new target, and studying implementation of testbeds for this technology. IoT must be efficient in processing data that is constantly being produced by a huge number of distributed IoT devices, so an infrastructure architecture suitable for IoT is needed. However, the performance necessary to handle IoT data cannot be achieved using conventional architectures like cloud computing, which concentrate computing resources centrally and can lead to inefficiencies. For example, to control equipment in real time using data from sensors, the delay between sensors and the remote cloud could be large, making the response too slow. If a sensor generates large amounts of data, transmission of the data to the distant cloud could also incur very high costs.

As such an ICT infrastructure concept called edge computing, which places computing resources near the devices generating the data (at the edges), has been attracting attention recently. We are developing a layered architecture for edge computing (Figure 1). The lower layers are infrastructure layers, which manage various types of distributed physical resources and provide abstract, virtualized infrastructure model and service instances to the upper layers. The upper layers are platform layers, providing interfaces to middleware functionality required by IoT services. They receive the various abstract resource models provided by the lower layers and use them to process data and supervise communication.

An important aspect of edge computing is consideration of the interface between these upper and lower layers. With edge computing, physical resources for computation and communication must be distributed, and interfaces must be able to define computing "at the edges." IoT devices are also being developed and sold by many companies, so a platform for IoT must maintain such diversity. For this, IoT service providers require simple, robust interfaces able to implement a certain type of ecosystem independently of the lower level infrastructure. We are studying use cases and prototypes where edge computing would be effective, developing a platform architecture, including interface design, and working to provide this as an IoT testbed in the future.

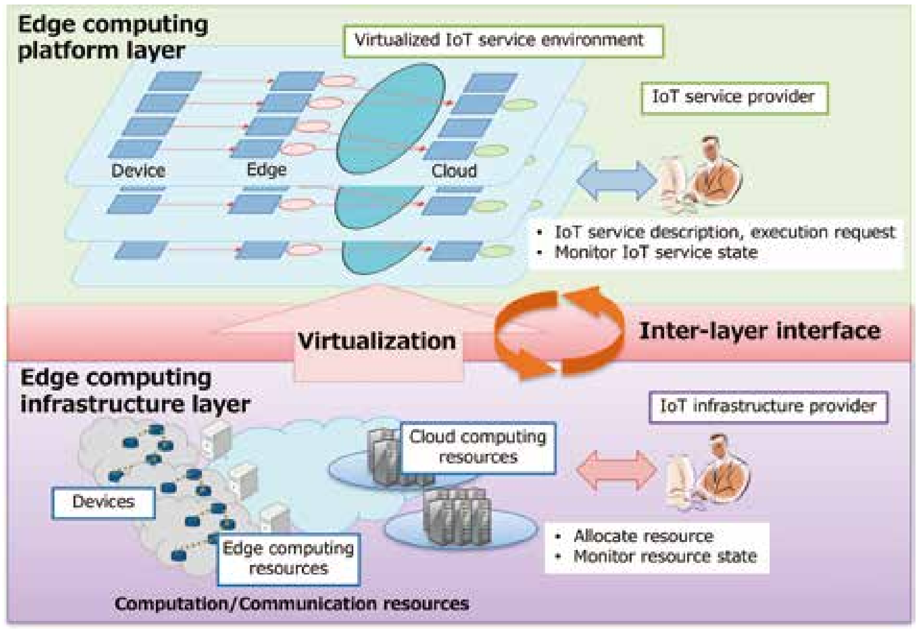


Figure 1　Layered architecture for edge computing

Service exchange as an IoT testbed function

An important aspect of an IoT platform architecture, in addition to being able to process data efficiently, is to improve cost benefits, and linking services is one way to achieve this. Even if individual IoT devices are inexpensive, costs to deploy many are high. If new services can be produced by linking diverse IoT services, we can expect to improve cost benefits. We are developing an IoT data sharing mechanism called service exchange platform to realize this sort of IoT service linking.

Currently, IoT services are composed of IoT devices, communication, message exchange, data management, data analysis, applications and other elements, and diverse technologies and standards are being developed for each (Figure 2). As such, it is not an exaggeration to say there are almost limitless ways to link IoT services and it would be impossible for a platform to support all of them. Also, most of the vertically-integrated service platforms being expanded by current cloud providers have not considered this type of service linking, which presents a problem for providing IoT services.

We are developing a simple mechanism called service exchange platform, which can handle all IoT device data consistently using a message exchange format called MQTT (Figure 3), as our approach to service linking. This mechanism focuses on sharing data near the IoT device producing the data. We are also studying provision of this as a function of the IoT testbed.

IoT device	Communication	Message exchange	Data management	Data analysis	Applications
• Single function sensors: temperature, pressure, acceleration, position, motion, etc. • Smartphones • Automobiles • Drones, etc.	• LTE • WiFi • Bluetooth • Wi-SUN • ZigBee • RFID • NFC, etc.	• DDS • MQTT • QMQP • JMS • REST • CoAP • XMPP etc.	• CSV • OWL • EXI • RDB/SQL • NoSQL • Fluentd • Kinesis, etc.	• Hadoop • Spark • Jubatus • TensorFlow • Elasticsearch • Bluemix • AML, etc.	• Healthcare • Manufacturing • Electricity, gas • Smart homes • Security • Agriculture, fisheries • Transportation, etc.

Figure 2　Various IoT elemental technologies and related standards

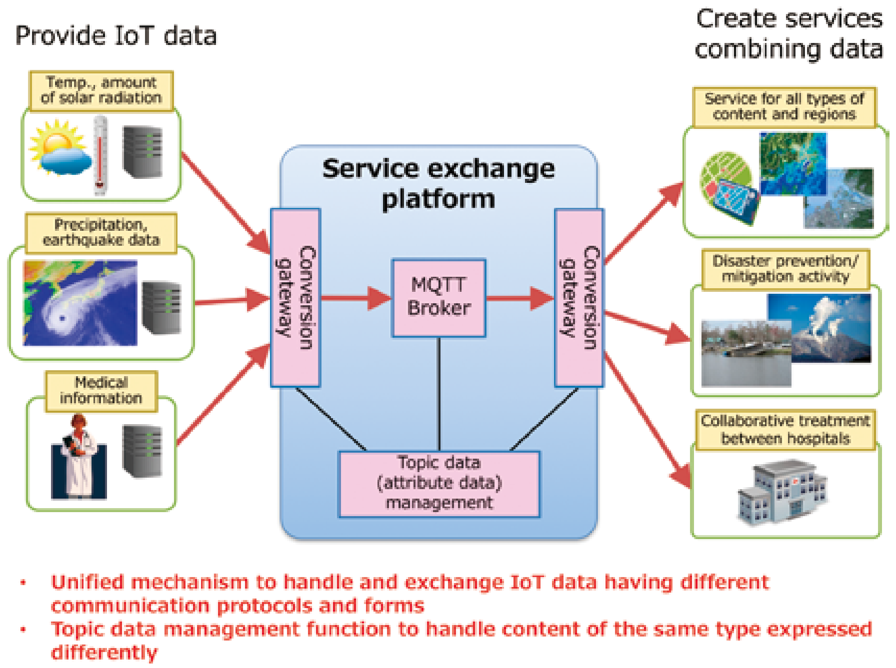


Figure 3　Service exchange platform overview

Collaboration with the Smart IoT Acceleration Forum

In this article, we have introduced our R&D on testbed technologies, and in particular, technologies we have begun studying for implementation of an IoT testbed. We plan to establish a testbed subcommittee within the Technology Strategy Study Group of the Smart IoT Acceleration Forum to advance our IoT testbed efforts through open discussion. A anyone interested in verification of IoT technologies is welcomed to participate.

[Reference URL]
http://smartiot-forum.jp/tech-strategy/testbed/

StarBED as an IoT Testbed

Expanding ICT technology testbed infrastructure to evaluate IoT technologies as well

Toshiyuki MIYACHI
Associate Director of ICT Testbed Research, Development and Operations Laboratory/
Director of Hokuriku StarBED Technology Center
ICT Testbed Research, Development and Operations Laboratory
Technical Center of ICT Testbed Research and Development Promotion Center
Social Innovation Unit
Joined NICT in 2013. Engaged in research on building and operating network testbeds and their applications. Ph.D. (Information Science).

Since FY2002, the NICT Hokuriku StarBED Technology Center has been promoting R&D on experimental environments, mainly for verifying Internet technologies, and has been providing realistic evaluation environments to industry and to universities.

These types of test environment are called testbeds, and the testbed we have built is called StarBED.

The StarBED approach and how it has changed

StarBED was designed to shed light on issues that occur in large scale systems, and is composed of many PCs to run application software that is actually used on the Internet and in corporate networks. Its main purpose is to evaluate products and technologies in an environment that is similar to real, large-scale, and complex environments, to expose problems and to correct them before deploying the products in real environments.

The project began in 2002 with 512 servers, and since then the equipment has been updated and expanded into an environment with about 1,100 servers as of 2016. Until 2015, the environment went through changes to support various projects, but it was built and remained a test environment for ICT technologies. However, there is now vigorous development of IoT technologies, and products incorporating IoT technologies are becoming quite familiar. IoT technologies are more closely connected to our living environments than ever before, and IoT devices are strongly linked to the movements of people. Ensuring the safety of IoT technologies will be very important for technical development in the future. As such, we are conducting R&D to utilize StarBED as a testbed for IoT technologies, starting this fiscal year.

StarBED as a testbed for IoT

As described above, the approach of StarBED is to operate real devices and applications, and facilitate doing experiments in environments that reproduce the large-scale, complex environments where the technologies being evaluated will be introduced. However, there are many types of IoT devices, and it is not possible to build realistic environments that would have many more devices than the ICT environments we have dealt with till now. So far, StarBED has been able to provide many devices on the assumption that general servers were being used, but such an approach is difficult with IoT devices. As such, our approach is to use virtualization technology on general servers, to run hardware such as Arduino, which is used in IoT technology. If many types of hardware can be emulated using software technology, the scale and connectivity of the environment can be changed with flexibility. It also has the benefits that emulator development costs less than providing many individual hardware components, and the emulator equipment requires less physical space. On the other hand, there is some loss of fidelity and accuracy in hardware components, which could cause issues. We have prioritized the benefits above, however, and aim to build environments able to run the application software as the main focus.

IoT devices generally assume wireless networking, but all servers in StarBED are connected by wired links, so this aspect must also be virtualized. For the past ten years, we have been promoting R&D on a technology called QOMET, which emulates wireless networking over wired networks and has already been used in various projects. Wireless networks are strongly affected by factors such as weather and geography, so it is difficult to conduct repeated experiments under exactly the same conditions. To accommodate this, we compute the communications conditions with other devices based on relative wireless device locations, and change the characteristics of the physical network accordingly when building virtual wireless networks on StarBED.

Future prospects

As mentioned earlier, IoT technologies have a very strong connection with people's movements. To evaluate IoT technologies, human behavior must also be introduced into the experimental environment. Weather conditions and geography also have effects on both IoT devices and people's behavior. To incorporate such elements into our environments, we are also promoting R&D to connect existing simulations of weather and flow of people to experimental environments built on StarBED.

These are all elemental technologies, and by building a large framework that links them together, we will continue to grow StarBED into a large scale emulation infrastructure for large-scale, flexible evaluation of IoT technologies.

Figure 1 StarBED and its equipment

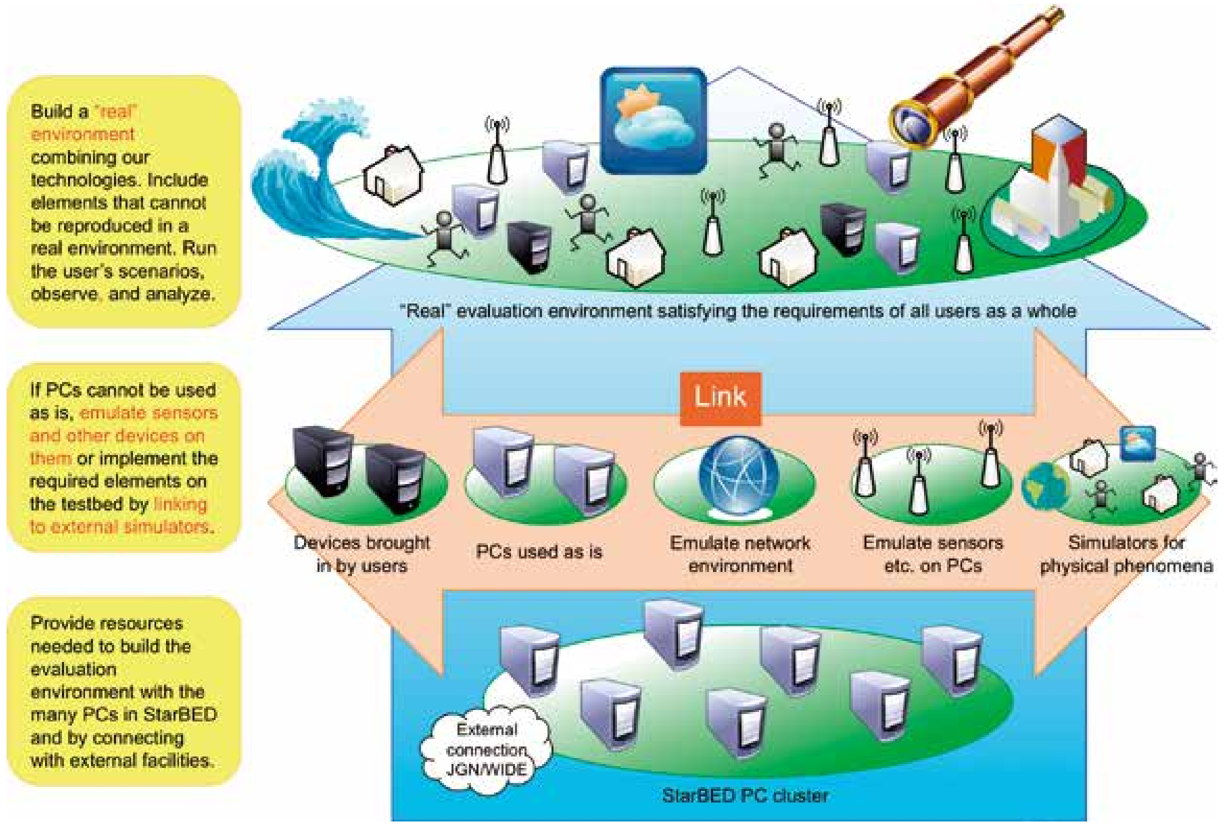


Figure 2 IoT evaluation platform on StarBED

IoT Big Data Analytics Technology

Towards sustainable smart society by linking "Watch," "Create," and "Connect"

Koji ZETTSU
Director of Big Data Analytics Laboratory
Big Data Integration Research Center
Social Innovation Unit/
Executive Researcher
Information Services Platform Laboratory
Universal Communication Research Institute

Employed by IBM Japan in 1992, and joined CRL (currently NICT) in 2003. Director of Information Services Platform Laboratory, Universal Communication Research Institute from 2011 to 2015, and has held current position since 2016. Research interests include data mining and information retrieval. Ph.D. (Informatics).

In recent years, IoT has been spreading rapidly and an estimated one billion devices will be connected to networks in Japan by 2020. It is anticipated that using IoT data, new services will be created in fields such as environmental measures, health management, and industrial optimization. In our real-space information analytics research, we are developing data collection and analysis technologies to effectively leverage real-space information obtained from the environment and societal life. We are also developing a data mining technology that will integrate advanced environmental data with social data to analyze their cross-domain associations. It will facilitate model case studies of environmental influences to social systems such as transportation. We are also conducting R&D on methods to feedback the analysis results to sensors and devices in real space, as well as R&D on sensor technologies to realize feedback efficiently and effectively. This will allow us to create, develop, and verify IoT platform for advanced situation recognition and behavior support, with the goal of optimizing social systems (Figure 1).

Practical example of localized torrential rain risk management

Disasters of localized torrential rain have increased dramatically and become a serious issue because of global warming and heat-island phenomena. As a practical application of our real-space information analytics technology, a decision support system for localized torrential rain is being developed. This system uses phased-array weather radar installed in Osaka and in Kobe for early detection of vortexes that indicate development of cumulonimbus clouds (localized torrential rain baby cells). It then predicts areas on the ground where a rainfall exceeding 50 mm/h will occur within 30 minutes, visualized on a digital map (localized torrential rain early detection). It also sends warnings to pre-registered e-mail addresses, indicating areas such as water catchments that rainfall will flow into, underpasses and other areas susceptible to flood damage, before the localized torrential rain occurs. We are currently conducting a field test of this system in cooperation with the Kobe city office.

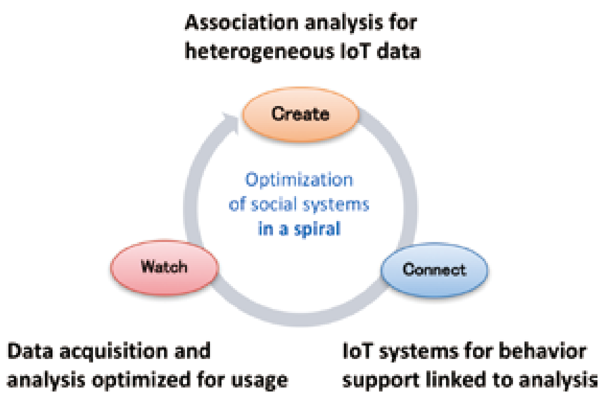


Figure 1 R&D on real space information analytics technology

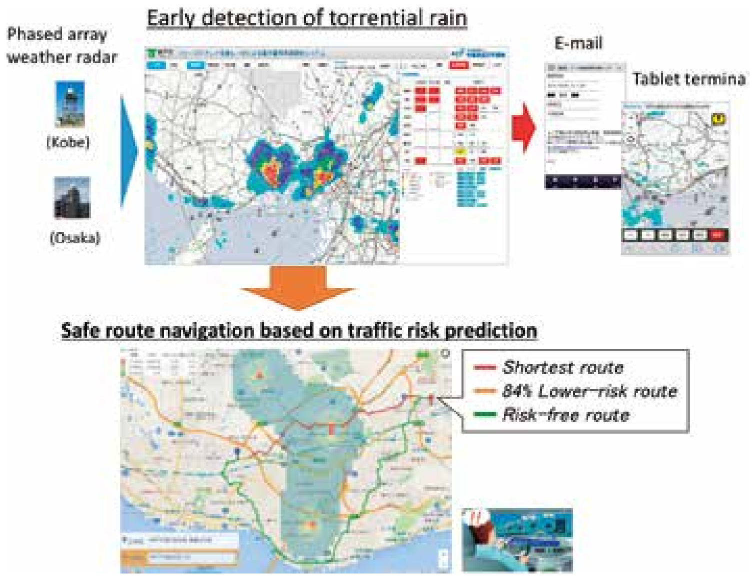


Figure 2 Decision support system for localized torrential rain

Through this test, in addition to further improvement of early detection accuracy, we also realized that estimating various risks caused by the torrential rain is also important in order to take effective countermeasures with the limited human resources available. This has lead us to develop AI technology for predicting risks co-occurring with localized torrential rain such as traffic hazards. Our R&D scope also includes behavior support for avoiding the predicted risks, such as map navigation for safe route navigation (Figure 2).

IoT data gathering and analysis optimized for behavior support

To make social systems more efficient and optimized by utilizing IoT data, it is important to organically link data collection, analysis, and behavior support on the IoT platform. In our recent R&D on air pollution risk management, we are developing a scalable method for air pollution prediction based on atmospheric simulation models, which integrates multi-scale, multi-modal atmospheric data captured by satellite sensors, Lidar, and other means at scales from global down to the level of towns and roadways (Figure 3). This is a world-leading technology realizing air pollution predictions for local living areas, from several hours to several days in advance, by taking into consideration the widespread cross-border pollution in Asia. We are also developing applications that provide pinpoint forcasts of adverse affects on health from the prediction results, as well as behavior support for prevention and mititgation. In the future, we plan to integrate data from mobile and personal sensors in order to provide even more detailed predictions.

To make such analysis possible, we are developing a data mining technology, called Event Data Warehouse, that will gather and integrate heterogeneous sensing data from IoT, and extract event information representing environmental phenomena or people's behaviors. This will be used to discover and predict spatial, temporal, and thematic associations among those data (Figure 4).

We are also developing user interface and interaction technology for effective behavior support using various IoT devices in conjunction with the data mining. Our research aims at optimizing information visualization, presentation, and user interactions based on extrinsic factors such as the types and situations of behavior (working, driving, walking, interacting, etc.), as well as intrinsic factors such as attentiveness and psychological stress. Quantative evaluation of these is also in our scope.

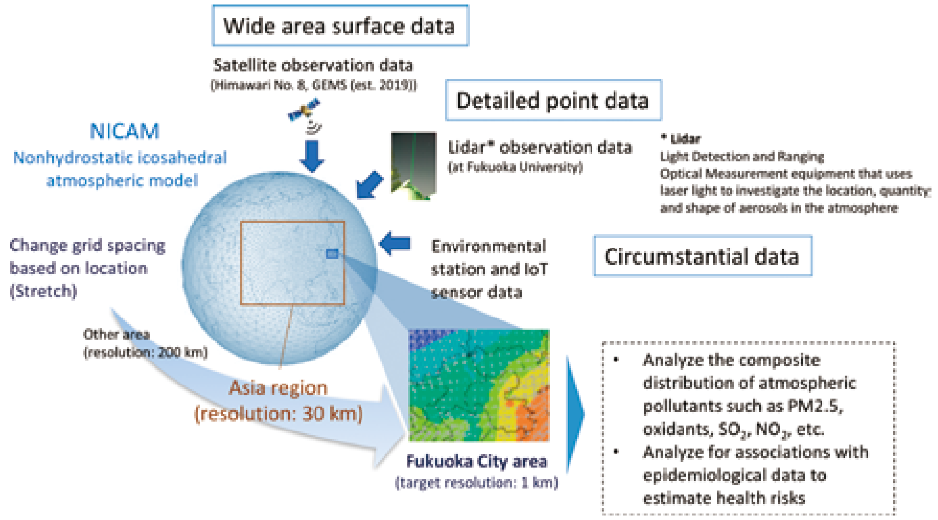


Figure 3 Scalable air-pollution prediction method using the Stretch NICAM-Chem model

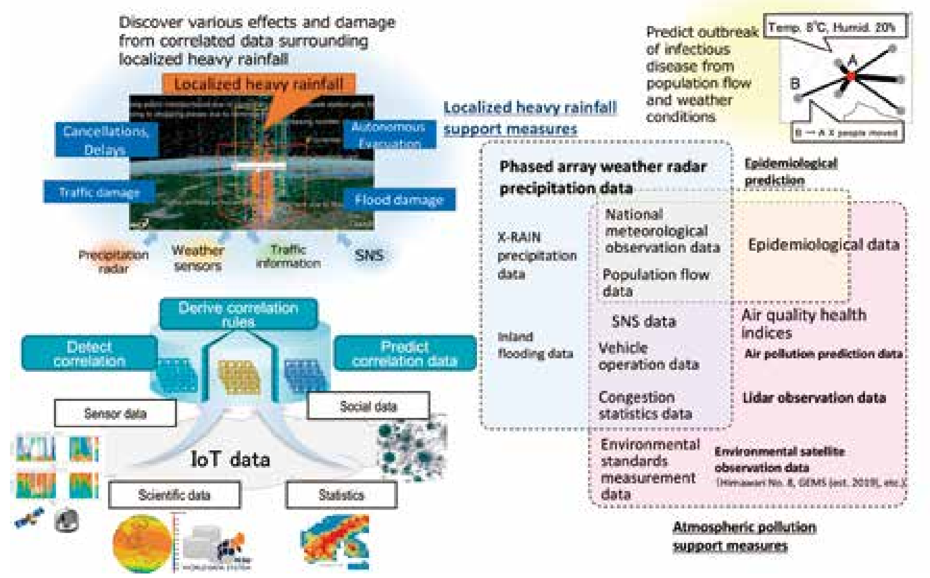


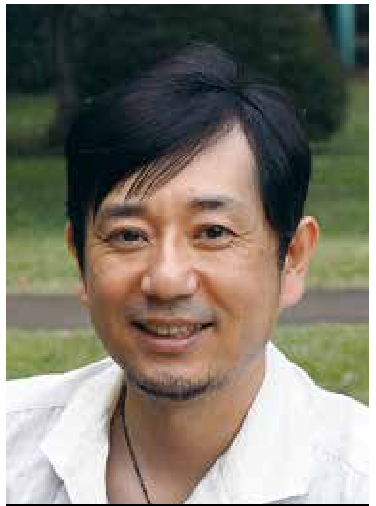
Figure 4 Event Data Warehouse system for collection, integration, and association analysis of heterogeneous sensing data

Future prospects

Advancing real space information analytics technology R&D even further, we will implement a platform for IoT data analytics based on our technology on top of the NICT integrated testbed. It will facilitate data-driven analysis of environmental and social issues with social Big Data. Our risk management applications for localized torrential rain and air pollution are to be its prototypes. We will also make technical proposals and standardizations for the IoT data analytics technology through organizations such as the Cross-Data Collaboration Project at the Smart IoT Acceleration Forum.

Community-based IoT Infrastructure for a Safe & Secure Society

Strategies to deploy wireless IoT gateways based on the concept of "Local data production and local data consumption"



Yozo SHOJI
Director of Social-ICT Innovation Laboratory
Big Data Integration Research Center
Social Innovation Unit

Joined Communications Research Laboratory, Ministry of Post and Telecommunications in 1999. Since then, he has been engaged in the research for millimeter-wave communications systems, coherent optical communications systems, and the synergy of wireless and wired network virtualization. He is the director of Social-ICT innovation laboratory.

The Social-ICT Innovation Laboratory has inherited the vision of the Social-ICT Promotion Research Center, began in FY2014, conducting R&D on ICT systems and services that contribute to solving social issues, integrating different fields and links different industries. Among the diverse systems making use of ICT, we are focusing R&D on the field of IoT technologies, which is expected to grow into a large market in the future both in Japan and internationally.

Background

One of the societal issues on which NICT is working broadly with industry is the so-called "2025 issue". Japanese society is getting aged, with one in four people already 65 years old or older. This trend will continue in the next decade, till one-in-three are 65 or older, and one-in-five are 75 or older, putting Japan in the lead as the first "super-aged society" in history. As such, in Japan, there is a market for solutions that deal with this super-aged society and a venue for testing them. This could become a large export industry in the future and presents a great business opportunity for domestic industry. Our laboratory is promoting early commercialization by domestic industry in this domain, through R&D on ICT systems and services, and demonstrations in society, under the theme, "Creation of a Safe and Secure Society."

R&D on wireless technologies that will collect data from sensors in the innumerable devices in our everyday environments, and on technologies to process and analyze this data is important for IoT technology, but strategic promotion to consolidate infrastructure and conduct R&D on services and applications that will foster use of these technologies and spread them throughout society is also needed. As such, our laboratory will promote R&D and practical demonstrations with a strategy of spreading IoT infrastructure in three areas of society, starting this year. These areas are: (1) Developing services and applications based on the concept of "local data production for local data consumption," (2) incorporating wireless IoT gateways in vending machines, and (3) incorporating wireless IoT gateways in commercial vehicles (Figure 1).

Spreading community-based IoT infrastructure in society through the concept of "local data production for local data consumption"

There are an increasing number of cases of IoT-related business success through big-data utilization. On the other hand, although there have been various trials led by government organizations as a means of regional revitalization, there are still no noticeable instances of success. Most of the reasons for this stem from capital or operating costs of equipment for analysis of the "big" data that is collected.

Our laboratory is promoting R&D on systems or services for a safe and secure society using simple and inexpensive mechanisms to use and consume locally produced data, even if it is "small" data, based on a concept of "local data production for local data consumption" to monitor regional safety and security (Figure 2).

With general big-data utilization models, data are collected and analyzed, and services are provided based on the results, but our concept has a simpler data utilization model. We study services based on a cycle of (1) taking data produced in a region, (2) sharing them within the region, and (3) stimulating or supporting action by people in the region (Figure 2).

To give a more concrete example of a service that contribute to safe and secure living, a service that shares information about wandering elderly persons with dementia who have gone missing could enable a whole community to look after them or quickly mobilize a search for them. Another example is a service that reports minute-to-minute changes in traffic conditions and other anomalies or dangers at local intersections and street corners to surrounding pedestrians and vehicles in real time could.

Figure 1 Strategies to spread "Community-based IoT infrastructure" into society

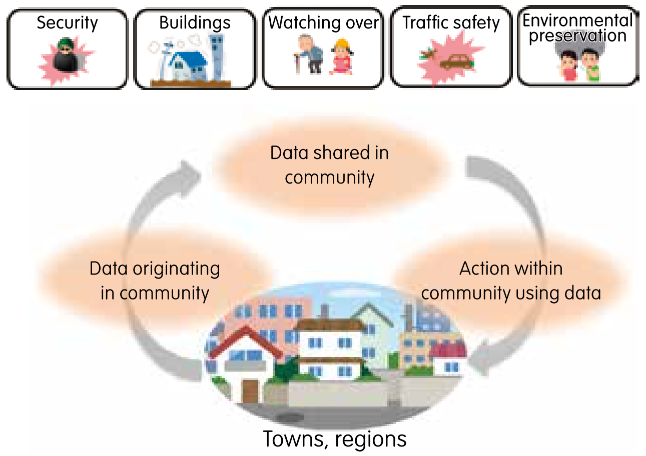


Figure 2 "Local data production for local data consumption" to monitor safety and security in society

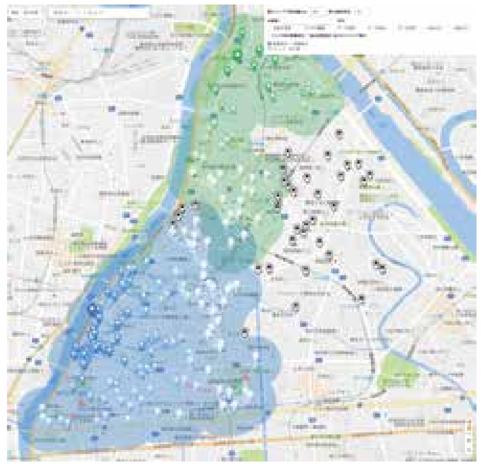


Figure 3 Example mesh network design with bases in beverage vending machines

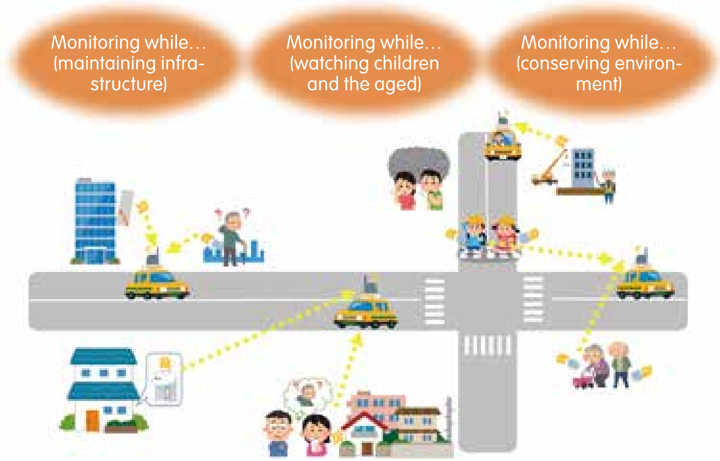


Figure 4 "Monitoring while…" *moving* urban infrastructure

Spreading community-based IoT infrastructure in society through wireless IoT gateways in beverage vending machines

For IoT services to permeate society, regional IoT infrastructure must be built, installing wireless IoT gateways at relatively high density so that data can be collected from the various IoT sensors, but the increasing cost of securing locations for this equipment is a concern.

We have designed a regional IoT infrastructure using a strategy of mounting wireless IoT gateways in the approximately two million beverage vending machines located throughout Japan. We are currently developing a testbed and applications to verify this concept. Particularly within cities, there are beverage vending machines everywhere, at intervals of a few hundred meters. Using beverage vending machines as bases for Wi-SUN* wireless IoT gateways would make it possible to develop a broad service area at low cost. Wi-SUN is a wireless communications standard for IoT that enables easy expansion of services areas using multi-hop communication.

We are currently working, in cooperation with a major beverage manufacturer, to build the regional IoT infrastructure, to develop applications, and to plan a demonstration in Sumida Ward of Tokyo. Figure 3 shows an example configuration for a mesh network with base stations in beverage vending machines that are actually installed by the beverage company in outdoor locations in Sumida Ward. This configuration assumes that bases are able to communicate with each other if beverage vending machines were located within 300 m of each other. We expect that there will be segments that the signal will not reach due to obstructions, but this design shows that a mesh network configuration could cover more than 60% of the area of Sumida Ward in its service area.

Spreading community-based IoT infrastructure in society through wireless IoT gateways in commercial vehicles

We are also considering placing wireless IoT gateways in taxis, buses, delivery trucks, and other commercial vehicles that operate locally, in addition to beverage vending machines, as a strategy for deploying IoT infrastructure in society at low cost. These vehicles are always active in areas where there is human activity, so even in areas that wireless signals do not reach easily or on the outskirts of town, vehicles frequently come within several hundred meters of wireless IoT sensors and can receive the sensor data as needed. This mechanism enables regional businesses that have vehicles to contribute to the community, by functioning as infrastructure to monitor community safety and security while they move around (Figure 4).

Since we will have IoT gateways installed in these vehicles, we are also considering services that will give them access to surrounding wireless sensor data in real time, which can bring their attention to traffic safety information or give sight-seeing information based on their current locations.

Our laboratory is currently getting cooperation from vehicle navigation system manufacturers, while also testing communication between vehicles with devices based on the Wi-SUN wireless communication standard and studying the utility of such services.

Future prospects

We will continue building community-based IoT infrastructure integrating wireless IoT gateways installed in beverage vending machines and moving vehicles such as taxis, and promoting social verification tests for safe and secure communities in cooperation with local governments.

* Wi-SUN: A wireless communications standard for IoT wireless devices, promoted by the Wi-SUN Alliance. It provides reciprocal connection and authentication, and that uses the IEEE 802.15.4g standard. Several lifeline businesses in Japan have decided to adopt it as the wireless communication standard for smart meters, and it is expected that device size and cost will continue to decrease further in the future.

Equipment and Method for Microbe Analysis

— Detecting chemical substances using biological sensors —

Research on using the sensing capabilities of living organisms to investigate chemical substances is advancing. Specifically, we are aiming to identify mixture materials using the chemotaxis* of the microbe, E. coli bacteria, by applying machine learning to the collective response patterns of the bacteria. In the future, we may be able to exceed the capabilities of even sommeliers of wine and Japanese sake.

■ Technology overview and applications

Conventionally, microbes' sensitivity to chemical substances has been studied by placing the substance and a small amount of bacteria in a Petri dish (a container used for bacterial culture experiments prepared with nutrient-providing agar) and observing its movement over time. This process required approximately one full day. Newer methods dispense with agar cultures and observe the movements of many individual E. coli bacteria with a microscope, determining their state over a fixed period of time as either static, rotating clockwise, or rotating counter-clockwise. These results are then analyzed statistically to determine a test result. This process requires approximately ten minutes, which is a great improvement relative to conventional methods.

Analysis time reduction also results from using a sample-flow mechanism that enables measurements to be taken one after another.

■ Search for uses, applications, and collaboration

Chemical substances are generally analyzed using techniques such as chromatography, which analyzes each component of a substance. Methods that use microbes as discussed here provide results more like a human sense, indicating an overall "flavor" of the substance. As such, this analysis is similar to wine tasting. It is not yet clear what substances this technique is good at detecting, but utilizing the advantages of this method should reveal scenarios that will generate great demand (or need) in the future. This will bring clear opportunities for research collaboration or licensing, so future development in this research is very promising.

Any companies or organizations interested in this technology are welcomed to inquire as indicated below.

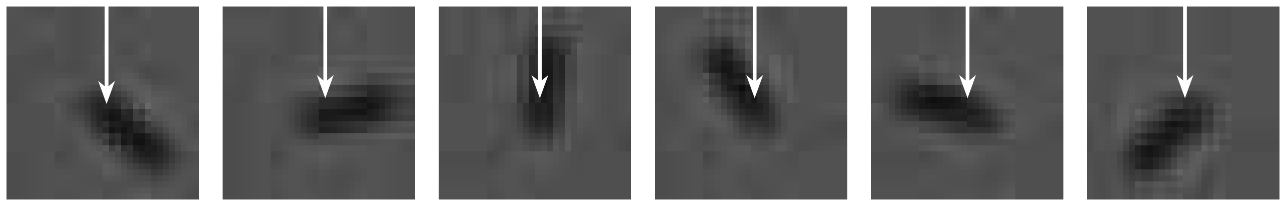
<Patent Information>
Publication No.: Patent Pub 2016- 208928
Name of Invention: Equipment and method for microbe analysis

<Contact (Inquiries, etc.)>
Intellectual Property Promotion Office, Innovation Promotion Department
E-mail: ippo@ml.nict.go.jp
TEL: +81-42-327-6950 FAX: +81-42-327-6659

＊ Chemotaxis: In this case, the phenomenon that E.coli bacteria rotate in a counter-clockwise direction in the presence of a desirable substance (an attractant), and in a clockwise direction in the presence of an undesirable substance (a repellant).

Microscope used for microbial analysis

Center of rotation



Time

E. coli counterclockwise rotation time-lapse photo sequence

Awards

The Merit Awards for Industry-Academia-Government Collaboration are presented for instances of great success, which contribute significantly to promoting collaboration among industry, academia, and government, either reaping great success through such activity at corporate, university, or public research institutions, or otherwise conducting pioneering initiatives.
The Conference on Electrical Insulation and Dielectric Phenomena (CEIDP) has been held every year since 1931, and is the most important conference on dielectric and insulating materials in the world. Since 1955, the keynote lecture of this conference has been treated as an award, and has been given by well-known scholars in the physical sciences such as Peter Debye and Herbert Frohlich.

Cabinet Office, Government of Japan
Minister for Internal Affairs and Communications Award of 14th Annual Merit Awards for Industry-Academia-Government Collaboration

Daisuke INOUE

Director of Cybersecurity Laboratory,
Cybersecurity Research Institute

Daisuke INOUE is the second from the left

Comment from the recipient

DAEDALUS has been a collaborative initiative among industry, academia, and government from R&D through to implementation. It currently provides alerts free-of-charge to educational institutions and public organizations in Japan. Over 600 organizations participate in the program (as of the end of December 2016). A commercial service for enterprise has also been started and development of new results continues on all fronts. We would like to express heartfelt thanks to all those taking part in DAEDALUS R&D, at NICT, Yokohama National University, and clwit Inc.

data

- Co-recipients: Katsunari YOSHIOKA (Associate professor for Graduate School of Environment and Information Science / Institute of Advanced Sciences, Yokohama National University)
  Yasuhiro KUNIMINE (CEO, clwit Inc.)
- Date: August 26, 2016
- Description: In recognition of R&D work and deployment of results related to the DAEDALUS anti-cyber-attack alert system.

IEEE CEIDP Whitehead Lecture

Kaori FUKUNAGA

Executive Researcher
Electromagnetic Applications Laboratory,
Applied Electromagnetic Research Institute

Above: Keynote lecture
Below left: Award ceremony
Below right: Award plaque

Comment from the recipient

Research on evaluation of dielectrics and insulating materials often sounds old-fashioned, but I am so honored to receive such a prestigious award from a long-standing organization that dates back to 1931, before the IEEE was established. Infrastructures including electric power apparatus continue to age, just as human society is aging. I believe electromagnetic sensing technology at NICT can contribute to the maintenance of such infrastructures.

data

- Date: October 17, 2016
- Description: The IEEE CEIDP opens each year with the Whitehead Lecture. The lecture is given by a distinguished researcher in the field of electrical insulation and dielectric phenomena.

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4-2-1 Nukui-Kitamachi, Koganei, Tokyo
184-8795, Japan
TEL: +81-42-327-5392 FAX: +81-42-327-7587
E-mail: publicity@nict.go.jp
URL: http://www.nict.go.jp/en/
Twitter: @NICT_Publicity

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