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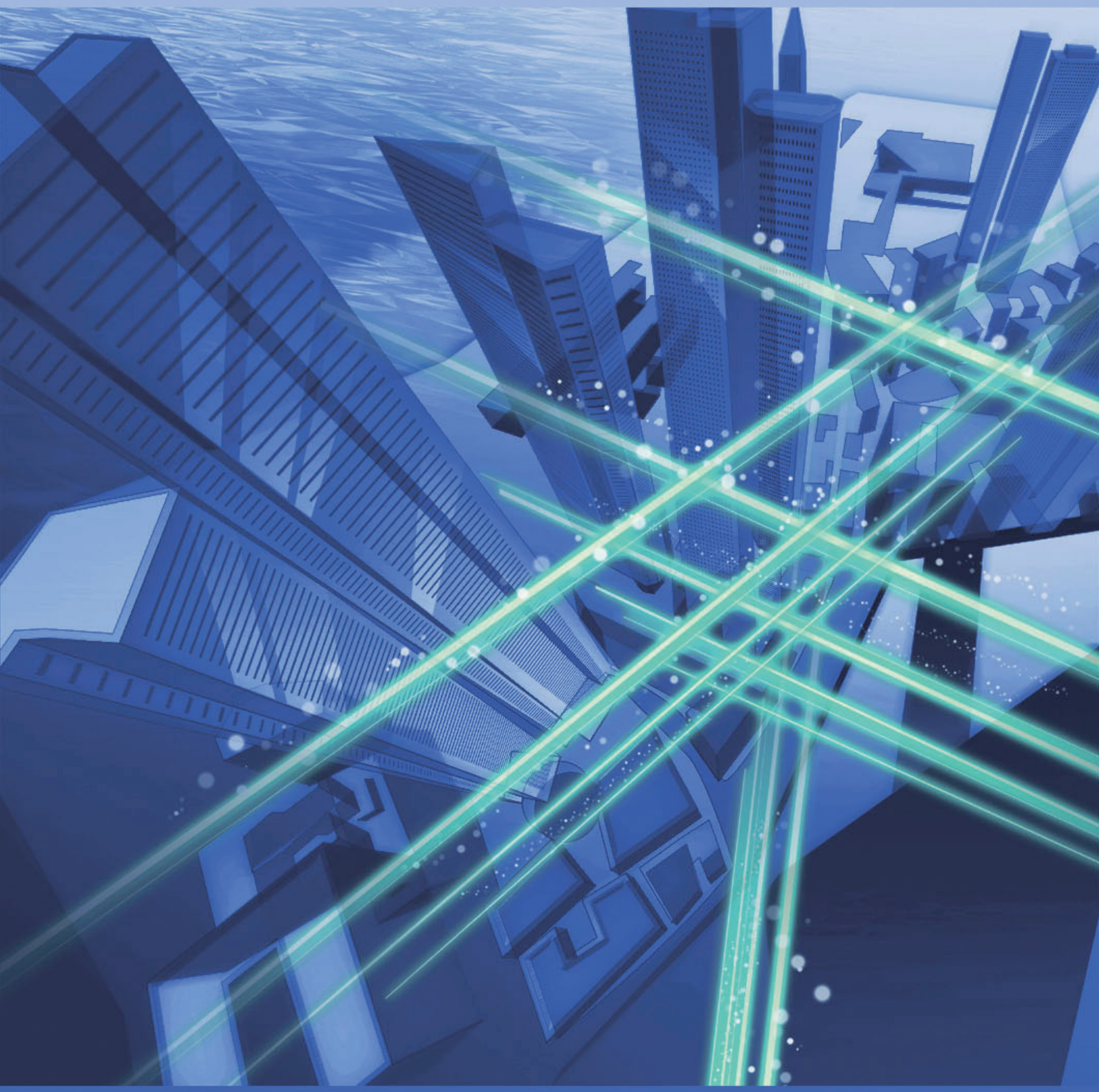

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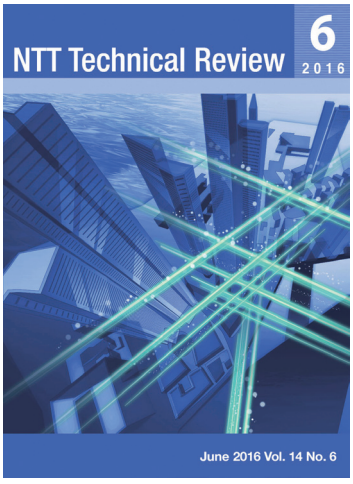


Supporting the Social Infrastructure with a Challenging Spirit!—Connecting and Designing the Future of Japan

Yoshihiro Kuroda
Executive Vice President, NTT WEST

Overview

This is an era of ever-increasing use of the Internet. Enabling stress-free use of the Internet requires much effort, experience, and wisdom, and this is provided by NTT employees who work tirelessly behind the scenes to maintain a rock-solid infrastructure. How should NTT WEST take up the challenge of creating an even friendlier communications environment? We asked Yoshihiro Kuroda, NTT WEST Executive Vice President, about the company's business strategy and future outlook.

Keywords: Hikari Collaboration, business user, social infrastructure

Achieving business objectives through constant effort and steady work

—Mr. Kuroda, can you first update us on business conditions in the NTT WEST Group?

NTT WEST aims to create new lifestyles that will change the way people live and work using Hikari (optical) broadband services. In fiscal year 2015 (April 1, 2015–March 31, 2016), the company declared three key objectives: transforming the business strategy, contributing to regional revitalization, and promoting the business areas with the potential for growth.

To achieve the first objective of transforming our business strategy, we changed our business strategy from a B2C (business-to-consumer) business model to the Hikari Collaboration Model and positioned business-user sales as an additional revenue stream for the company.

Let me explain why setting these three objectives was necessary, using telecommunication facilities as an example. The fact is, the work of providing an optical service for consumers is simply a cycle of opening up lines and discontinuing services. For example, in the peak period of February and March, the workload is 1.5 times greater than that of other months. Somehow, we get all this work done within that period through an all-out mobilization of NTT WEST personnel. Later, however, on breaking down the work performed, we would find that the number of orders for opening up lines was almost the same as that for discontinuing services, meaning there was no increase in the number of subscribers. As a result, the company's revenue would not increase, and a large amount of operating expenses would go to waste, so this is not a sustainable model.

This is why we created the Hikari Collaboration Model. This is a collaborative business mechanism that involves the wholesaling of FLET'S HIKARI,

our flagship fiber optic broadband service, to various players that see value in combining broadband capabilities with their own services. The Hikari Collaboration Model drastically reformed the business model across the entire NTT Group and helped us rethink the way in which operating expenses were used. On launching the service in February 2015, the goal was to achieve a net increase of 200,000 subscribers, but this number was actually exceeded, demonstrating a positive response to the model.

Furthermore, in terms of business-user sales, we essentially achieved the initial target of 600 billion yen, though we narrowly missed the target of an operating profit. As we go forward, we have to improve earnings in order to make business-user sales a pillar of our business.

To improve earnings in business-user services, we need to reduce overall facility costs. We therefore established a plan to reduce facility costs by 80 billion yen over a three-year period starting in fiscal year 2015 by implementing a variety of measures such as discontinuing selected services, removing unnecessary facilities, and curtailing operating costs.

—What are the key issues that must be addressed in achieving these business objectives? How do you plan to face the future?

In the Hikari Collaboration Model, we have been working with service players in preparing to enable consumers to use our services in a smooth and one-stop manner. In addition, we must construct a mechanism that makes it easy for Hikari Collaboration service players to sell Hikari services. To this end, we enabled a portion of our troubleshooting system to be used by those players.

Consequently, we have been receiving feedback and proposals from Hikari Collaboration service players on ways of using our Hikari service that we had not thought of before, so the opportunities to use our infrastructure in more beneficial ways have increased. Furthermore, in business-user sales, we must combine a variety of services as required and provide those services in the time requested. Upgrading our delivery system and customer control functions are therefore issues that we need to address.

It is also important that we create the systems and facilities to support these Hikari services. As more and more people come to use video streaming websites to enjoy videos on their smartphones or tablets, the volume of traffic is increasing. Thus, with this and the "big event" in 2020 (Tokyo Summer Olympic and

Paralympic Games) in mind, we are increasing network capacity and data transmission speeds. In terms of Wi-Fi, we are working with local governments on projects to expand access points in conjunction with regional revitalization. Also of concern here is the provision of optical access facilities that will enable new technologies to be used in remote sightseeing areas, including mountainous regions. However, since tourist sites such as Kumano Kodo (ancient pilgrimage routes) and Shirakawa-go (historic villages) that are popular with foreign tourists are often in areas surrounded by nature, a communication infrastructure that avoids damage to cultural assets and the beautiful surroundings must be set up. To this end, we are installing access points in low-profile locations and conducting service trials at a steady pace.

Going to the source of a problem to learn about it in person

—It appears that taking on reform has also provided you with useful feedback.

We have learned a great deal. In Hikari Collaboration sales, having extensive talks with service players over a one-year period has helped us to see key points that we were not initially aware of. We found many problems in our business-user services, where we had not made major efforts in the past compared with mass consumer services. I tend to sense problems in the form of noise (complaints) coming from here and there, and to deal with a particular problem, it's important to find it and fix it immediately. When a problem arises in the field, my job is to see what kind of support the head office can offer. That is, when I visit a particular location, I talk directly to the people

involved to find out if any problems exist and what can be done about them. My goal here is to work out what the head office can do and what on-site personnel can do to help resolve the problem. Listening to people and checking out the true nature of the problem in person helps me to make good decisions and minimize mistakes. In the field, it's important that I listen to people having all sorts of viewpoints, including department and section managers. A small number of opinions can be biased, so listening to as many people as possible helps me to understand the various aspects of a particular matter.

This practice of mine of meeting with people and listening to what they have to say in person is something that I have done at meetings and gatherings not only within the company but outside as well. I favor this face-to-face approach because I can pick up things that I cannot hear over the telephone, and I can get more details. I am not asking people to visit our head office but rather I myself am making a visit to talk to them on their territory. This enables more direct and frank discussions.

It is also important that we constantly reassess our way of doing things—if we don't, we can't be adept at meeting our customers' expectations. For example, though we make predictions and plans regarding facilities three to five years in advance, it can still happen that traffic dramatically rises beyond our expectations, which would require us to take emergency measures. It is therefore essential that I keep a close watch on marketing trends and even individual customer trends and technical possibilities in order to make comprehensive judgments about facility upgrades. We must always have some leeway to respond and adapt as needed.

—So there is a need for comprehensive judgments and timely responses that consider not just technology but marketing and consumer trends, too.

That's right. However, it's not simply a matter of making preparations and providing adequate services in time for some upcoming event with specific needs. That is, while forecasts can be made to some extent with regard to an increase in the volume of video traffic, there are some aspects of the Internet of Things (IoT) that cannot be predicted; there is no telling how it will change in the years to come. We must consider how those things that cannot be seen today might be reflected in future network services. The use of IoT will certainly be extended to agriculture and other industries, but we need to carefully examine what types of business models and what types of networks will be required.

Meanwhile, we cannot forget about the need to strike a balance between corporate growth and social contributions. The NTT Group takes great pride in supporting Japan's social infrastructure and providing a telecommunication infrastructure. To fulfill this mission perpetually into the future, it must continue to grow as a single firm. To this end, I would like to create a "virtuous cycle" in which we make appropriate investments to provide an even better infrastructure for beneficial use by our customers, and then reinvest profits from this use to improve our infrastructure once again.

At present, the working group that we convene to create new services consists of employees recruited from various departments inside the company, including sales, service development, research and development (R&D), and facilities. This working group came about in response to comments voiced within the company such as "I don't know which department to talk to when a problem arises, so I want to learn about the work of each department so that I can consult with the right people." Thus, to meet this need, it was decided that some employees in related departments, from sales to R&D, would make time in their busy schedules to participate in a working group. All of the members of these departments are

proud of the work that they do, so arriving at a consensus takes some time. However, once discussions pass a certain point, the goal may come into view just as fog gives way to sunshine. If the goal is nowhere in sight, however, there may be some hesitancy to proceed and a desire to give up, but I recommend that the group go back to square one and try another approach. I feel that my role here is to give the group a clear direction, so while the goal may change a little according to varying opinions and the results of meetings, I strive to convey the objective clearly and to see that it is shared by all concerned.

In short, I want to have a goal to aim for, while placing importance on a sense of process and time. Results are not necessarily proportional to the time spent on achieving them. However, reprimanding others because the results that I envisioned are not being obtained will only serve to weaken everyone's motivation. I would rather praise a job well done and use that as a motivating force to get everyone to work toward a common objective.

Don't be afraid of change—take up the challenge!

—Mr. Kuroda, what advice would you give to our researchers?

As everybody knows, a variety of companies and research laboratories make announcements about new technologies and services on a daily basis. In the past, NTT has served as a driving force for all fields related to information communications in Japan, but we have entered an era in which this role has become increasingly difficult. However, I believe that NTT should abandon the closed innovation policy and instead, evaluate technologies developed by a variety of companies and combine them with its proprietary technologies to create something new. This is the kind of firm that NTT should become.

Starting from scratch and spending development time in terms of years as we have been doing up to now is no longer a viable approach if we are to keep up with the needs of the times. Even with specialists in targeted technologies, I would like to see us create new technologies and services from the viewpoint of a "producer." In this regard, I think it's a good idea to visit operating companies such as NTT WEST as often as possible. Seeing problems with your own eyes and talking with people face to face should provide you with a treasure trove of ideas.

—Finally, can you leave a message for all NTT WEST employees?

Employees who work in development and service departments will eventually encounter "work with no answers, and work with no certain future." Similarly, among department and section managers, an increasing number of people are probably having such an experience. In such a situation, a capable colleague around me nevertheless proceeded one step at a time. At first, it appeared to me that it was difficult for him to proceed with the work without a concrete clue, but he just did what he could do step-by-step without thinking about it too much, and in the end, got the job done swiftly and successfully.

I often use the word "challenge." I ask our employees to take on a bold attitude in their work without fear of change. Real risk lies in making no changes to techniques, strategies, or methods. It's okay to fail! No one loses their job by failing. At the same time, there is nothing more exciting than making a proposal, executing it, and succeeding. In the past, when I was in charge of service development, I pushed through one new service after another, but the only one remaining today is IP (Internet protocol) telephony. Of course, having a perfect record is just an ideal—it never goes that well in real life. But if you do not take up the challenge of creating something regardless of results, you may never be successful.

Actually, the company is setting up an environment to make it easier for everyone to take up challenges. As a trial this fiscal year, we are authorizing a budget for proposals voluntarily presented from each department in order to stimulate a challenging spirit. Whether the result is a success or failure is immaterial. I believe that some form of knowledge will be obtained whatever the result and that the curiosity

generated and sense of accomplishment obtained above and beyond everyday routine will itself constitute success.

Please have the courage to explore new possibilities!

Interviewee profile

■ Career highlights

Yoshihiro Kuroda entered Nippon Telegraph and Telephone Public Corporation (now NTT) in April 1981. After serving at NTT Communications Corporation as Director of Consumer & Office Users Business Division, Strategy Planning Department and Director of Human Resource Development Group, he became Senior Director of NTT General Affairs Department in 2008, Director of NTT WEST Hiroshima office and General Manager of NTT WEST Chugoku regional headquarters in 2011, and Executive Director of NTT WEST Network Department in 2014. He took up his current position in June 2015.

The Future Created by NTT Group's Agriculture × ICT

Tsuyoshi Onozato, Ryuichi Kobayashi, Yoshikazu Kusumi, Nobukatsu Takei, Eikazu Niwano, Takao Nakamura, and Shinji Sugimoto

Abstract

The Japanese agriculture industry is facing a range of challenges including an aging and shrinking farming population and an increase in the area of abandoned farmland that was formerly under cultivation. Information and communication technology (ICT) is considered to offer promising ways to address these challenges. The NTT Group is tackling such issues in the agricultural field by capitalizing on its ICT capabilities developed through its involvement in telecommunications. This article introduces the NTT Group's agriculture × ICT strategy.

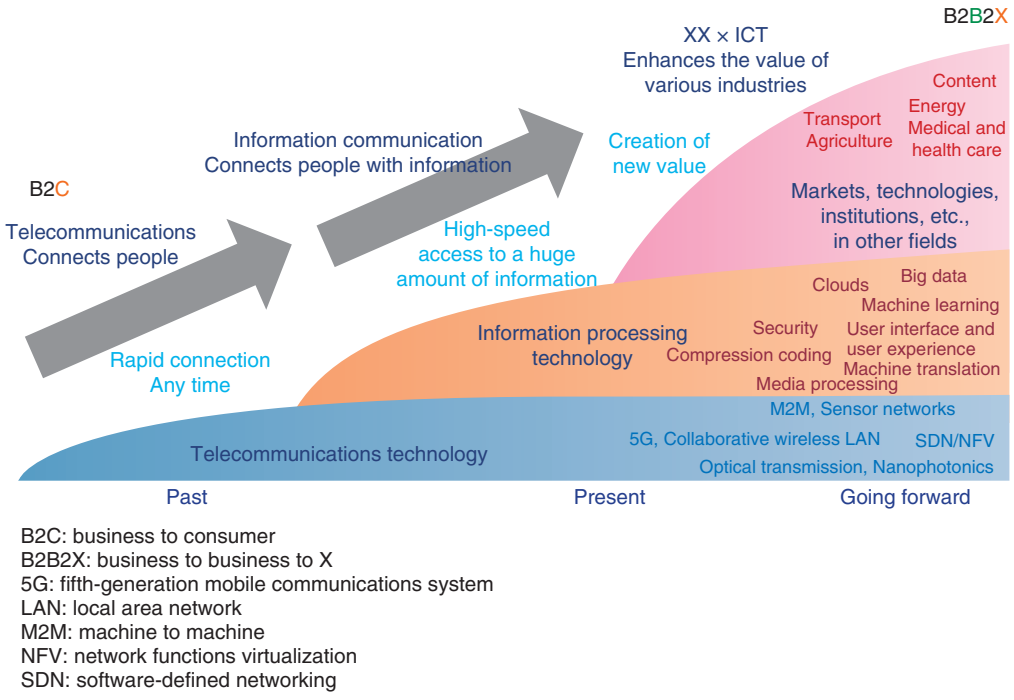
Keywords: agriculture, ICT, NTT Group

1. Introduction

Japanese agriculture is facing a number of challenges. Farmers are aging and decreasing in number. The agricultural workforce has shrunk by 60% in the last 30 years, and more than 60% of farmers are 65 or older, with the average age hovering around 66.7. No sign of an increase has been seen in the last several years in the number of people entering farming. Furthermore, the initial cost of farming is so high that it takes a long time before a net profit can be made, which explains why nearly 30% of new farmers quit in less than three years [1, 2].

The amount of farmland is also shrinking. It has decreased from 6 million hectares in 1965 to about 4.5 million hectares today. The area of abandoned cultivated land has increased by more than 15% in the last decade to nearly 400 thousand hectares, which accounts for about 10% of all cultivated land in the country. Adding to that, the land area per management unit is extremely small in Japan, being only about 1/20 to 1/30 of an average unit in Europe and about 1/70 to 1/80 an average unit in the United States. If agriculture is to be developed into a sound industry, it is necessary to attract younger people into farming, amalgamate smaller farm holdings in order to boost the land area per management unit, and improve productivity.

However, there are some bright signs. Since the revision of the Agricultural Land Act in 2011, both the number of agricultural corporations and the volume of agricultural and fishery products exported have been growing. The government's national revitalization strategy has proposed aggressive policies for agriculture, forestry, and fisheries, and has identified priority areas with specific numerical targets. These include: 1) consolidating small farms and reducing the area of abandoned cultivated land, 2) increasing the number of new farmers and agricultural corporations, 3) raising the income of producers, including those engaged in farm product processing and distribution, and 4) raising the level of farm exports. The signing of the Trans-Pacific Partnership (TPP) points to the need to strengthen the competitiveness of Japanese agriculture and to the heightened expectations for smart agriculture, a concept that involves the introduction of robots and information and communication technology (ICT) to improve productivity.



B2C: business to consumer
B2B2X: business to business to X
5G: fifth-generation mobile communications system
LAN: local area network
M2M: machine to machine
NFV: network functions virtualization
SDN: software-defined networking

Fig. 1. Roles of the NTT Group.

2. Advances in ICT and the changing role of telecommunications providers

Advances in the information and communication industry are pushing telecommunications providers to take a new look at their role. In the bygone days of the *Age of the Telephone*, the telecommunications provider was the leading player, owning all of the vital telecommunication-related hardware and software, from the communications infrastructure to the upper layer services, and providing services to customers. The past decades have seen dramatic advances in ICT, including cloud computing, that enable customers to select and combine service providers at will rather than meekly accepting what the monopolistic service provider has to offer. In the face of this transition, the NTT Group believes that it should regard ICT as a catalytic agent that enhances the value of various industries (**Fig. 1**).

The NTT Group has selected agriculture, medical care, transportation, town revitalization, and tourism as strategic target industries and has embarked on introducing ICT into the field of agriculture (an activity represented by the expression *agriculture* × *ICT*), among others.

3. NTT Group's agriculture × ICT strategy

The NTT Group has identified two areas where ICT can make a major contribution to agriculture. The first is in production support, in which ICT will encourage the consolidation of smaller farming units, improve productivity, and promote standardization of production processes. The second area involves supporting distribution, in which ICT will be used to help match supply and demand, improve distribution efficiency, and help to develop and expand markets. The NTT Group companies are working together and conducting research and development (R&D) to make progress in these areas with the goal of strengthening the competitiveness of Japanese agriculture.

To kick start the above endeavors, the NTT Group is pressing ahead with three types of strategic collaboration (**Fig. 2**).

3.1 Collaboration within the NTT Group

The solutions that the NTT Group will provide are classified into three categories. The first is the *good harvest solution* that supports production. This includes production management and remote monitoring, involving the visualization of farm and

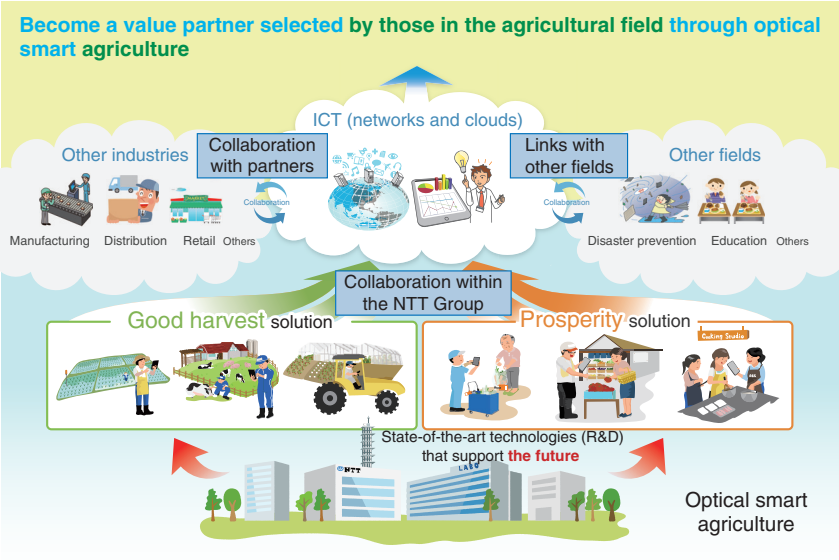


Fig. 2. NTT Group's agriculture × ICT strategy.

livestock environments to facilitate efficient operation and management. The second is the *prosperity solution* that supports distribution and sales. This is a service intended to enhance efficiency in product sales and management, and safety and security in delivering products to consumers. The third is the *state-of-the-art technology (R&D) that supports the future*. This means that technologies developed by NTT laboratories will serve as the foundation that will support future agriculture.

The NTT Group already has an extensive portfolio of agricultural solutions applicable to different stages of the value chain of agriculture, from production to distribution and sales. However, these are currently independent solutions with no links between them. We will gradually join them together in an organic manner so that the integrated solutions will run through the entire value chain, enabling us to provide solutions that have greater added value than before.

We will start by creating links between processes in the value chain, for example, linking individual solutions that make up the *good harvest solution*. We will also link information between sensing systems and production management systems that are provided by individual NTT Group companies, and incorporate this with high-definition maps and weather forecasts to make farming a more precise operation.

We will then move on to ensure there are links between different stages in the value chain, that is, links between the solutions that make up the *good harvest solution* and those that make up the *prosperity solution*. For example, our production solutions can be linked with direct farmers' markets (where products can be bought directly from farmers), online stores, and cooking schools in order to upgrade production, distribution, and sales.

Our ultimate goal is to contribute to solving a variety of problems in agriculture by building an integrated solution that runs through the entire agricultural value chain, which includes activities overseas, on an agricultural platform, and by utilizing big data processing and analysis technology.

3.2 Collaboration with partners

The NTT Group aims to become a value partner by solving agricultural problems and creating new value. This will be achieved by combining the Group's ICT capabilities with the know-how owned by those partners who are involved in manufacturing, distribution, and retailing of agricultural products (**Fig. 3**).

For example, by linking agricultural machines with the cloud via a wireless network, it is possible to realize smart agriculture, in which maps, weather forecasts, and other solutions are combined with peripheral technologies such as speech recognition. In smart agriculture, simple agricultural machines will be integrated into a sophisticated agricultural system, and farmers can easily input work records using speech into a cloud system or retrieve high-definition satellite maps and information about the constantly

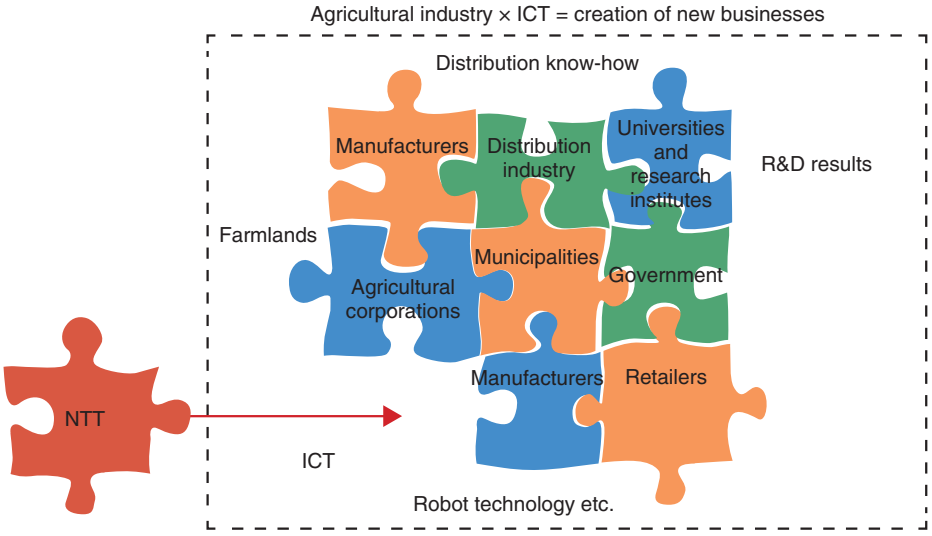
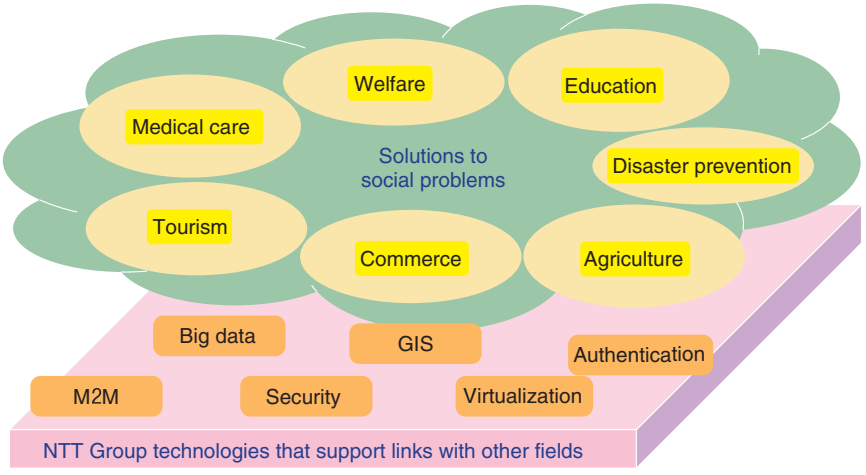


Fig. 3. Collaboration with partners.



GIS: geographical information system

Fig. 4. Links with other fields.

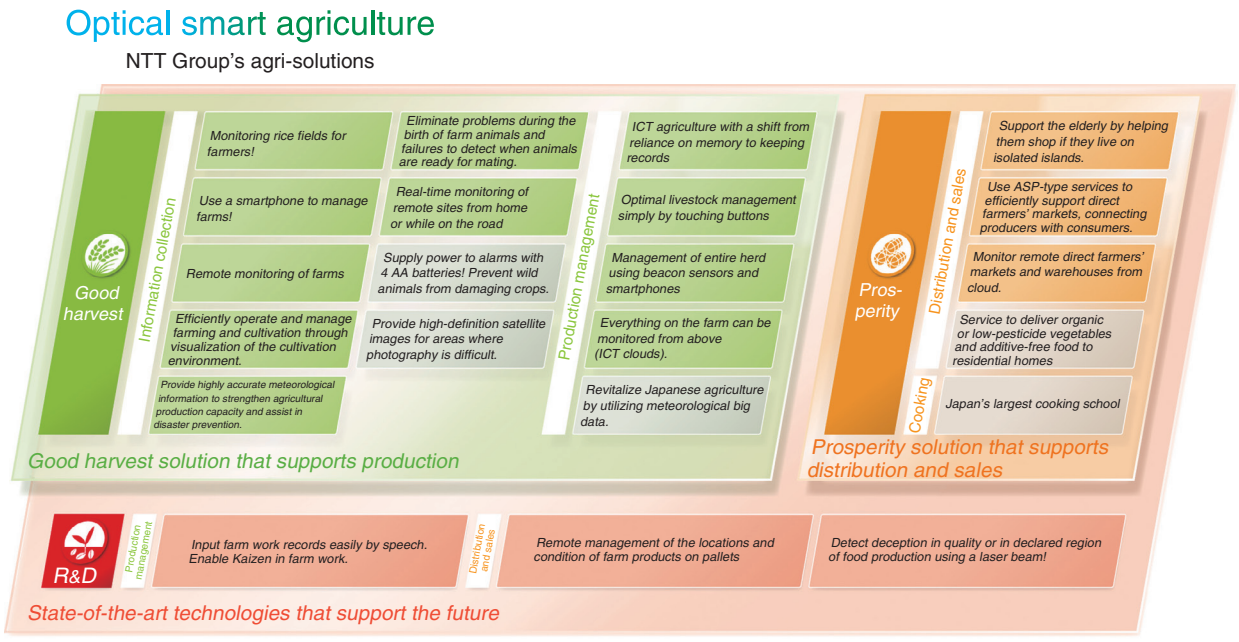
changing weather.

3.3 Links with other fields

The NTT Group will expand its ICT-enabled business beyond agriculture to a wide variety of fields, including disaster prevention, education, and tourism. Combining activities in different fields will make it possible to reduce costs, and by establishing links between different fields, we will be able to create new value (**Fig. 4**).

For example, in education, there are mechanisms for distributing educational content and making it possible for a group of students to share content to enhance their understanding [3]. Such mechanisms can be employed to distribute videos of veteran producers demonstrating their skills so that novice farmers can learn these skills any time, anywhere.

In disaster prevention, meteorological information is used to formulate disaster prevention programs and to work out responses should a disaster occur. If this information is applied to agriculture, it will be possible to implement measures in advance to address



ASP: application service provider

Fig. 5. List of exhibits.

weather-related risks such as strong winds, frosts, and heavy rain, thereby making agriculture more resilient in extreme weather conditions.

4. Activities to widen applications of ICT

We are trying to raise the awareness of the general public about the NTT Group's agriculture initiatives. Participating in exhibitions and increasing our media exposure in publications and on the web can be effective ways of doing this.

As part of these efforts, NTT Group companies jointly participated in AGRINEXT 2015 (held October 14–16, 2015 at Makuhari Messe, Chiba Prefecture), Japan's largest agricultural exhibition. To make visitors aware of the wide range of agriculture-related activities jointly covered by the NTT Group, 9 group companies presented 22 exhibits (including catalog exhibits), which were arranged according to the sequence of farming activities, from production to distribution and sales (**Fig. 5**). Agricultural solutions that were exhibited by NTT Group companies at AGRINEXT 2015 will be introduced in detail in the separate articles that follow [4–8].

Participation in this exhibition gave us the chance to meet visitors coming from a diverse range of industries and to hear their valuable comments and requests. These will help us identify technical issues that must be addressed in creating new services. By incorporating these comments into the NTT Group's agricultural strategy, service creation, and R&D, we will be able to contribute to the development of Japan's agriculture.

5. Future plan

As an ICT enterprise, the NTT Group seeks to become a value partner selected by people in the agricultural industry and to help the industry flourish by building on its deep reservoir of know-how to establish links between products of different group companies, links with other fields such as education and disaster prevention, and collaboration with partners in other industries such as manufacturing, distribution, and sales.

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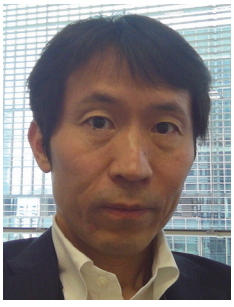
He received a B.S. and M.S. in engineering from Waseda University, Tokyo, in 2003 and 2005. He joined NTT EAST in 2005 and engaged in designing and operating network systems and network services development. He has been with NTT since 2013, where he is in charge of information and communication technology (ICT) business creation for the agriculture domain.

Ryuichi Kobayashi
Senior Manager, Environment Protection Office and Strategic Business Creation Team, Research and Development Planning Department, NTT.
He received a B.E.E., M.E.E., and Ph.D. from the University of Electro-Communications, Tokyo, in 1991, 1993, and 2008. He joined NTT Telecommunication Network Laboratories in 1993. In 1997, he began working at the Technical Assistance & Support Center, NTT EAST, finding solutions to electromagnetic compatibility (EMC) problems in the field. He then moved to NTT Energy and Environment Systems Laboratories, where he was responsible for human resources as well as for research on EMC measurement methods, secondary batteries, and a solid oxide fuel cell system. He has been a member of ITU-T SG5 since 1997 and is now the Rapporteur of issues related to EMC problems in home networks. He is currently in charge of environmental protection management and ICT business creation for the agriculture domain. Dr. Kobayashi is a member of the Institute of Electronics, Information and Communication Engineers (IEICE), the Electrochemical Society of Japan, and the Institute of Electrical and Electronics Engineers (IEEE).



Yoshikazu Kusumi
Senior Manager, Strategic Business Creation Team, Research and Development Planning Department, NTT.
He received a B.S. and M.S. in nuclear engineering from Osaka University in 1993 and 1995. He joined NTT in 1995 and was assigned to the long distance communication business division. He then worked at the network engineering center, where he designed a network system for personal handyphone systems. He also worked at NTT Communications in the carrier sales division, where he was in charge of wholesale business for foreign companies and later, for planning global strategies. He is at NTT again, where he is responsible for ICT business creation for the agriculture domain.

Nobukatsu Takei
Senior Manager, R&D Produce Group, Research and Development Planning Department, NTT.
He received a B.S. in physics from the University of Tokyo in 1989 and an MBA from MIT Sloan School of Management, USA, in 2008. He joined NTT in 1989. He spent time working at the Network System Development Center, where he designed and tested optical transmission systems. Since 1999, he has been managing the research and development laboratories at NTT and designing and operating network systems at NTT EAST. In his current role as a senior manager of the R&D Produce Group, he is researching new business through collaboration with various industries.

Eikazu Niwano

Director of Research and Development Planning Department, Senior Research Engineer, Supervisor, NTT Secure Platform Laboratories.

He received a B.S. and M.S. in mathematics from Waseda University, Tokyo, in 1987 and 1989. He joined NTT in 1989 and has been researching distributed system architecture and social information systems including the areas of mobile/messaging, agents, ubiquitous computing, smart cards, e-government, and smart cities. During 2002–2005, he worked in the European office in Paris and was involved in a number of European and international standardization activities. Mr. Niwano has been a member of ISO/IEC SC17 and was the editor of eEurope/Smart Card Charter/TB7/WG4 (multi-application architecture). He was also a member of the CEN e-Authentication Workshop and the CEN TC224 WG 15. He is a Fellow and a member of the Board of Directors of NICSS (Next generation IC Card System Study Group). He has also served on the GlobalPlatform Board of Directors since 2005 and is the Chair of the Japan Task Force. He received the GlobalPlatform Star Award in 2006. He is a member of IEICE and IEEE.

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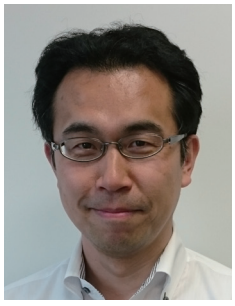

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Efficient Operation and Management of Agriculture through Visualization of the Production Environment

Yoshio Shinya and Rie Ueda

Abstract

One of the primary efforts to use information and communication technology (ICT) in the agricultural sector is for visualization of the production environment. Traditional production techniques rely on intuition and experience, but visualization of the data of the production environment and working conditions makes it possible to manage work effectively and to achieve more efficient production management. This is expected to lead to improved quality and increased yield. Production information is being further utilized through increased cooperation with sales and distribution departments and in the areas of environmental control and prediction. This article introduces the system mechanisms and the use cases for information utilization by ICT as part of efforts to realize efficient and stable agricultural management.

Keywords: agriculture, production, ICT

1. Introduction

With the rapidly aging and declining number of farmers and an increase in the area of cultivated land that has now been abandoned, there is a need to change production methods in Japanese agriculture. To achieve the sustainable development of agriculture, it is necessary to introduce cutting-edge technologies such as those that can help to expand the size of individual farming units, reduce labor requirements, and cut costs. Also needed are technologies that make production adaptable to demand and enhance added value, and technologies that mitigate the risks around abnormal weather. Steps are being taken to implement these technologies in order to reform production and distribution systems [1].

There are greater expectations that information and communication technology (ICT) will play a major role because it serves as the foundation for these technologies. The government's agricultural ICT strategy for promoting creation and distribution of agricultural information, part of its plan to become the world's most advanced information technology (IT) nation [2], advocates the active use of IT in agriculture. Use of information made possible by ICT can contribute to strengthening the industrial and international competitiveness of Japan's agriculture.

In the field of agricultural production, initiatives have been introduced to ease the transition from management that involves simply relying on intuition and experience to efficient management and operation based on ICT in order to achieve higher product quality and greater profitability. Among these activities, the one that is rapidly bearing fruit is visualization of the production environment.

2. Visualization of the production environment

In the field of production management, a lot of labor and time is consumed in order to obtain visual images of plant conditions and the production environment. Visualization of the production environment using ICT enables users to obtain data on the environment and working conditions in real time. By checking and analyzing data, farmers can improve production management and operation efficiency,

resulting in better product quality and increased crop yields. A wide variety of services based on different sensor network technologies and cloud services targeting different types of farmland have been developed and introduced.

The first step in implementing visualization is to install sensors and cameras in fields and collect data automatically. In the case of vinyl greenhouses, temperature, humidity, the amount of solar radiation, CO_2 level, the electrical conductivity (EC)* of soil, pH level, and the amount of water can be measured using sensors that are suited to the particular crop. Data are stored in servers in a cloud via a network such as a 3G (third generation) mobile phone network or an optical network.

Users can check the collected data anytime or anywhere using smartphones, tablets, or computers. In this way, they can obtain environmental data and the growth status of crops in different fields in real time. Also, various convenient cloud services are available for processing and displaying the stored data.

Conventionally, users who wanted to monitor their production environment faced the problem of huge initial and ongoing operational costs because they had to own and manage their own computers. The advent of cloud services has reduced these costs dramatically and led to the widespread use of ICT in the area of production. Cloud services that store information about fields and daily farm activities are also available.

In Japan, the larger the total area of a farm tended by a single farmer, the more scattered his/her individual fields tend to be, which adds to the amount of labor and time required for managing the farm. Visualization of the production environment is therefore an essential tool for expanding the sizes of farms without increasing labor and costs.

3. Production management using agRemoni, an agricultural management support system

NTT FACILITIES is building on its monitoring and environment construction (including facility operation) technologies developed in the fields of construction and energy and providing an agricultural production management service. This is a cloud-based service designed to turn existing greenhouses and appliances into smart agricultural facilities. Specifically, with our agriculture management support system called agRemoni, we are expanding the capabilities of this cloud service to support, in particular, facility construction, environmental monitoring, and optimal use of energy.

The agRemoni system collects data on temperature, humidity, and the amount of solar radiation fields are exposed to, and stores the data in a cloud via the Internet using mobile phone or optical network access (**Fig. 1**). Users can easily view the collected data using their smartphones or tablets (**Fig. 2**). If any value exceeds a preset threshold, an alert is emailed to users, enabling them to respond quickly even if they have many greenhouses.

In addition to the above monitoring capability, the system supports maintenance of an optimal farming environment by providing functions for farm schedule management, recording of daily work reports, monitoring of crop growth, sending an alert in the event of abnormal conditions, and integrated management of data related to crop growth.

4. Low-cost monitoring of multiple fields scattered over a wide area

While visualization of the production environment is gradually being adopted, there are still some barriers for existing small- and medium-sized producers regardless of how motivated they might be. One major stumbling block is the communication cost. Fields are often far from the farmer's residence and may consist of multiple plots scattered over a wide area. To monitor the production environment of every field, it is necessary to establish a communication link with every single field. Ordinary Wi-Fi cannot cover a wide area, and the use of 3G or other mobile phone links is costly, especially when there are many fields to monitor.

A solution to this problem is a 920-MHz wireless sensor network, which allows communication over a relatively long distance (**Fig. 3**). Using this technology, farmers can build their own wireless wide area networks (WANs). Since there is no need to subscribe to communication links, this setup can reduce both the initial and the ongoing running cost.

5. Test to ascertain the feasibility of monitoring and controlling the production environment using a self-owned wireless WAN

NTT FACILITIES is conducting a test to assess the feasibility of remote monitoring and control of the production environment using a self-owned wireless

* Electrical conductivity is used in agriculture as an indicator of the amount of fertilizer in the soil or in a nutrient solution.

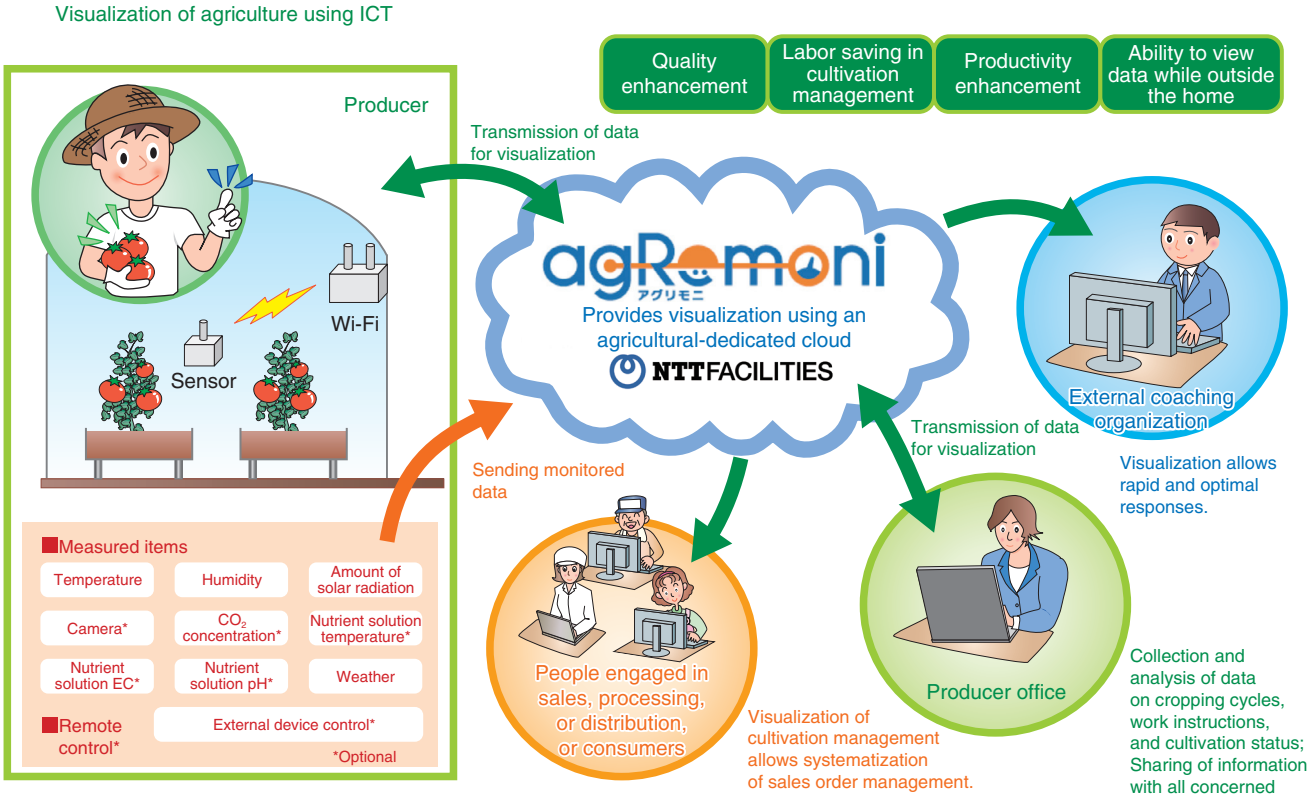


Fig. 1. Overview of agRemoni.

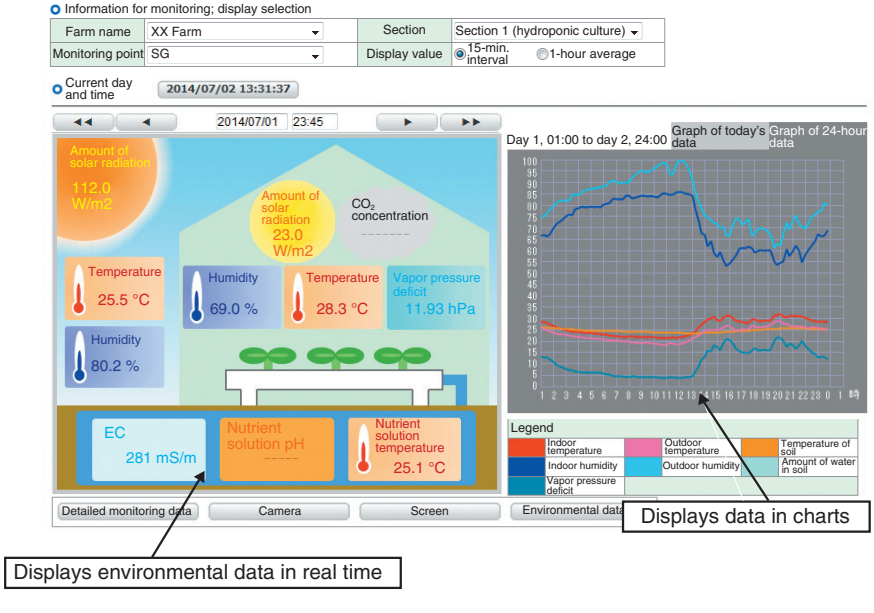


Fig. 2. Screen image displayed by agRemoni.

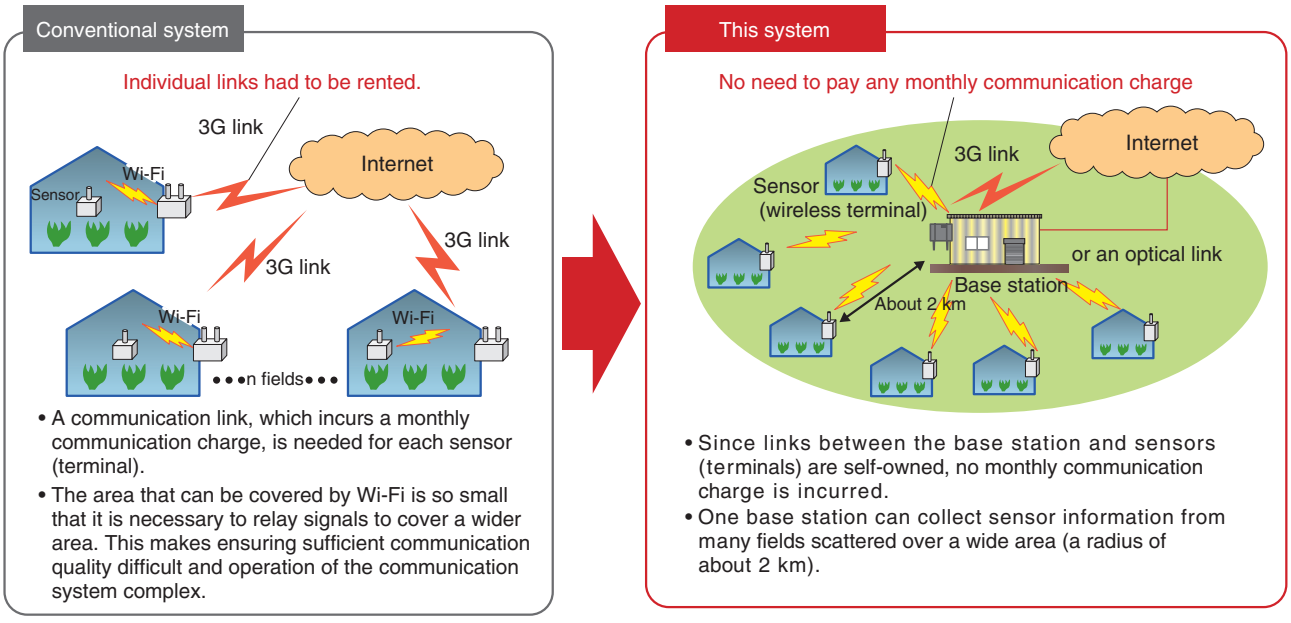


Fig. 3. Features of the self-owned 920-MHz wireless WAN.

WAN as part of a project [3] commissioned by the Ministry of Agriculture, Forestry and Fisheries. The test continued until the end of March 2016.

The test was being conducted in Fukushima Prefecture, where many farmers were adversely impacted by the Great East Japan Earthquake and were compelled to move to temporary housing. They have to commute to their fields, far from where they are living, which means that they need to spend a long time just for travel and cannot respond quickly to changes in the weather.

This feasibility test, which targets small- and medium-sized producers, provides these farmers with capabilities to collect environmental data from remote fields and to control them remotely. The objectives are to enable construction of an optimal greenhouse culture environment, reduce labor, and maintain/improve product quality.

Mechanisms for remote monitoring and simple environmental control using 920-MHz wireless links have been introduced into the fields (**Fig. 4**). This is the first time that a self-owned 920-MHz wireless WAN has been applied to agriculture. The technology for this network was provided by NTT Electronics, a partner in this test. The use of this wireless system developed by NTT has made it possible for a single base station to cover a number of fields, which can be up to 2 km away from the base station. The equipment at both the base station and in the fields is small, lightweight, power-thrifty, and easy to install.

We focused on developing two remote control capabilities for which there was the strongest need: remote control of ventilation and watering in greenhouses, and we placed priority on ensuring ease of operation.

6. Significant benefits derived from data analysis and environmental control

Remote monitoring and simple remote environmental control, both using a self-owned wireless WAN, have raised the efficiency of production management and have also increased crop yields. Data on the temperature, humidity, and amount of water in the fields are obtained in real time and used to control ventilation and watering in plastic greenhouses. Now that data on the production environment and crop growth are available for analysis, numerical management has become possible in the field of agriculture.

The feasibility test in Fukushima Prefecture revealed that production management based on the analysis of data on the production environment has improved farm work efficiency, despite the increased travel time caused by the earthquake, and has made it possible to extend the harvest period. As a result, it has become possible to reduce the workforce needed

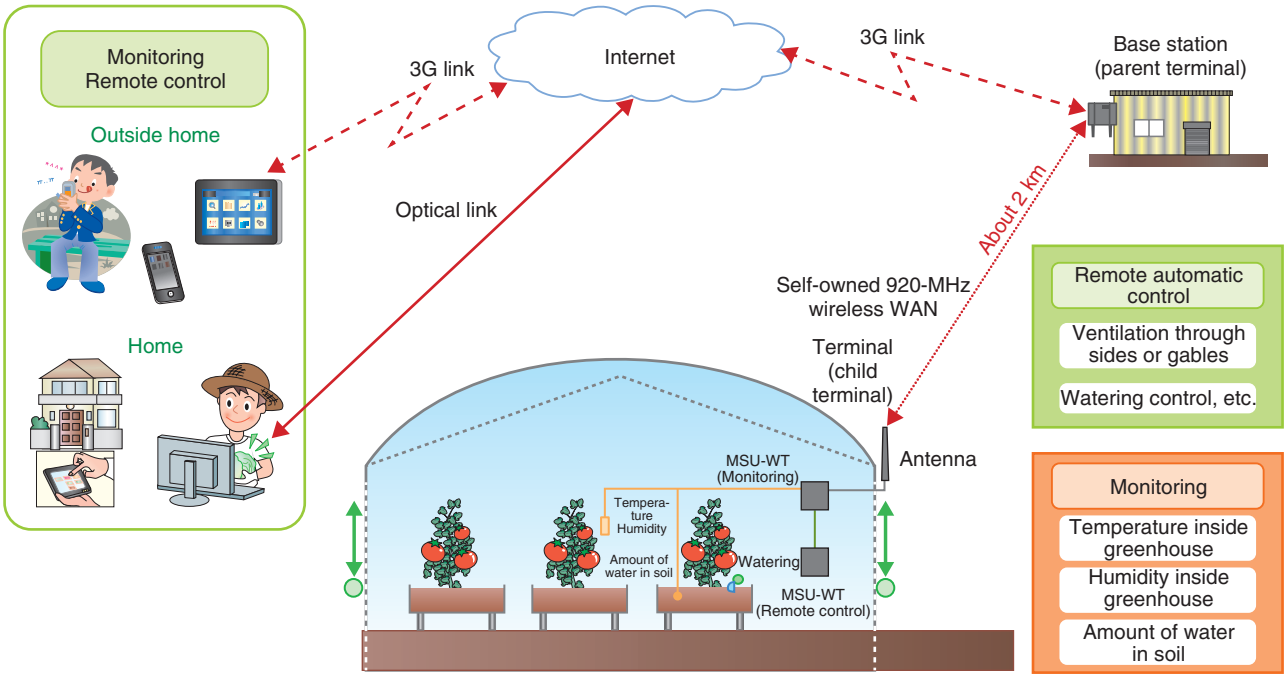


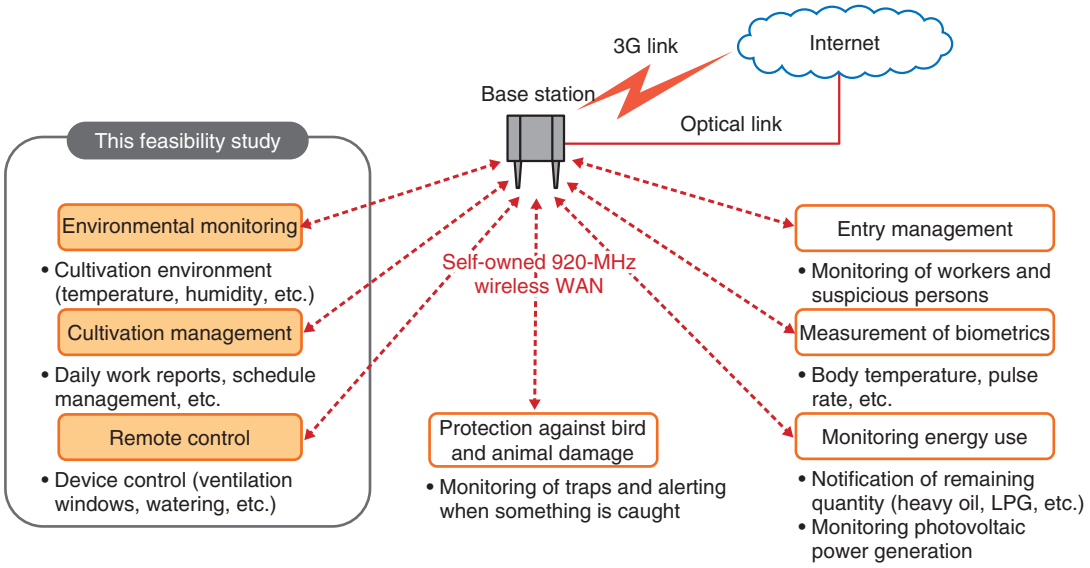
Fig. 4. System configuration.

for harvesting and to shift the harvest time from that of other producers in the neighborhood so that harvested products can be sold at higher prices. Furthermore, the annual crop yield has increased by 35%, a clear indication that visualization of data and remote control of the production environment is effective.

7. Conclusion

The agriculture support solution provided by NTT FACILITIES makes it possible to remotely monitor many fields scattered over a wide area. This is useful even for large-scale producers and communities that want to share and accumulate information about their production environments. The solution will provide strong support for *fail-free* agriculture, that is, efficient and stable farm management, and encourage the entry of new farmers and farm corporations.

Sensor network technology that uses self-owned wireless WANs can also be expanded to cover an entire community (**Fig. 5**). This will make it possible to integrate management of entry into buildings, measurement of biometrics, monitoring of energy, and protection against bird and animal damage into a comprehensive form of smart agriculture. This will lead to enhanced distribution of information vital for farm communities and will contribute to the revitalization of rural communities.



Note: The base stations and wireless terminals used in the self-owned 920-MHz network are prototypes. Their specifications are subject to change.
LPG: liquefied petroleum gas

Fig. 5. Deployment for monitoring of a farm community.

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Application of Information and Communication Technology to Agriculture and Animal Husbandry

Hiroshi Uehara

Abstract

NTT DOCOMO is poised to revitalize Japanese agriculture by using information and communication technology (ICT) to tackle the industry's major issues: enhancing productivity and saving labor. This article introduces agriculture and animal husbandry solutions that utilize NTT DOCOMO's nationwide mobile networks and cover the entire range of data handling, from collection to management and presentation of sensor information. These are the positive outcomes of co-creation efforts with venture companies that have professional expertise and are aggressively applying ICT to agriculture.

Keywords: ICT, agriculture, animal husbandry

1. Introduction

NTT DOCOMO is introducing information and communication technology (ICT) to agriculture with an emphasis on providing mobile networks and cloud solutions that are useful for farm organizations and municipalities. Together with venture companies that have professional expertise and are aggressively applying ICT to agriculture, NTT DOCOMO is co-creating solutions that use wireless networks. These are a stable communication environment available nationwide even in remote rural or mountainous areas.

Our activities are not limited to providing smartphones and tablets. We have held hearings with the JA (Japan Agricultural Cooperatives) Group and agricultural production corporations in order to learn about their problems and listen to their requests so that the ICT solutions we offer will be carefully crafted to fit their needs.

At AGRINEXT 2015, held in October 2015, NTT DOCOMO exhibited sensors and cameras for use in agriculture and animal husbandry, agricultural management applications, and examples of their use by the JA Group.

2. ICT solutions for agriculture

Our booth exhibiting PaddyWatch, a paddy field sensor developed and provided by Vegetalia, Inc., attracted a particularly large number of visitors. PaddyWatch automatically measures the water level and water temperature in paddies, both of which are critical in rice cultivation, and stores the data. It can also record changes in temperature and humidity above the ground (**Fig. 1**). It is resistant to water and mud and can measure the water level to within a few millimeters. The measured data are recorded in the memory unit in its main body and sent to a dedicated server via a mobile phone network and the Internet. Producers can check the state of their fields using a dedicated application on their smartphones or tablets. In this way, PaddyWatch can reduce the amount of labor required for water management.

In May 2015, the Niigata Prefectural Government, Vegetalia, Water Cell Inc., and NTT DOCOMO signed an agreement on the "Demonstration Project on the Innovative Rice Cultivation Management System," which is designed to enhance productivity and increase added value in rice production. This project is intended to support the introduction of PaddyWatch by farm organizations that are seeking to

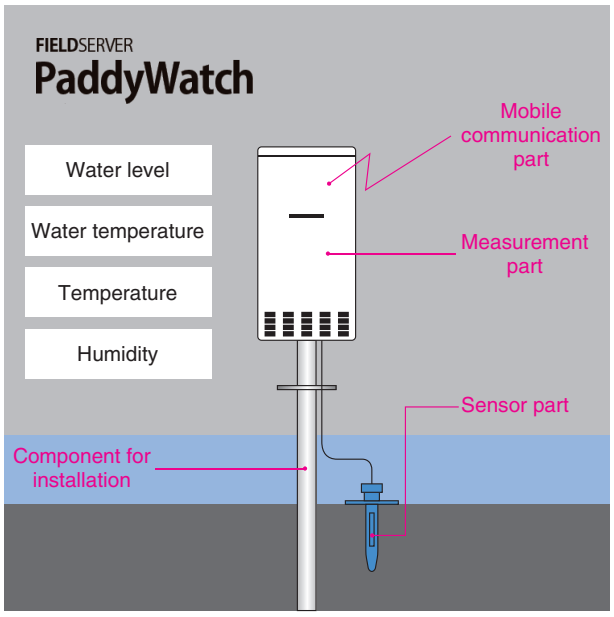

Fig. 1. Paddy field sensor: PaddyWatch.

revitalize large-scale farming in Niigata City, which has the country's largest area of rice paddy fields and has been designated a national strategic district (special district practicing innovative agriculture).

In addition, since June 2015, NTT DOCOMO has been collaborating with the Ministry of Agriculture, Forestry and Fisheries to carry out the "Demonstration Project on Introduction of ICT to Agriculture by Technology Diffusion Organizations Using Rice Paddy Sensors," in which PaddyWatch devices and NTT DOCOMO's tablets are rented to applicants in areas covered by the Ministry's Regional Agricultural Administration Offices in 36 prefectures. Since the latter project covers many areas around the country, it will give momentum to the initiative of the use of ICT to agriculture and to the use of NTT DOCOMO's networks.

NTT DOCOMO is involved in other initiatives designed to provide comprehensive support for agricultural ICT through co-creation with venture companies. One is FieldServer (developed and provided by Vegetalia), a system that monitors not only water-related data in rice paddy fields but also a variety of environmental data related to light, water, soil, and air, all of which are essential for the growth of plants. Another is agri-note (developed and provided by Water Cell), which is a farm work reporting and management tool that uses maps and aerial photos available on the Internet.

3. ICT solution in the area of animal husbandry

NTT DOCOMO is also making efforts to apply ICT to animal husbandry. Today, the number of livestock farmers is decreasing, resulting in a declining number of calves being traded and rising livestock prices. Under these circumstances, it is critical for livestock farmers to enhance productivity by eliminating any failure to detect signs that cows have come into season or that they are about to deliver. Conventionally, such monitoring was done by farmers, who had to stay at the barn around the clock. The use of ICT can reduce their workload dramatically and improve productivity.

Mobile Gyuonkei is an agricultural ICT solution developed and provided by Remote, Inc., a venture company in Oita Prefecture (**Fig. 2**). Since there are few mobile ICT solutions for animal husbandry and Mobile Gyuonkei seems promising, NTT DOCOMO signed a tie-up agreement with Remote. Mobile Gyuonkei is a service that monitors the body temperature of female cows to detect the subtle signs that the delivery process is about to begin or indications that they are ready for mating, and notifies farmers of these signs by email. To use this service, farmers need to insert a body temperature sensor inside the vagina of the cow. The sensor is equipped with a stopper to prevent it from falling out. Additionally, child terminals and a parent terminal are installed in the barn. The sensor has been certified as a medical instrument for animals, so farmers can use the sensor with no concerns about safety. It has a built-in weak wireless device. A child terminal can cover several sensors up to 7.5 m away from it. Wi-Fi is used for communication between the child and parent terminals. The distance between them can be up to 30 m. The parent terminal sends data to a server via NTT DOCOMO's 3G (third generation) network.

Each sensor measures the body temperature of a cow to an accuracy of 0.1 °C every five minutes. The server monitors changes in temperature (**Fig. 3**). When the server detects a drop in body temperature, which is a sign that delivery is imminent, it sends a *get-ready* email, which arrives at the farmer's domicile about 24 hours before delivery. When the server detects a sharp drop in temperature as a result of the sensor being pushed out when the animal's water breaks, it sends a *rush-to-barn* email. A joint patent application was filed on the system configuration and monitoring algorithm of this service by the Industrial Science and Technology Center, the Agriculture, Forestry and Fisheries Research Center (both of Oita

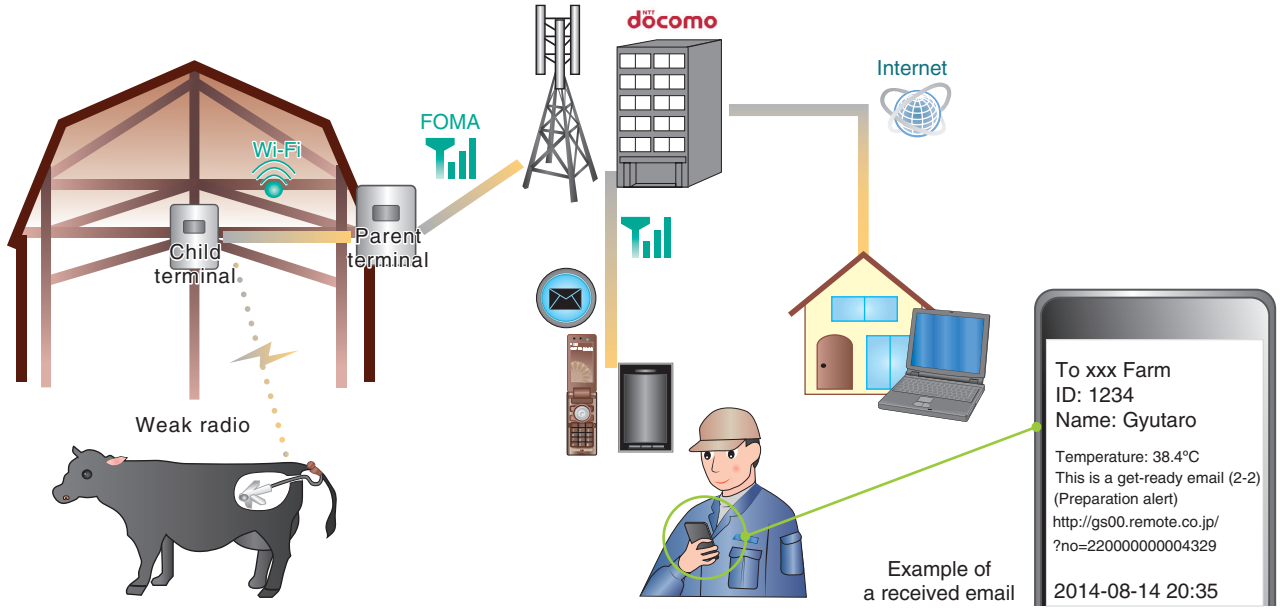

Fig. 2. Mobile Gyuonkei.

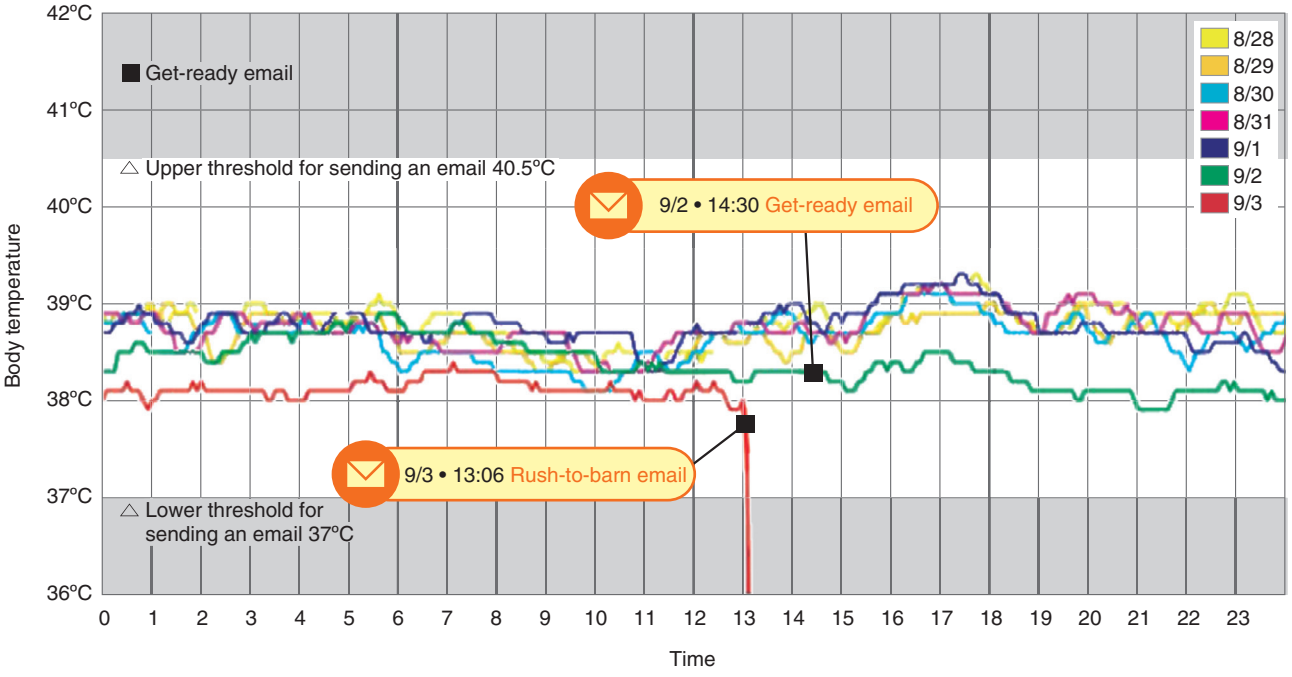

Fig. 3. Delivery monitoring graph.

Prefecture), and Remote, and a patent (No. 3938786) was granted under the title of "Delivery Anticipation and Notification System" in 2007.

Systems that assist farmers in being present at the time of delivery can reduce complications when farm animals are born. In fact, farmers who have introduced Mobile Gyuonkei say that the number of birth-related problems has been reduced dramatically. This

is thanks to the high accuracy of detecting subtle changes in a cow's body temperature. In addition, livestock farmers are freed from the burden of being constantly present at their barns, and they say that they could no longer live without this service.

In July 2014, Zen-Noh Livestock Co., Ltd., a subsidiary of the National Federation of Agricultural Cooperative Associations (Zen-Noh; a JA Group organization responsible for the marketing and supply business), concluded a distribution agent agreement for Mobile Gyuonkei. The service is now being sold through JA Group channels, and sales have been growing. NTT DOCOMO is working with its branch offices nationwide to support the construction of mobile communication environments for Mobile Gyuonkei.

By January 2016, about 200 orders had been received. Nearly half of them have come from the Kyushu region, which has many farmers that raise beef cattle. NTT DOCOMO will continue to promote Mobile Gyuonkei throughout the country in collaboration with the JA Group.

4. Future plan

NTT DOCOMO will utilize its nationwide mobile networks to provide total support ranging from collection to management and presentation of sensor information, to agriculture and animal husbandry. By working with companies that provide agricultural ICT solutions, NTT DOCOMO will assist in the development of agriculture through the use of ICT.

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Service to Efficiently Support Direct Farmers' Markets, which Directly Connect Producers with Consumers

Masahiro Seo, Seiji Igarashi, and Kuniyasu Shiroto

Abstract

At NTT EAST, we are providing an application service provider (ASP)-type direct farmers' market system called *Sanchoku*. Offering this system as an ASP-type service enables us to introduce it to direct farmers' markets easily and at low cost. It streamlines the tasks of producers and managers at these markets. This article introduces the features of the system and the effects of its introduction.

Keywords: direct farmers' market, POS system, application service provider

1. Introduction

Here, we describe the ways in which farmers can sell directly to consumers, focusing in particular on direct farmers' markets.

1.1 Background of direct farmers' markets

Direct sales of agricultural products occur in different forms and on varying scales. Producers, that is, farmers, may sell what they have harvested right in front of their homes or fields. Some farmers sell certain products such as raw eggs or flowers in vending machines. Farmers may also bring their crops to direct farmers' markets run by the JA (Japan Agricultural Co-operative) Group or other agricultural organizations.

Direct farmers' markets are gaining in popularity for a number of reasons. Roadside stations, which usually include a farmers' market, are increasing in number as they become popular resting places for people traveling by car. People are also becoming more and more interested in food, particularly in the *locavore* movement focusing on local production for local consumption. Not only local consumers but also visitors from cities flock to direct farmers' markets, where they can buy locally harvested fresh agricultural products at reasonable prices and get to know who the producers are.

1.2 Features of direct farmers' markets

Since local production for local consumption is now a favored concept, a majority of products sold at direct farmers' markets are locally harvested fresh crops. The name and photo of the producer is included on the packaging of each item so that shoppers can see who produced the item.

In contrast to retailing at supermarkets, producers bring their crops directly to farmers' markets. The markets receive a commission for each item sold, and the remaining revenue goes to the farmers. Consigned sales and deduction of commissions by the market are major features of these markets (**Fig. 1**).

2. Direct farmers' market system: Sanchoku

The Sanchoku system is described in detail in this section.

2.1 Features of the system

The direct farmers' market system known as Sanchoku is designed to solve problems encountered by staff members of direct farmers' markets and also by producers. For example, market staff may require a lot of time and labor to manage the deduction of commissions, and producers may have difficulty knowing exactly what vegetables are in demand at a particular time. In addition to improving the efficiency of business

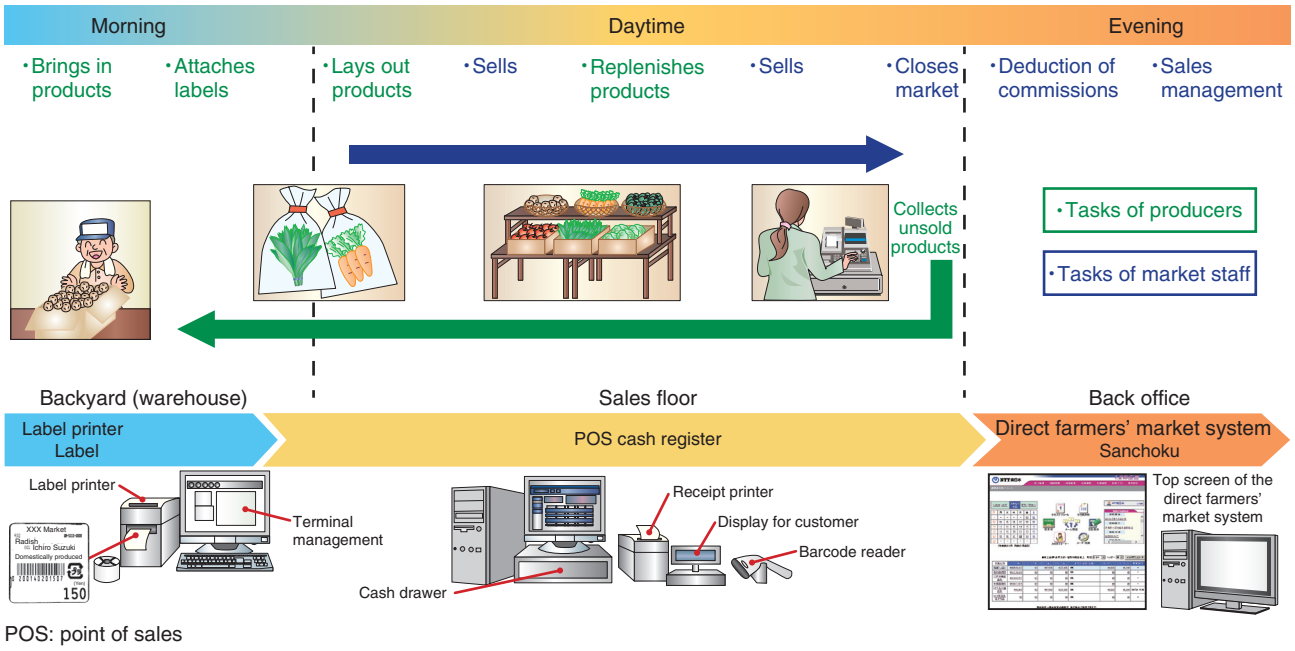


Fig. 1. Agricultural solutions that support a series of tasks at a direct farmers' market.

management, the system provides a variety of functions that support the operation of direct markets such as quick sales reporting and sales analysis.

Sales data are sent to a datacenter via the Internet using a system such as FLET'S HIKARI NEXT optical access and centrally managed there. The series of tasks carried out at a direct market are linked to point of sales (POS)[*1] cash registers and the Sanchoku system, making it possible to analyze collected sales data from different perspectives and provide quick sales reports to producers (**Fig. 2**). A major feature of this system is that it is provided in the form of an application service provider (ASP)[*2,3] service. This is beneficial to all three parties concerned: direct farmers' market managers, producers, and consumers [1]. The main features of the system are described below:

1) Since the system is provided as an ASP-type solution, it can be introduced easily and at low cost to direct markets that cannot afford to invest in a more complicated system or hire engineers.
2) Commissions can be deducted quickly.
3) Producers can receive information about the sales of their own products.
4) If a number of direct markets are run by a single body, they can be linked via the Internet and managed and operated in an integrated manner.
5) Sales can be analyzed from different perspectives such as monthly sales, sales of each type of product, and sales at different times of the day.
6) The master formats of data used by different devices, for example, POS cash registers and label printers, are all managed and provided by the system.

2.2 Functions provided by the system

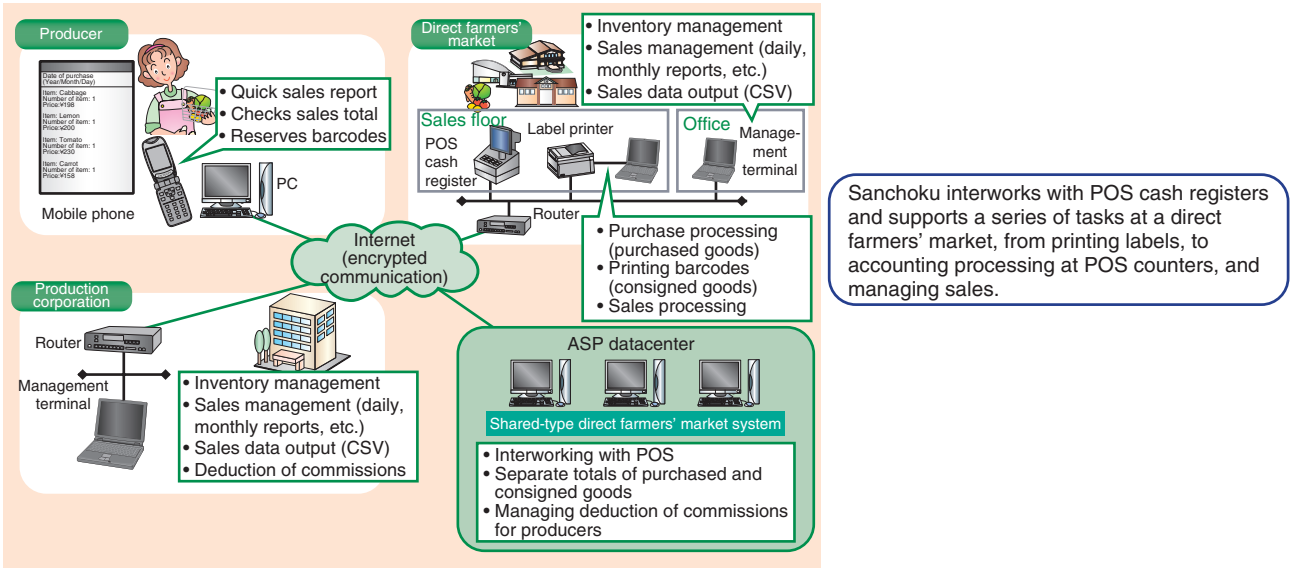
(1) Deduction of commissions

This function calculates the commissions and labeling fee for each producer and generates transfer data that are compliant with the format specified by the Japan Bankers Association. This function reduces the workload of transferring the accounts payable to producers.

(2) Sales management

The direct market management can use data on the sales of each type of product, the sales at each market, and hourly, daily, and monthly sales to improve the

*1 POS: A system that records and aggregates information on sales at the exact time a product is purchased. The functions for recording and aggregating data as well as managing and analyzing aggregated data are generally referred to simply as POS, POS cash register, or POS system.
*2 ASP: An enterprise that has application functions and business software in its server and provides capabilities to customers via the Internet.
*3 This ASP-type service is operated by BUSICOM.



CSV: comma separated values

Fig. 2. Framework of the direct farmers' market system, Sanchoku.

operation of their markets. Direct markets and producers' organizations can work together to analyze the optimal time to carry out sowing and cropping, as well as the harvest yield from the volume of products delivered by individual producers. This enables them to provide advice and guidance on effective farm management to producers.

(3) Quick sales reporting

Producers can obtain information on the sales of their products via the Internet on their mobile phones, smartphones, or computers. This enables them to refill products at direct markets in a timely manner. The markets can increase their sales by avoiding lost sales opportunities as a result of their shelves being empty.

(4) Label printing

The label printers can print labels to be attached to products.

(5) Delivery of quick sales reports by email (optional)

This service delivers information about the total sales of the market to producers by email up to five times a day. The delivery time can be set by the market manager.

3. Effects of the introduction of the system

The Sanchoku system has been offered since 2004, and as of January 2016, it was in use at 76 direct farmers' markets throughout the country.

(1) Effects on direct farmers' market managers

The introduction of the system has improved the efficiency of store operation, including the management of sales and deduction of commissions. The ability to analyze sales data from various perspectives yields information that is useful for planning cultivation cycles. In addition, the centralized management of a number of direct markets makes it easy to adjust the quantities of products delivered to individual markets.

(2) Effects on producers

Producers can check their sales on their mobile phones, smartphones, or computers in a timely manner. This enables them to adjust how much they will deliver the following day. In addition, having knowledge of their daily sales may boost their motivation to increase production and consequently increase their sales.

(3) Effect on consumers

Consumers benefit by being able to buy fresh, local farm products and having access to information about their origin.

4. Future development

Sanchoku can be linked to other services provided by NTT EAST such as Giga-raku Wi-Fi and Giga-raku Signage, and further linked to information and

communication technology solutions provided by other NTT Group companies. This will help to make markets more attractive and by extension, revitalize local economies. We are hopeful that our efforts will succeed in meeting various needs related to the sales and distribution of farm products and help to improve the efficiency of direct farmers' market operation and boost sales, thereby increasing the income of producers.

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Research and Development Activities Related to Agriculture

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Abstract

NTT is undertaking research and development (R&D) on the application of information and communication technology in new business fields including agriculture. This article introduces three agriculture-related R&D activities exhibited at AGRINEXT 2015, which was held October 14–16, 2015 at Makuhari Messe: a farm work recording solution using an intelligent microphone and the VoiceRex speech recognition engine; a cloud-based pallet management system using the 920-MHz band; and laser gas sensing technology using laser light sources that NTT has developed to detect food labeling fraud.

Keywords: co-innovation, sensor network, speech recognition

1. Introduction

A number of NTT technologies can be applied to agriculture. They include 1) sensor device and wireless sensor network technologies that can be used to monitor weather and soil conditions relating to specific areas of farmland, 2) technologies that assist in reducing the workload for keeping farm work records and/or operating agricultural machinery, and 3) technologies that manage product distribution or verify the authenticity of production districts. NTT is carrying out research and development (R&D) aimed at commercializing these technologies (**Fig. 1**). This article introduces three such technologies that were exhibited at AGRINEXT 2015.

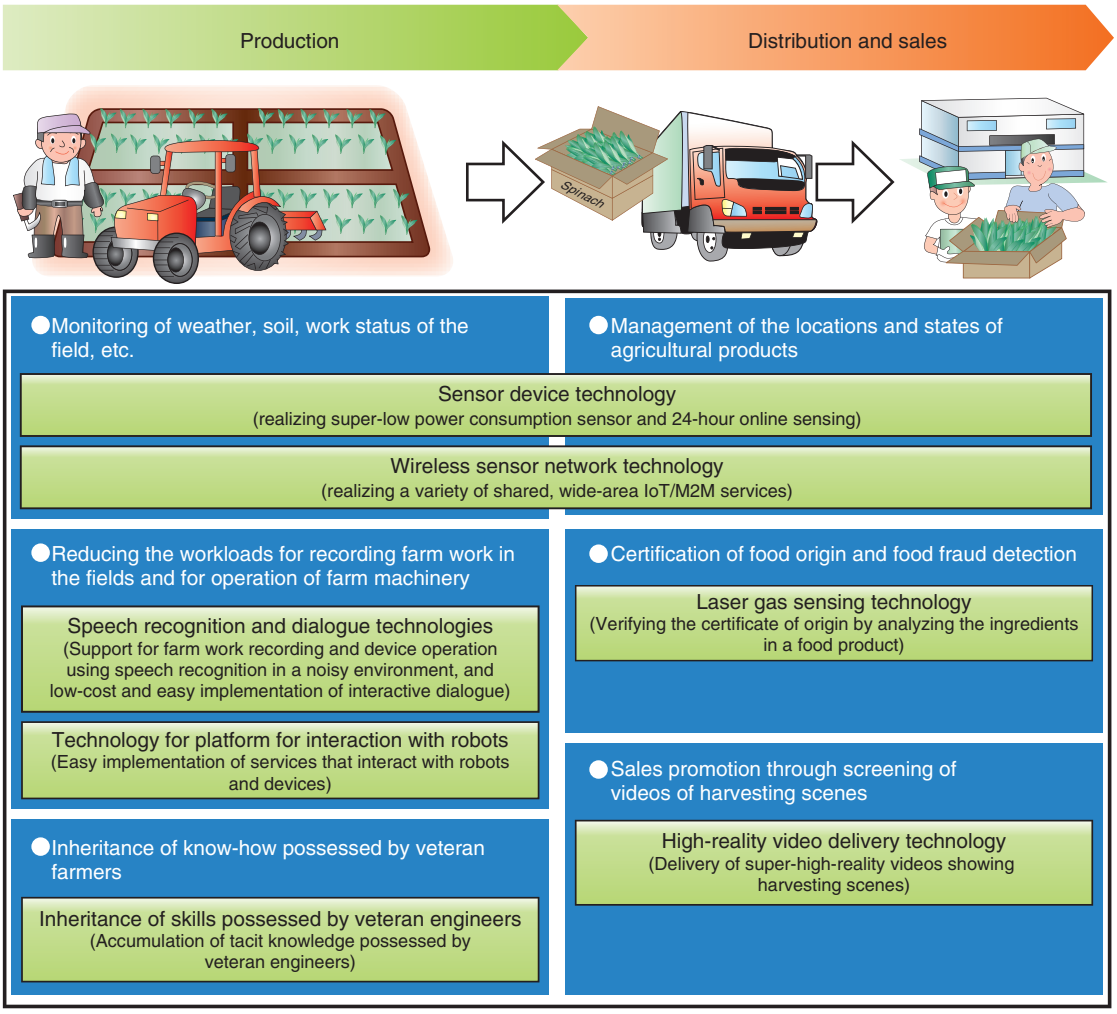
2. Farm work recording solution using intelligent microphone and VoiceRex speech recognition engine

We describe here an agricultural solution using an intelligent microphone in conjunction with NTT's VoiceRex speech recognition engine.

2.1 Overview and features of this technology

Japanese agriculture is facing three serious issues: the aging of the farming workforce, a shortage of young persons with aspirations to become farmers, and an increase in the area of abandoned farmland. The combination of these situations prompted a revision in 2009 to the Agricultural Land Act, newly allowing general corporations to enter the agricultural industry. As a result, the number of agricultural corporations has been on the rise. Perceiving an urgent need to improve efficiency in farm work and raise the quality of farm products, agricultural corporations are shifting from farm management based on intuition, experience, and memory to an approach that relies on keeping daily farm work records and analyzing the recorded data.

NTT Media Intelligence Laboratories has developed a solution that enables farmers to record information about their farm work using speech input so that they do not have to take time out from their work. This solution was exhibited at AGRINEXT 2015. It combines an intelligent microphone [1], which can clearly pick up sound even in very noisy environments, with a highly accurate speech recognition engine called VoiceRex (**Fig. 2**).



IoT: Internet of Things
M2M: machine to machine

Fig. 1. NTT R&D technologies for agriculture (examples).

(1) Intelligent microphones

Intelligent microphone technology uses acoustic signal processing that discriminates between ambient sound (noise) and the target sound, which it separates with a high degree of accuracy. This processing focuses on the directions from which different sounds are coming, the frequency characteristics of sounds, and changes in sound intensities over time (**Fig. 3**). With conventional technologies, it is difficult to suppress a loud noise without degrading the target sound. The new technology can reduce the surrounding noise to about one ten-thousandth the actual level while maintaining the integrity of the target sound. Thus, the target speech can be recognized with a high degree of accuracy, even amid an overall noise level of 100 dB. Since this technology can work with only two or three microphone elements, the intelligent microphone device can be made compact.

(2) VoiceRex

VoiceRex is a highly accurate speech recognition engine based on a deep neural network (DNN) (**Fig. 4**), which simulates information processing that occurs inside the human brain. Speech recognition requires pre-registration of the words. VoiceRex is a continuous speech recognition technology that covers a very large vocabulary, allowing up to 10 million words to be registered as a dictionary. Almost all regularly used words are already registered. VoiceRex can be adapted to a wide range of applications by enabling the addition of words that are specific to any

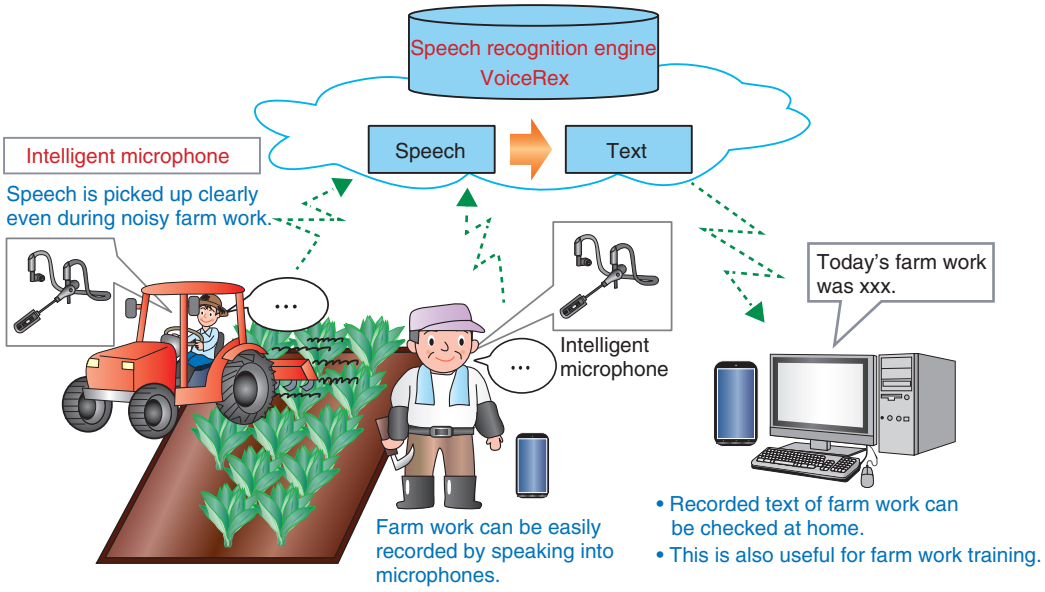


Fig. 2. Farm work recording solution.

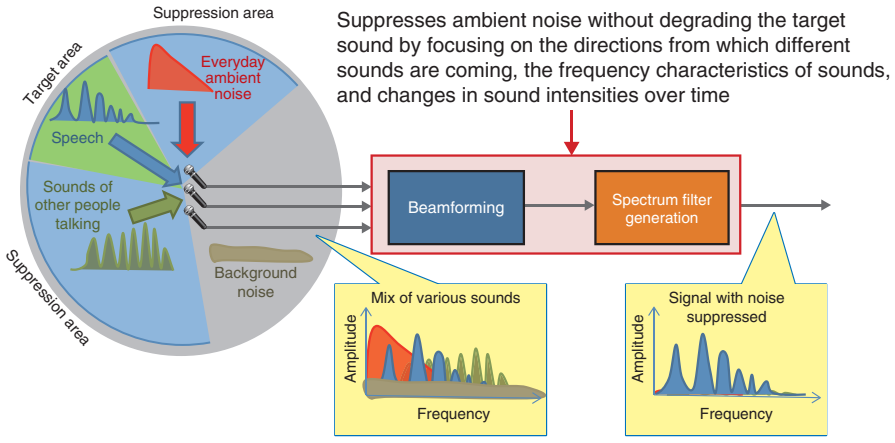


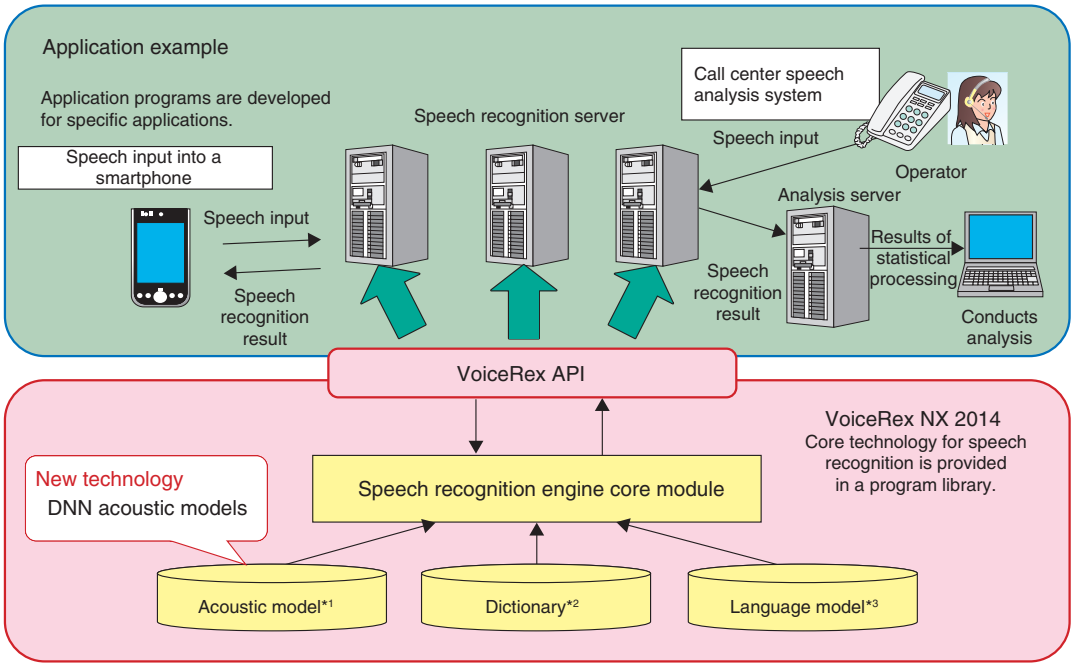
Fig. 3. Intelligent microphone.

particular field such as the names of farm machinery in the case of an agricultural industry application.

2.2 Assisting in recording farm work

Conventionally, farmers have recorded farm work after returning to their offices and sitting in front of a computer, or have used their smartphones to text the information to their computers while working in the fields. Inputting data at the end of the day is problematic because it is easy to forget details, and some farmers are likely to be reluctant to spend time on a computer after a hard day on the farm. VoiceRex enables farmers to input information by speaking the information aloud as they work. Because the details are input on the spot, more accurate information can be recorded.

However, voice recording of information in the field can be difficult due to the loud noise generated by farm machinery. The intelligent microphone solves this problem. It enables the farmer to input spoken data even while driving a roaring combine harvester or tractor. Information can be input effi-



*1 Acoustic model: Model that associates each phoneme with the characteristics of the sound.
*2 Dictionary: Model that defines the lexicon subject for speech recognition and pronunciations of the words in the lexicon.
*3 Language model: Model that represents the probability of connections between words.

Fig. 4. VoiceRex.

ciently without the need to interrupt their work.

Analysis of the farm work records can provide visualization of farming know-how or even help to identify inefficiencies. Such information is useful for improving product quality and reducing costs as well as work time.

The proposed solution of combining an intelligent microphone and VoiceRex can be applied to other areas besides agriculture. It is ideal for use in any situation where workers need to input spoken information in a noisy environment. We are studying the application of this solution in factory situations.

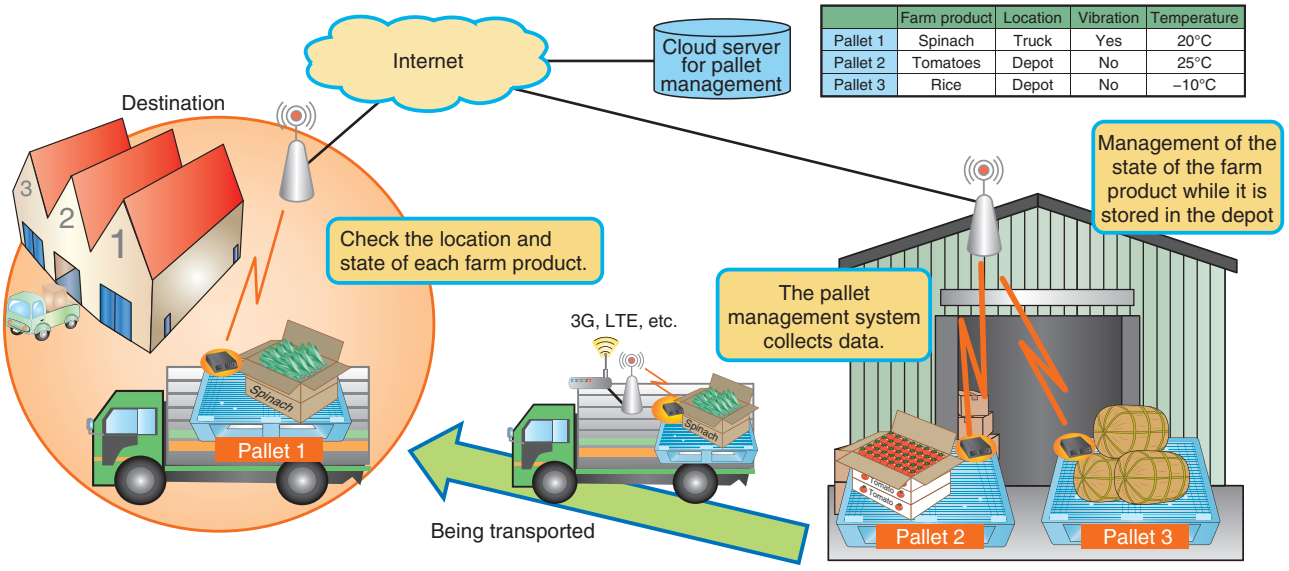
3. Cloud-based pallet management system using 920-MHz band

We have developed a pallet management system that uses the 920-MHz band. In this section, the features and management of the system are explained.

3.1 Overview and features of this technology

This pallet management system [2, 3] must be able to manage an inventory of tens of thousands of pallets stored in a large depot where the floor could stretch over several hundred meters. It is also required to handle several hundred inbound and outbound pallets, brought in or out by trucks, in a matter of several minutes. In addition, it is desirable that wireless terminals (WTs) used by the system remain operational without replacing batteries during the lifetimes of the pallets, which is about 10 years. To meet these requirements, we have developed a high-capacity protocol technology for the 920-MHz band.

The WT attached to each pallet manages two states: static and vibrating. The static state indicates that the pallet is stored in the depot. The vibrating state shows that the pallet is being conveyed by a truck or forklift. This state is recognized when the vibration sensor installed in the WT detects a vibration. The WT periodically transmits the state information, together with the WT ID (identification) and the temperature measured by the temperature sensor, using a beacon signal. The transmission intervals of the beacon signal are controlled according to the state of the WT. Transmission intervals are short in the vibrating state because it is necessary to detect this state instantly. Long transmission intervals are used in the static state so that many WTs can be handled and the batteries will last longer. The static state and the vibrating state use different frequencies in order to avoid interfer-



	Farm product	Location	Vibration	Temperature
Pallet 1	Spinach	Truck	Yes	20°C
Pallet 2	Tomatoes	Depot	No	25°C
Pallet 3	Rice	Depot	No	−10°C

3G: third generation
LTE: Long Term Evolution

Fig. 5. Application of pallet management system to agriculture.

ence between them.

3.2 Management of product location and state

The pallet management system can be used not only to manage the locations of pallets but also to manage the products stacked on the pallets. One example of the latter is management of agricultural products.

An overview of the application of the pallet management system to agriculture is shown in **Fig. 5**. A pallet is associated with the agricultural product stacked on it. For example, Pallet 1 is associated with spinach. This association is managed by the server in a cloud. The location and the state (information from the vibration sensor and the temperature sensor) of each farm product can be detected by receiving the beacon signal sent by the WT attached to the pallet on which the farm product is stacked. If a beacon signal from a WT is received by the base station installed inside the depot, the user can tell that the associated farm product is stored in the depot and can also ascertain the state of the stored product. If, however, a beacon signal is received by the base station installed in a truck, the user recognizes that the associated product is being conveyed by the truck and can also ascertain the state of the transporting product. Attaching the WTs to containers or other items used for transportation enables users to manage the locations and states of various agricultural products.

As a result, the locations and states of agricultural products in the distribution chain, whether being stored in a depot or being transported, can be managed without adding to the workloads of those who need to manage the products.

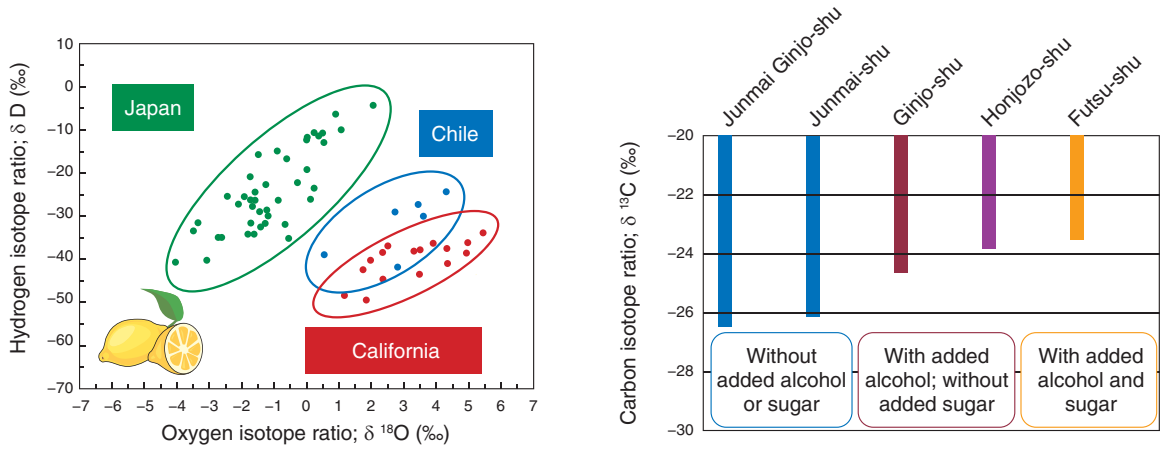
4. Preventing false food labeling with laser light

We report here on the use of laser gas sensing technology to prevent false food labeling.

4.1 Overview and features of this technology

The falsification of imported food as ‘made in Japan’ has been recognized as a social problem in recent years and has aroused the interest of consumers in food safety and authenticity of the geographic origin of food. The government is intensifying its efforts to protect regional brands of food products [4]. An effective way to prevent such falsification is to add scientific examination to the conventional document-based means of ascertaining authenticity in the supply chain of a food product. The geographic origin of food has been identified by analyzing the stable isotope ratios of hydrogen (H), oxygen (O), and carbon (C) contained in the food.

The stable isotope ratio can be measured quickly and accurately by using laser gas sensing technology



(a) Estimating geographic origin of lemons

(b) Estimating ingredients of Japanese sake

Fig. 6. Estimating geographic origin and ingredients using stable isotope ratio analysis.

with highly sensitive semiconductor lasers developed by NTT. Hydrogen, oxygen, and carbon contained in the food are converted into gas such as vapor (H_2O) and carbon dioxide (CO_2) through either vaporization or burning. Since the gas molecules absorb the energy of light at a particular wavelength, which depends on the atoms of which the molecule is composed, the stable isotope ratios in the gas can be analyzed by the precise measurement of the absorption ratio while the laser light passes through the gas [5].

It is known that the stable isotope ratio of precipitation (H_2O) is related to the geographic conditions. Most water molecules consist of two hydrogen atoms whose mass number is 1 and an oxygen atom whose mass number is 16. However, they also contain extremely small amounts of heavy water molecules that consist of an isotope of hydrogen whose mass number is 2 or an isotope of oxygen whose mass number is 18. The proportion of heavy water molecules in precipitation tends to be higher in hot regions, for example, near the equator, and lower in cold regions at higher latitudes. Since plants and animals consume the rainwater in the region where they have grown, the stable isotope ratios of hydrogen and oxygen in a plant or an animal are related to those in the rainwater. Therefore, the stable isotope ratio analysis of food products is helpful to estimate the geographic origin of food (**Fig. 6(a)**).

The stable isotope ratio of carbon depends on the process of photosynthesis. This means that it is possible to obtain information about the plant species in addition to environmental information about where the plant was grown. The stable isotope ratio of carbon among the main ingredients of Japanese *sake*, wine, or honey (rice, grapes, or plants that produce honey) differs greatly from that of added sugar (sugar cane and corn). Therefore, carbon stable isotope ratio analysis will be useful to prevent false labeling or adulteration with sugar to sake or honey (**Fig. 6(b)**).

4.2 Preventing food falsification in supply chain

The laser gas sensing device is compact (about the size of a desktop computer) and easy to operate, and it can reduce the measurement time dramatically compared to mass spectrometry, which is well known as the most widely used method for stable isotope ratio analysis. These advantages enable supply chain screening. By incorporating scientific inspections using a laser gas sensing device to a supply chain system used by trading firms and retailers, it will be possible to achieve a more reliable management system to prevent false labeling and adulteration (**Fig. 7**).

5. Future plans

In addition to the items introduced in this article, NTT R&D has a number of other technologies that can be applied to agriculture. With a view to accelerating the utilization of these technologies to open up new agriculture-related business opportunities, we plan to aggressively pursue co-innovation with a wide variety of partners.

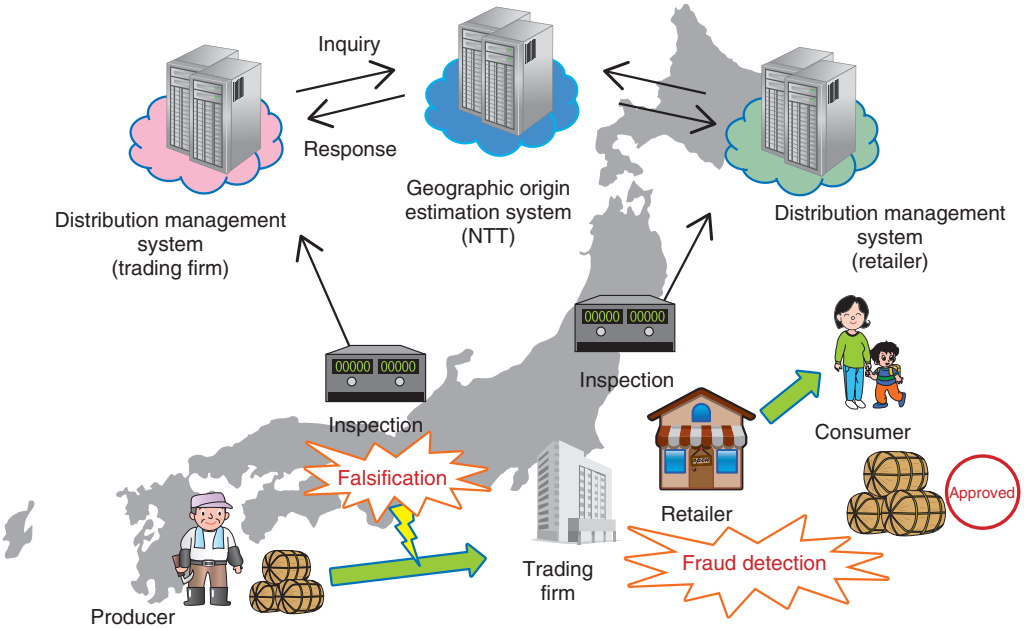


Fig. 7. Service examples (trading firm and retailer).

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NTT Group Activities to Support Smart Agriculture

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Abstract

The NTT Group is committed to strengthening the competitiveness of Japanese agriculture and is therefore supporting the implementation of smart agriculture through the use of information and communication technology. This article introduces the exhibits presented by NTT Group companies at AGRINEXT 2015 (held October 14–16, 2015 at Makuhari Messe) as examples of the group's activities related to the natural environment.

Keywords: weather, geography and terrain, wild animal damage

1. Introduction

Because most agricultural products are grown in outdoor fields, agriculture is one of the industries that is most sensitive to the elements of the natural environment. Such elements include weather, geography and terrain, and wild animals. There are major variations in Japan's natural environment from region to region because the archipelago runs in a long 3800-km arc from north to south, is filled with mountains and valleys, and is affected by ocean currents on all sides. If Japanese agriculture is to improve its competitiveness, producers need to practice farming that is adapted to the natural environment of the particular region.

This article introduces three activities of the NTT Group concerning weather, geography and terrain, and wild animal damage. These activities were exhibited at AGRINEXT 2015 held October 14–16, 2015 at Makuhari Messe in Chiba Prefecture.

2. Activities related to weather information

From ancient times, agriculture is said to have been at the mercy of the weather, and this still holds true today even though there have been great advances in agricultural technology. Crop yields vary year by year along with changes in climate and weather. In recent years, extreme weather events such as high temperatures and torrential rain have been occurring more frequently, causing serious damage to agriculture. In September 2015, for example, the intense rainfall in the Kanto and Tohoku regions (brought about by Typhoon No. 18) caused damage estimated at 4.84 billion yen. This serves as evidence of how serious weather-related damage can be [1].

To tackle this problem, Halex Corporation, an NTT Group company, has developed a meteorological data optimization system called HalexDream!. The system processes a huge volume of meteorological data provided by the Meteorological Agency in order to produce agriculture-related weather information that is specifically designed to support farming activities.

HalexDream! uses all data provided by the agency, including currently observed data and numerical forecast data as the input, and performs several unique forms of processing, such as developing two-dimensional 1-km-mesh data that reflect regional characteristics, correcting measured data based on currently observed data in order to keep data fresh, and ensuring easy data handling. This has made it possible to forecast the weather anywhere in Japan in

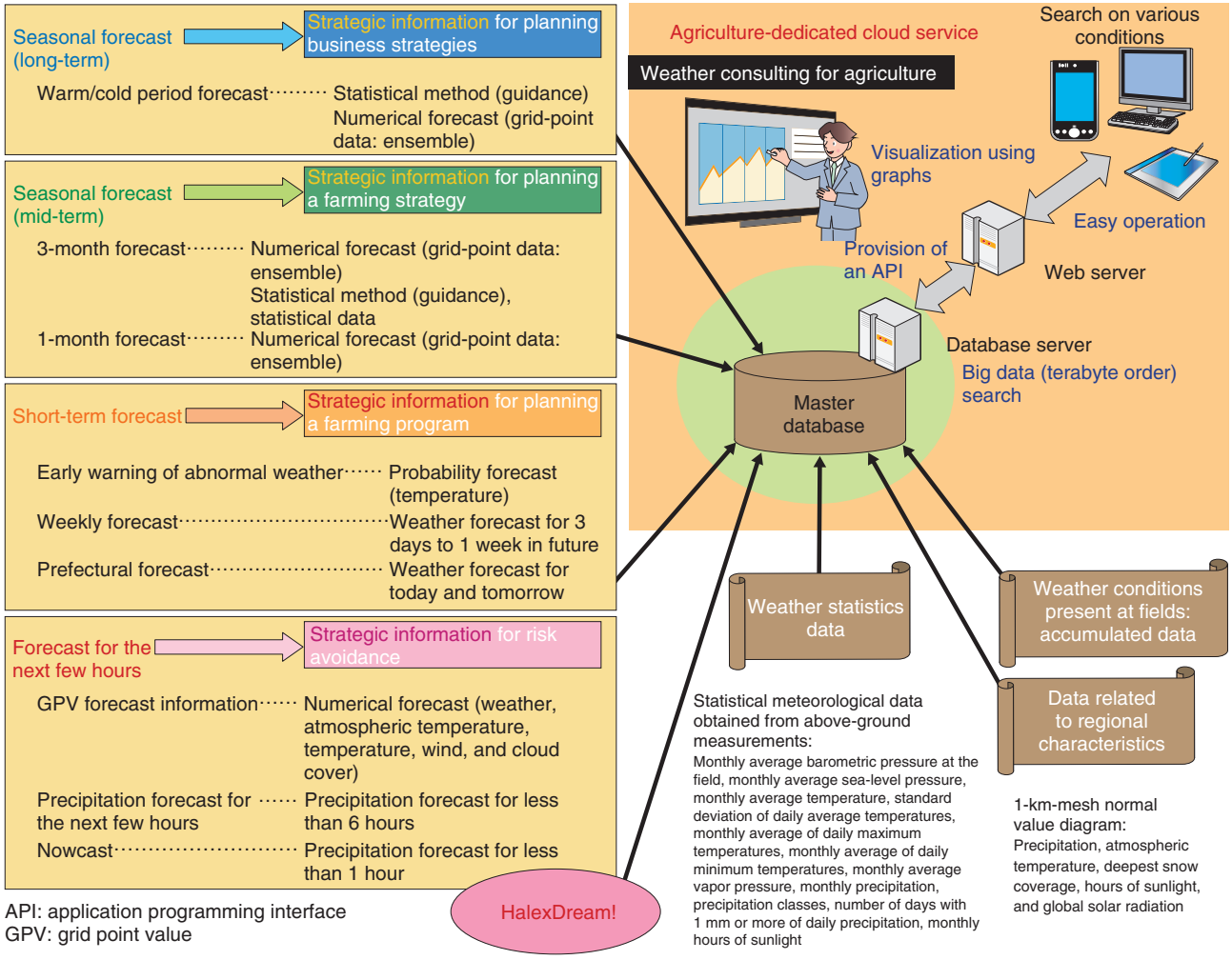

Fig. 1. Development of an agricultural weather forecast system and study of a new approach to farm management.

units of 1-km mesh for up to 72 hours from the current time.

The Sakanoue Cloud Consortium (comprising Halex and five other companies) in Ehime Prefecture utilized HalexDream! to develop an agricultural weather forecast system and is currently studying a new approach to farm management as part of the "Demonstration Project on Advanced Model Farming through Collaboration between the Agricultural and Economic Communities" of the Ministry of Agriculture, Forestry and Fisheries. Specifically, this system uses weather information for agriculture to generate short-term forecasts (72-hour forecasts, one-week forecasts, etc.), which can be used to avoid weather-related disasters or for daily field management such as reducing damage from pests and disease.

The system will be upgraded in the future to use seasonal forecasts to generate information useful for formulating a farming strategy, for example, when to plant seedlings, when to ship products, and what cultivars to use (**Fig. 1**).

3. Activities related to geographical and terrain information

Along with weather, geography and terrain greatly affects farming. Since the land area of Japan is small for its population, extensive areas have been developed and renovated to secure farmland. As a result, there are major variations in the geographical and terrain conditions of cropland. Some areas have been developed by reclaiming forests or wasteland, and some by draining swamps or lakes. If Japanese agriculture is to become more competitive, it is necessary

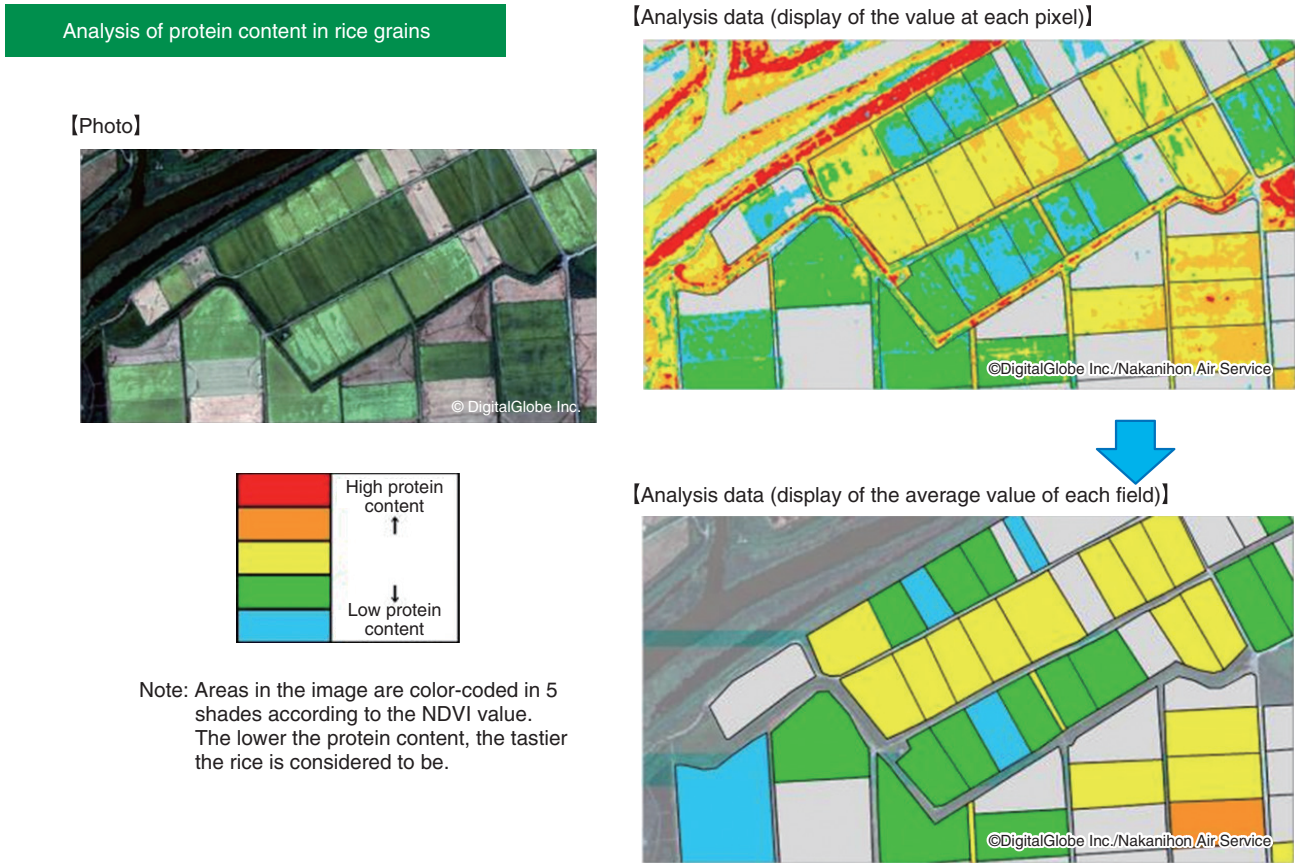

Fig. 2. Growth status management using satellite photos.

to select farming methods based on the geographical and terrain conditions.

NTT Geospace uses map information and satellite photos to support farmers in acquiring knowledge about geographical and terrain conditions of a particular area. The company uses four satellites to photograph a specified area with a resolution of up to 30 cm/pixel on the ground. Producers can use the photos to determine, for example, the condition of the borders of their fields in great detail.

NTT Geospace has a huge archive of images (covering a land area of about 2 billion km^2, which is equal to photographing the earth's entire land area eight times). These images make it possible to study the characteristics of a specific field by comparing satellite photos of the same field taken at different times of the year, or to study the agricultural conditions of a field by combining the photos of the field with meteorological data. Furthermore, by analyzing the spectrum of satellite photos, it is possible to analyze the growth status of crops in order, for example, to forecast the growth of wheat or determine the protein content of rice grains. This will allow visualization of the optimal harvest time or a stable supply of tasty farm products (**Fig. 2**).

4. Activities related to preventing wild animal damage

Wild animals can also seriously affect agricultural production. In recent years, losses caused by wild animal damage to farm products have been on the order of 20 billion yen annually. Deer and wild boar are the chief culprits. To cope with this situation, damage prevention programs are developed in accordance with the Law Concerning Special Measures for Prevention of Wild Animal Damage. These programs involve community-wide efforts to catch the animals causing the damage [2]. One problem with catching animals is the tremendous workload involved in

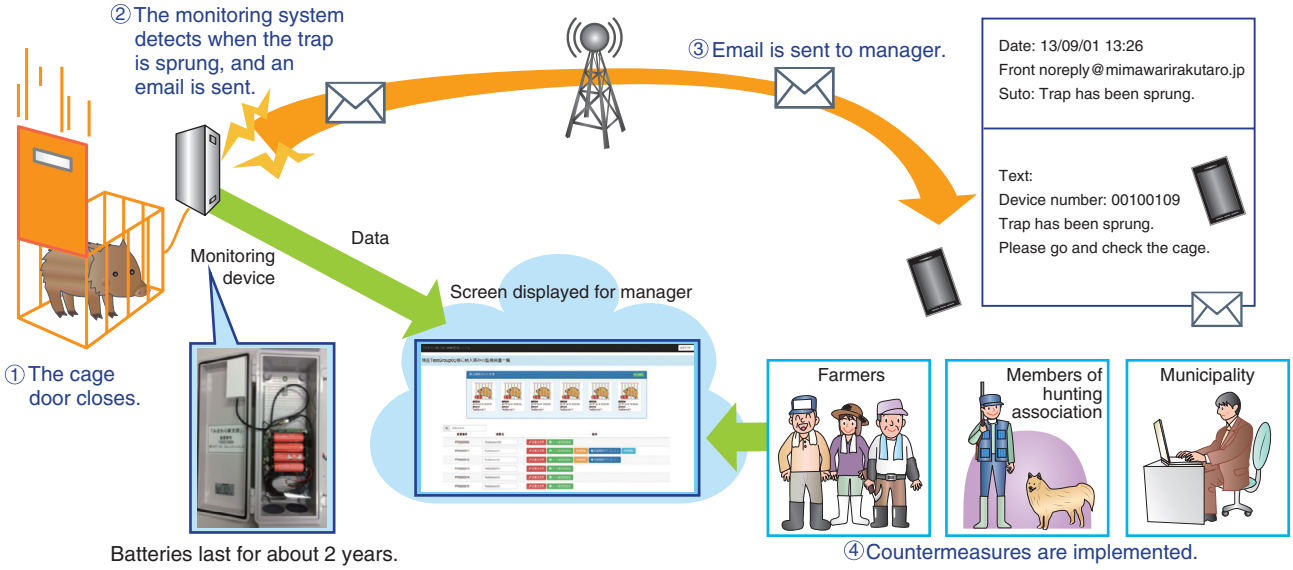

Fig. 3. Trap monitoring system that combines M2M technology, a network, and a cloud.

repeatedly going out to inspect traps, which are usually installed in mountainous areas.

NTT PC Communications has been working to solve this problem and has developed a trap monitoring system called *Mimawari-Rakutaro* that combines M2M (machine to machine) technology, a network, and a cloud. The system has proven to be highly effective. It works as follows. The monitoring device detects when a trap has been sprung and sends an email to the manager of the trap. Since traps are usually installed in areas away from residential areas, it is difficult to supply power to monitoring devices. To avoid this problem, Mimawari-Rakutaro is powered by batteries, which can last for about two years without replacement (**Fig. 3**).

A type of monitoring device equipped with a camera is also available. This device sends a photo when the trap on which it is installed is sprung. This makes it possible to determine whether the trap has been sprung in error. The system has been sold since July 2011. Today, about 300 systems have been installed in 40 municipalities around the country, helping to reduce wild animal damage to agricultural products.

5. Future plan

In addition to the solutions introduced in this article, the NTT Group provides an extensive portfolio of agricultural solutions applicable to different stages of the value chain of agriculture, from production to distribution and sales. We plan to gradually join them together in an organic manner so that the integrated solutions will run through the entire value chain, enabling us to provide solutions with greater added value.

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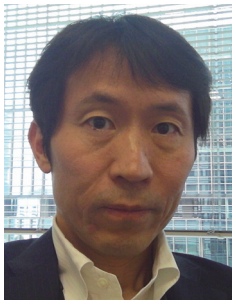

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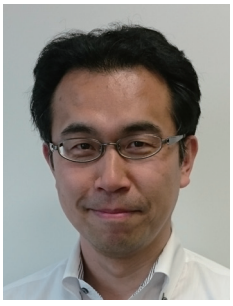

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Development of Transport Systems for Dedicated Service Provision Using Packet Transport Technologies

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Abstract

To date, NTT has been providing high-quality dedicated services such as analog and high-speed digital services on its time division multiplexing network. NTT has also been shifting its relay networks to packet transport networks in conjunction with the shift to the Next Generation Network. This article introduces a new packet transport multiplexing adapter for dedicated service provisioning on packet transport networks using circuit emulation technologies.

Keywords: dedicated service, leased line service, MPLS-TP, CEP

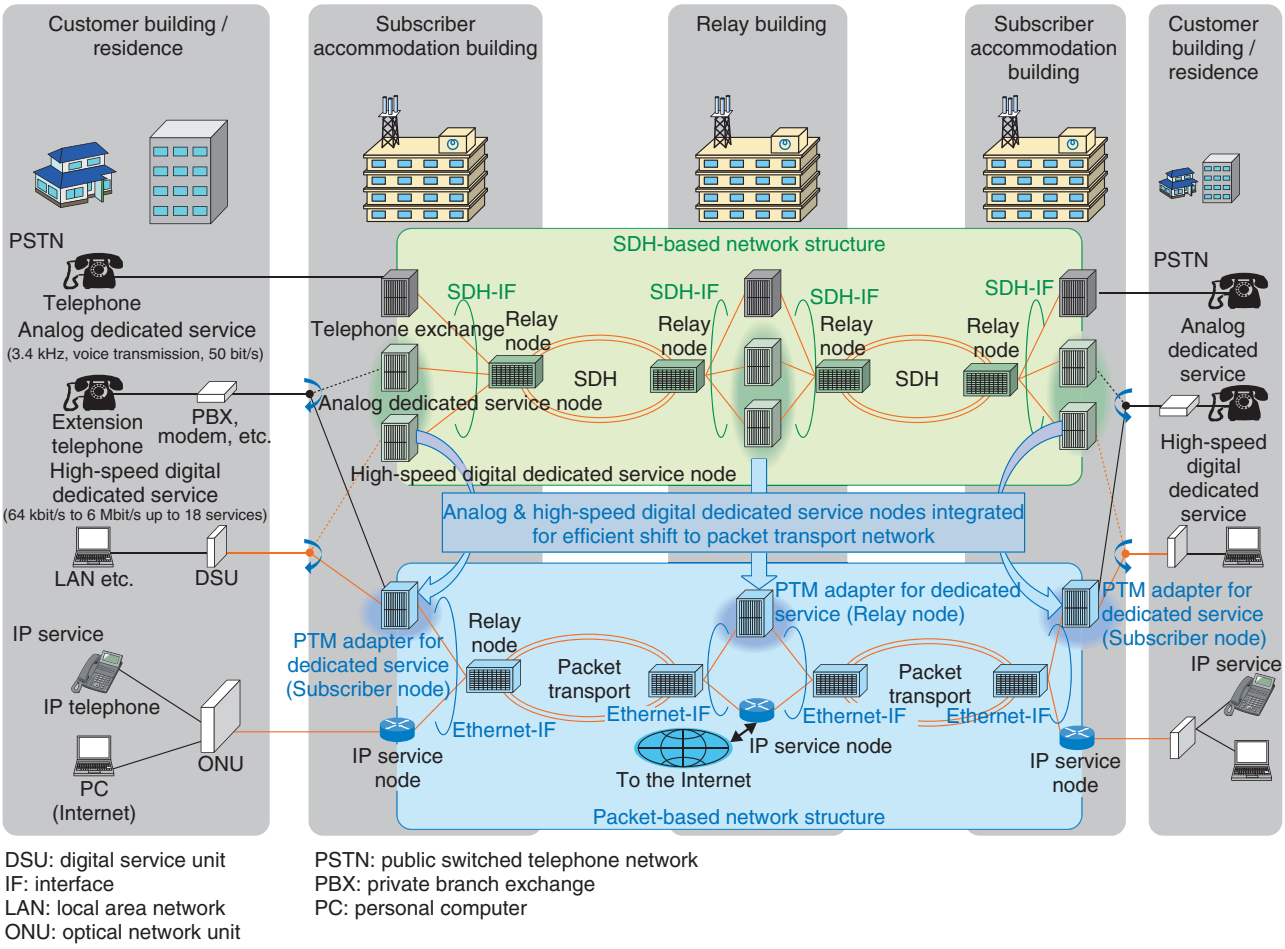
1. Introduction

Dedicated services such as analog and high-speed digital services differ from the best effort lines typical of the Internet, in that they are communications services designed to achieve high reliability and high quality (low latency, low error rates) by constantly allocating a fixed bandwidth to subscribers. There is still some demand for these services, especially services that are geared to corporate users.

For the link systems that perform the relay transmissions supporting these dedicated services, NTT laboratories have adopted synchronous digital hierarchy (SDH) based on time division multiplexing (TDM) technologies appropriate for multiplexing with fixed-rate lines and public networks. However, as Internet protocol (IP) services such as the Internet have spread, there has been a shift towards adopting packet transport technologies for link systems since these technologies have a high affinity with IP traffic. Packet transport technologies are connection-oriented transmission technologies with the same transmission quality as SDH and are based on Ethernet and multiprotocol label switching (MPLS) technologies. These technologies enable line and path administration functions, operations, administration and maintenance (OAM) functions, and protection functions similar to SDH.

With this background, the objective is to simplify the entire network by shifting from TDM technologies to packet transport technologies, even for dedicated service nodes. For this reason, NTT laboratories have applied MPLS-TP (transport profile), which is a packet transport technology, to develop the packet transport multiplexing adapter (PTM adapter) for dedicated services. This adapter is a new dedicated service node that will ensure the high quality and high reliability required for dedicated services. The PTM adapter is designed for migration from existing dedicated service networks to packet transport networks (**Fig. 1**).

An overview of the PTM adapter is shown in **Fig. 2**. It consists of three types of node: a relay node, subscriber node, and user-installed subscriber node, all of which can be connected to other link systems via Ethernet interfaces. These nodes also have clock



DSU: digital service unit
IF: interface
LAN: local area network
ONU: optical network unit
PSTN: public switched telephone network
PBX: private branch exchange
PC: personal computer

Fig. 1. Migration to packet transport networks with PTM adapter for dedicated service.

functions that enable synchronization with synchronous network clocks via a synchronization supply unit (SSU), monitoring and warning functions that are the same as existing equipment, test functions, and monitoring and control functions that enable switching control. Here, we describe some key elements in the development of these PTM adapters.

2. Migration issues

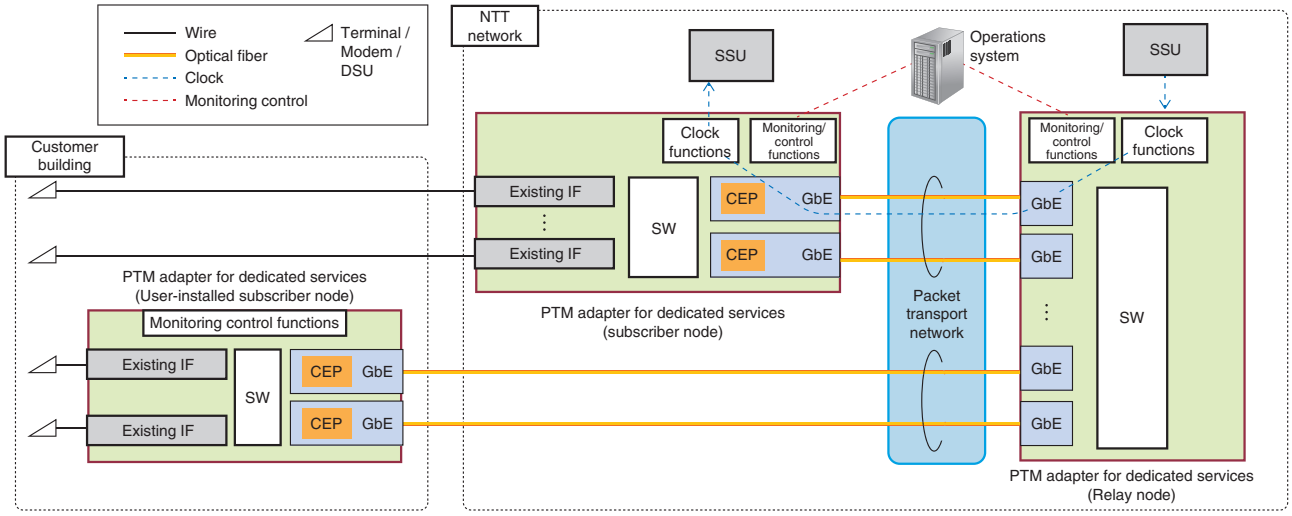
We describe here three migration-related issues that occurred with the PTM adapter.

2.1 Accommodation on the packet transport network

(1) Handling accommodation efficiency and latency

To accommodate dedicated services on the packet transport network, processing is required in order to packetize fixed-rate user line signals in each type of dedicated service at a set period and to restore packet signals as user line signals (depacketization). Furthermore, there are standard values for latency time in dedicated service networks that must be satisfied.

One cause of increased latency that occurs in the packetizing process is buffering latency due to waiting for user line signals to reach packet lengths of a certain size. For this reason, it is necessary to shorten the period of packetization and reduce the amount of buffering to achieve lower latency. However, a smaller packet size means there will be proportionally more packet headers, which lowers the accommodation efficiency. In contrast, lengthening the period of packetization lowers the proportion of headers and hence raises the accommodation efficiency, but it also increases the amount of buffering, which increases latency. Thus, to optimize accommodation efficiency and latency, it was necessary to design an optimal packetization period.



Main items	Sub-items		Details
Nodes	Interface	Relay node	GbE (synchronous Ethernet, hitless switching, OAM)
		Subscriber node	GbE (CPE, synchronous Ethernet, hitless switching, OAM)
			Existing interface (analog dedicated service, high-speed digital dedicated service, line testing)
	Clock		Receiver (64+8 kHz, 64+8 kHz + 0.4 kHz), Receiver (6312 MHz)
	Switch		Per line
	Monitoring control functions		Alert output, testing control, switching control
Operations system	Monitoring control functions		Implementation management, alert management, path settings, testing control, switching control

CEP: circuit emulation over packet
GbE: gigabit Ethernet
SW: switch

Fig. 2. Overview and main specifications of PTM adapter for dedicated services.

In depacketizing, a cause of increased latency lies in the process of absorbing fluctuations in packet delay that occur on packet transport networks. Because user line signals are at a fixed rate, it is not possible to normally restore user line signals if there are fluctuations in packet latency. Hence, it is necessary to absorb packet latency fluctuations by buffering packets. If the size of the buffer for absorbing packet latency fluctuations is small, it is possible to reduce latency, but it is not possible to normally restore packets with large latencies as user line signals. In contrast, if the size of the buffer for absorbing packet latency fluctuations is large, it is possible to normally restore packets as user line signals, although the latency becomes large. For this reason, it is necessary to gain a sufficient understanding of latency fluctuation on packet transport networks so that an optimum buffer size can be set to absorb these fluctuations.

(2) Handling clock frequency transmissions

To handle fixed-rate user signals synchronized with clock frequencies in dedicated systems, it is necessary to ensure that the clock frequencies of each device match. However, because Ethernet is an asynchronous system, clock frequencies at the sending and receiving ends are not synchronized, and frequency deviations up to ±100 ppm occur at the sending and receiving ends. These frequency deviations cause misalignment in packetization and depacketization periods which accumulate and make it impossible to reproduce user line signals, and thus make it impossible to ensure quality of dedicated services. For this reason, clock frequencies must be transmitted via Ethernet.

2.2 High efficiency, high accommodation, energy saving

As new service items were added to dedicated service nodes, new equipment had to be developed, which created issues with installation space and accommodation efficiency. Hence, there are demands to accommodate multiple service items in single pieces of equipment to achieve greater efficiency and reduce space requirements. Lower power consumption has also become a requirement with the increased demand for greater energy saving in recent years.

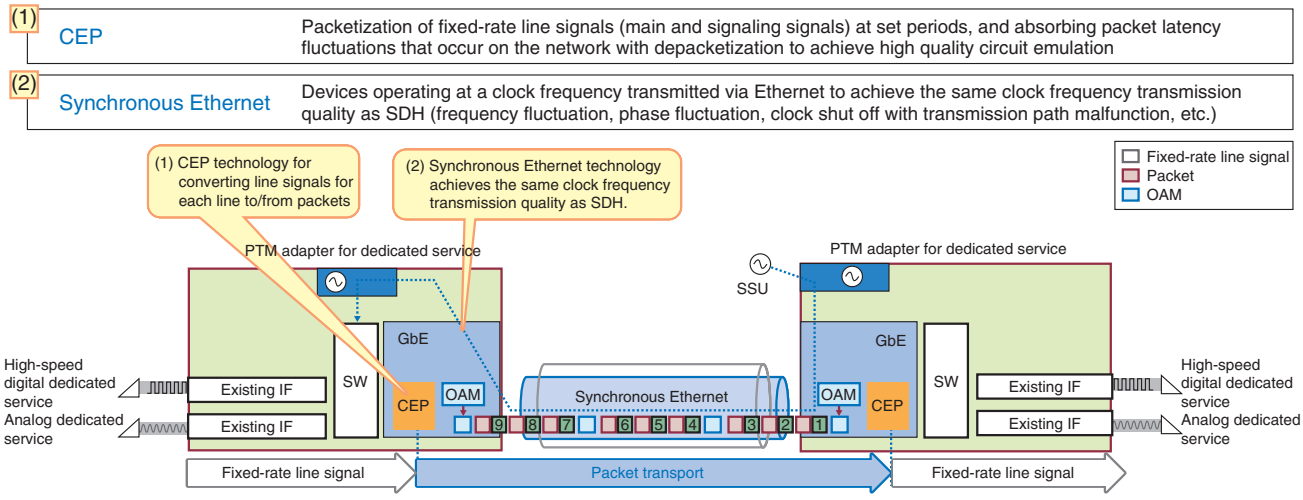


Fig. 3. Synchronous circuit emulation technology.

2.3 Improved maintenance operability and reliability

When new dedicated service nodes are migrated to a system, the existing dedicated service nodes adopting the conventional SDH technology must coexist with the PTM adapters until all the circuits are migrated to the newly installed nodes. Hence, from the viewpoint of maintenance operations, it is necessary to seamlessly carry out circuit testing and alarm monitoring from the same control terminal without operators having to identify which equipment is SDH-based and which is PTM-based.

Furthermore, service continuity is also required for handling dedicated services. Hence, hitless switching functions are required so that services are not affected during maintenance work and failures.

3. Technical issues

Here, we explain some technical points regarding these technologies.

3.1 Synchronous circuit emulation technologies

Synchronous circuit emulation technologies are used to achieve a level of communications quality similar to conventional dedicated services (latency, bit error rate). They consist of circuit emulation over packet (CEP) and synchronous Ethernet technologies. An overview of synchronous circuit emulation technologies is shown in **Fig. 3**.

CEP technologies are specified by the Internet Engineering Task Force (IETF) RFC5086 [1]. They convert fixed-rate line signals (including signaling signals) into packet signals. With transmission, fixed-rate line signals are packetized at 1–2 ms intervals and can be accommodated on the packet transport network by conversely depacketizing them upon reception.

Moreover, the PTM adapter is equipped with the following functions for packetizing and depacketizing. First, the PTM adapter can satisfy the latency requirement specified by dedicated services by setting optimal packetization periods for each service item. This also reduces the facility costs by improving the accommodation efficiency. Second, high-quality circuit emulation has been achieved by absorbing latency fluctuations that occur in the depacketization process. We have designed the optimal buffer size by simulating and measuring the expected maximum value on packet latency fluctuations with high accuracy, which is specified by dedicated services. We have also reduced the buffer size for latency fluctuations by depacketizing at an optimized timing with statistical processing. As a result, we have reduced the network latency.

Synchronous Ethernet technology is technology specified by the Telecommunication Standardization Sector of the International Telecommunication Union (ITU-T) in Recommendation G.8261 [2] for transmitting clock frequencies between devices via the physical layer of the Ethernet. After a reference clock frequency is generated in an oscillator in the transmitting device by using the clock frequency signal that was input, frequencies are converted to gigabit Ethernet

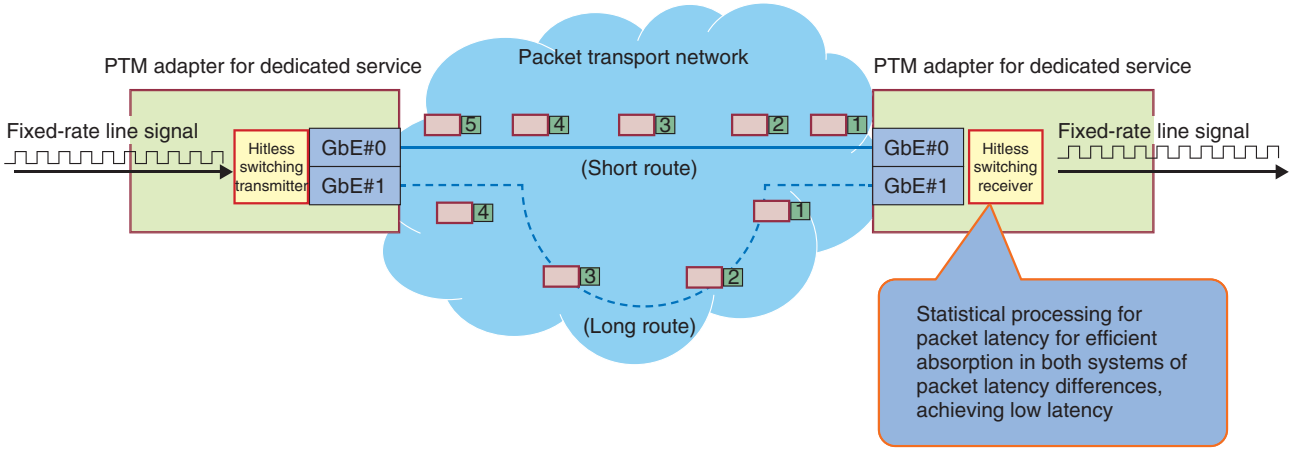


Fig. 4. Overview of hitless packet switching.

(GbE) signaling speeds to send Ethernet signals. The transmitting equipment clock signals are reproduced by extracting the clock timing from the received Ethernet signal (the rise timing of the bit string) in the receiving equipment. This technology enables each piece of equipment to operate with the transmitted clock frequency, even via Ethernet.

3.2 High efficiency, high accommodation, energy saving

We have made it possible to reduce the maximum power consumption to about one-third that of conventional systems for the maximum number of accommodations by integrating existing dedicated service nodes required for each service item with the PTM adapters. We have also made more effective use of existing facilities by making subscriber interface packages compatible with existing equipment. Furthermore, we have drastically reduced the amount of space required by making it possible to house circuits in one rack, whereas five racks were previously required.

3.3 Improving maintenance operability

With the PTM adapters, we have made it possible to achieve seamless alert monitoring and line testing functions for SDH and packet transport segments from the same terminal by sorting the details required for testing and by coordinating each layer for SDH segments and packet transport segments. In terms of alert monitoring in particular, we have optimized determination criteria so that the transport error occurrence thresholds would be the same level for SDH and packets because the packet transport system detects errors packet-by-packet and discards errored packets, whereas the conventional SDH system detects errors bit-by-bit. This gives maintenance teams improved maintenance capabilities by enabling them to confirm normal operations in batches without having to consider the individual technologies used in each segment.

Additionally, we applied hitless switching technology to the PTM adapters to improve service quality. The hitless switching technology is illustrated in **Fig. 4**. This technology adjusts latency for short and long paths and uses systems to select first-come packets.

Moreover, since latency fluctuation is an issue with packet transport networks, we have enabled hitless switching with lower latency than the conventional system by using technology that efficiently absorbs packet latency differences between both paths through the use of statistical processing for the latency of each packet.

4. Future development

This article described a PTM adapter for dedicated services developed by NTT Network Service Systems Laboratories.

Going forward, we aim to respond to customers seeking high quality and high reliability by developing Ethernet networks that satisfy the quality standards of dedicated services.

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https://datatracker.ietf.org/doc/rfc5086
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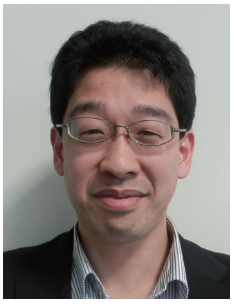

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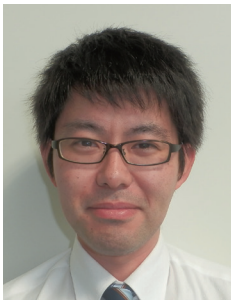

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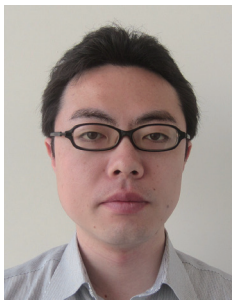

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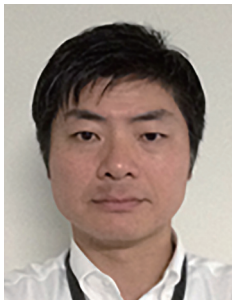

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Report on ITU World Radiocommunication Conference 2015

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Abstract

The International Telecommunication Union (ITU) World Radiocommunication Conference 2015 (WRC-15) was held in Geneva, Switzerland in November 2015. This conference is normally held every three or four years to discuss updating the Radio Regulations (RR), a formal document issued by the ITU. The RR is enforced on the ratifying member states as international regulations regarding radiocommunication in the ITU Constitution and Convention. The RR is updated after each WRC, and national regulations such as the Radio Law in Japan are enacted accordingly. This article reports on the results of WRC-15.

Keywords: WRC-15, World Radiocommunication Conference, RA-15

1. Introduction

The World Radiocommunication Conference (WRC) is the largest international conference in the International Telecommunication Union - Radiocommunication Sector (ITU-R)*1 to discuss updating the Radio Regulations (RR) and is normally held every three or four years. The RR provides international rules and regulations for allocation of the spectrum to radio services, use of satellite orbits, and administrative and operational procedures for radio stations. The RR must be updated based on the results of the WRC in order to allocate the spectrum to new services. The last WRC, WRC-15, was held November 2–27 in Geneva, Switzerland (**Fig. 1**). Approximately 3800 participants from 162 member states attended WRC-15, including 82 delegates from Japan [1].

In the RR, the world is divided into three regions, as shown in **Fig. 2**, and frequencies are allocated to services in each region. As shown in the figure, there are four regional telecommunication organizations in Region 1, and one organization each in Regions 2 and 3. Japan is a member of the Asia-Pacific Telecommunity (APT)*2 in Region 3. Reaching consensus in the APT is very important in order to carry out Japan's policy on usage of the spectrum.

The structure of WRC-15 is shown in **Fig. 3**. The chairman of the Plenary, which coordinates all conference activities, is Mr. Daudu. He is the first WRC chairman from Africa. Under the Plenary, there are seven committees (COMs 1–7), as shown in Fig. 3. COM 4, COM 5, and COM 6 respectively discussed terrestrial/aeronautical/maritime matters, satellite matters, and general issues/new agenda items. At WRC-15, 36 agenda items listed in **Table 1** were discussed, and an output document called the Final Acts was produced [2]. The agenda item on Global Flight Tracking (flight tracking system by satellite) was newly established in response to an aviation accident, and the discussion on this item resulted in a

*1 ITU-R: The sector of ITU that develops regulations and standards for radiocommunication systems.

*2 APT: A regional telecommunication organization in accordance with the Constitution of the International Telecommunication Union. As of January 2016, 38 countries in the Asia-Pacific region were members of APT.

Fig. 1. WRC-15 meeting in session.

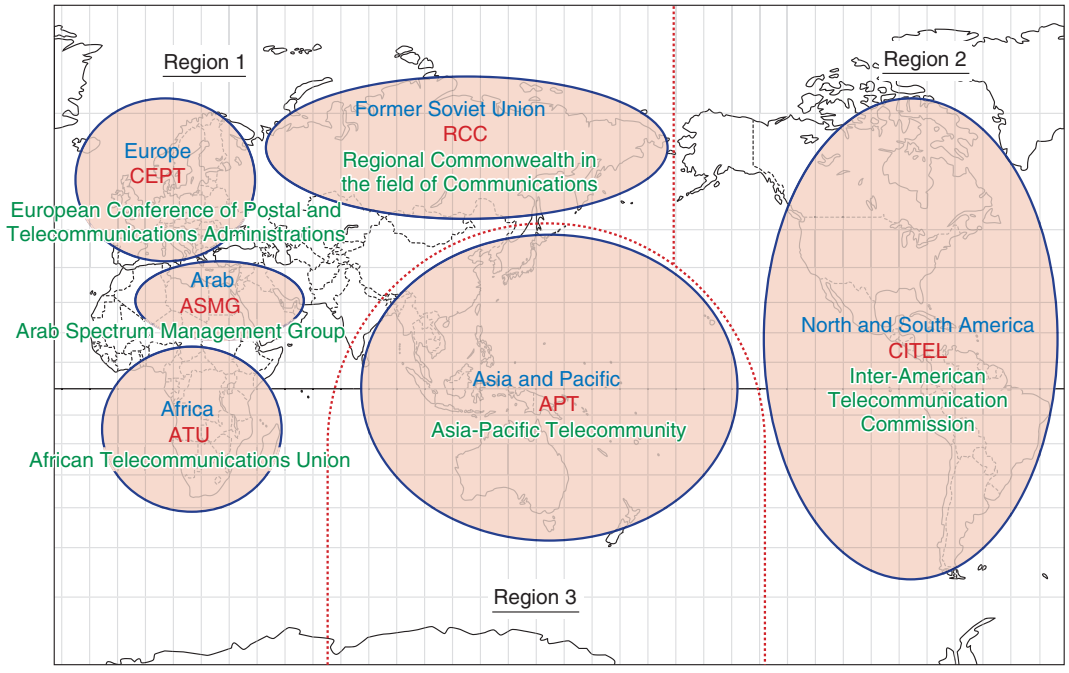

Fig. 2. Regions in the RR and regional telecommunication organizations.

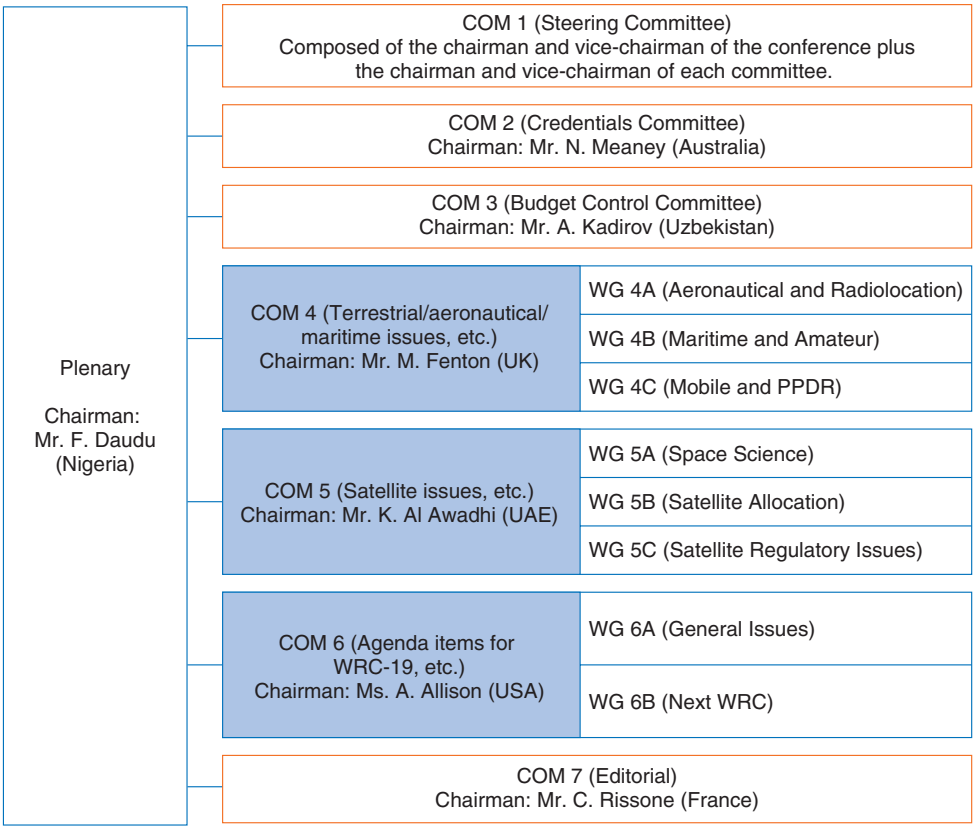

Fig. 3. Structure of WRC-15.

resolution to allocate the same frequency band (1090 MHz) as terrestrial flight tracking systems.

1.1 Identification of additional frequency bands for International Mobile Telecommunications

In response to strong demand for International Mobile Telecommunications (IMT), the identification of additional frequency bands for IMT was discussed, after which it was resolved to identify the new frequency band of 1.5 GHz (1427–1518 MHz) as a global IMT band, which is already used in Japan.

1.2 Additional allocation to satellite services

Additional allocation to satellite services such as the fixed satellite service (FSS) and the mobile satellite service (MSS) was also discussed at WRC-15. Under agenda item 1.6.2, "Possible primary allocations to the FSS (Earth-to-space) of 250 MHz in Region 2 and 300 MHz in Region 3 within the range 13–17 GHz," additional allocation in the frequency band of 14.5–14.8 GHz was resolved with some conditions, for example, to prohibit the deployment of earth stations within a distance of 500 km from neighboring countries.

Regarding agenda item 1.10, "To consider spectrum requirements and possible additional allocations for the MSS within the frequency range from 22 GHz to 26 GHz," although the RCC (Regional Commonwealth in the field of Communications; Russian Federation) was strongly in favor of additional allocations, no allocations were agreed to after a long discussion. As for agenda item 1.9.2, "The possibility of allocating the bands 7375–7750 MHz and 8025–8400 MHz to the maritime MSS (MMSS)," it was resolved to allocate the frequency band of 7375–7750 MHz to the MMSS with the condition that stations in the MMSS shall not claim protection from interference from radio stations in the terrestrial services. The results of these agenda items will therefore have no harmful influence on stations in the terrestrial services in Japan.

Table 1. Agenda items of WRC-15.

No.	Agenda item
1.1	Studies on frequency-related matters on International Mobile Telecommunications and other terrestrial mobile broadband applications
1.2	Use of the frequency band 694–790 MHz by the mobile, except aeronautical mobile, service in Region 1 and related studies
1.3	Studies to support broadband public protection and disaster relief
1.4	Possible allocation to the amateur service on a secondary basis at around 5300 kHz
1.5	Use of frequency bands allocated to the fixed-satellite service not subject to Appendices 30, 30A and 30B for the control and nonpayload communications of unmanned aircraft systems in nonsegregated airspaces
1.6	1. Possible additional primary allocation to the fixed-satellite service (Earth-to-space and space-to-Earth) of 250 MHz in the range between 10 GHz and 17 GHz in Region 1
	2. Possible additional primary allocation to the fixed-satellite service (Earth-to-space) of 250 MHz in Region 2 and 300 MHz in Region 3 within the range 13–17 GHz
1.7	Studies on compatibility between new systems of the aeronautical radionavigation service and the fixed-satellite service (Earth-to-space) (limited to feeder links of the non-geostationary mobile-satellite systems in the mobile-satellite service) in the frequency band 5091–5150 MHz
1.8	Provisions relating to earth stations located on board vessels which operate in fixed-satellite service networks in the uplink bands 5925–6425 MHz and 14–14.5 GHz
1.9	1. Possible new allocations to the fixed-satellite service in the frequency bands 7150–7250 MHz (space-to-Earth) and 8400–8500 MHz (Earth-to-space)
	2. Possibility of allocating the bands 7375–7750 MHz and 8025–8400 MHz to the maritime-mobile satellite service and additional regulatory measures
1.10	Additional primary allocations to the mobile-satellite service within the bands from 22 GHz to 26 GHz
1.11	Allocation for the Earth exploration-satellite service (Earth-to-space) in the 7–8 GHz range
1.12	Possible extension of the current worldwide allocation to the Earth exploration-satellite (active) service in the frequency band 9300–9900 MHz by up to 600 MHz within the frequency bands 8700–9300 MHz and/or 9900–10,500 MHz
1.13	Use of the band 410–420 MHz by the space research service (space-to-space)
1.14	Future of the Coordinated Universal Time time-scale
1.15	Consideration of improvement and expansion of on-board communication stations in the maritime mobile service in the ultrahigh frequency band
1.16	Consideration of regulatory provisions and spectrum allocations for enhanced Automatic Identification System technology applications and for enhanced maritime radiocommunication
1.17	Consideration of regulatory actions, including allocations, to support wireless avionics intra-communications
1.18	Allocation of the band 77.5–78 GHz to the radiolocation service to support automotive short-range high-resolution radar operations
2	Examine the revised ITU-R Recommendations incorporated by reference in the Radio Regulations communicated by the Radiocommunication Assembly
4	Review the resolutions and recommendations of previous conferences with a view to their possible revision, replacement or abrogation
7	Possible changes, and other options, in response to Resolution 86 (Rev. Marrakesh, 2002) of the Plenipotentiary Conference, an advance publication, coordination, notification and recording procedures for frequency assignments pertaining to satellite networks
8	Delete country footnotes or have country name deleted from footnotes, if no longer required
<AI 9*> 9.1	1. Protection of the systems operating in the mobile-satellite service in the band 406–406.1 MHz (Issue 9.1.1)
	2. Studies on possible reduction of the coordination arc and technical criteria used in application of No. 9.41 in respect of coordination under No. 9.7 (Issue 9.1.2)
	3. Use of satellite orbital positions and associated frequency spectrum to deliver international public telecommunication services in developing countries (Issue 9.1.3)
	4. Updating and rearrangement of the Radio Regulations (Issue 9.1.4)
	5. Consideration of technical and regulatory actions in order to support existing and future operation of fixed-satellite service earth stations within the band 3400–4200 MHz, as an aid to the safe operation of aircraft and reliable distribution of meteorological information in some countries in Region 1 (Issue 9.1.5)
	6. Studies towards review of the definitions of fixed service, fixed stations and mobile stations (Issue 9.1.6)
	7. Spectrum management guidelines for emergency and disaster relief radiocommunication (Issue 9.1.7)
	8. Regulatory aspects for nano- and picosatellites (Issue 9.1.8)
9.2	Any difficulties or inconsistencies encountered in the application of the Radio Regulations
9.3	Action in response to Resolution 80 (Rev.WRC-07)
<New item>	Global Flight Tracking
10	Preliminary agenda for the 2019 World Radiocommunication Conference

* Report of the Director of the Radiocommunication Bureau

1.3 Review of provisions related to earth stations on board vessels

At WRC-03 held in 2003, it was decided to allow earth stations on board vessels (ESV) to use certain frequency bands allocated to the FSS. In this case, to prevent harmful interference to stations in the terrestrial services, Resolution 902 (WRC-03) was agreed to, which prohibits the use of ESV within a certain distance from coastal lines. The required distances are 125 km for the Ku band (14–14.5 GHz) and 300 km for the C band (5925–6425 MHz). In agenda item 1.8 at WRC-15, the possible revision of these distances was discussed. As a result, it was resolved that no revision to Resolution 902 (WRC-03) would be made, and footnote No. 5.457A in the RR was revised so that the use of ESV is allowed with a separation distance of 330 km from coastal lines with a minimum antenna diameter of 1.2 m for the C band. These results do not affect existing ESV services using the Ku band.

1.4 Agenda items for WRC-19

Thirty-three agenda items for the next WRC (WRC-19), to be held in 2019, are listed in **Table 2**. The group responsible for each agenda item at WRC-19 was decided at the first session of the Conference Preparatory Meeting (CPM19-1), which was held immediately after the close of WRC-15. Studies on these agenda items are carried out in ITU-R Study Groups for the study period of 2016–2019 (**Fig. 4**). Japan proposed four agenda items for WRC-19, and all were approved. The proposed agenda items are as follows:

- Global or regional harmonized frequency bands for evolving Intelligent Transport Systems (Agenda item 1.12);
- Identification of frequency bands for the future development of IMT (5G) in the frequency range 24.25–86 GHz (Agenda item 1.13);
- Identification of frequency bands for applications in the land mobile and fixed services operating in the frequency range 275–450 GHz (Agenda item 1.15);
- Studies concerning Wireless Power Transmission for electric vehicles (Agenda item 9.1 Issue 9.1.6).

Some other agenda items for WRC-19 adopted in WRC-15 are as follows:

- Global or regional harmonized frequency bands for railway radiocommunication systems between train and trackside (Agenda item 1.11);
- High-altitude platform stations (Agenda item 1.14);
- Issues related to wireless local area networks in the frequency bands 5150–5925 MHz (Agenda item 1.16).

The discussion on item 1.16 is based on contributions from the Inter-American Telecommunication Commission and multiple European countries. As a result, it was decided that the frequency bands of 5150–5470 MHz and 5725–5925 MHz will be considered. In addition, agenda items of WRC-23, which will be held after WRC-19, were also discussed, and it was decided that a review of the leap second (WRC-15 agenda item 1.14) will be discussed at WRC-23 toward abolishing leap seconds.

2. ITU Radiocommunication Assembly 2015 (RA-15)

Preceding WRC-15, ITU Radiocommunication Assembly 2015 (RA-15) was held from 26–30 October 2015 at the same venue as that of WRC-15. RAs are convened to set the overall direction such as to decide study items for the next study period, and they are usually associated in time and place with the WRCs. Approximately 460 participants from 107 member states attended RA-15, including 30

Column—Languages used in international meetings—

The ITU is a specialized agency of the United Nations (UN) for information and communication technologies. The official languages of ITU are Arabic, Chinese, English, French, Russian, and Spanish in accordance with Article 29 of the Constitution of the ITU as well as the official languages of the UN. The Constitution also states that the original documents are to be written in French, and the seating order at meetings is based on the alphabetical order of the French names of the member states. At the Plenary, simultaneous interpreters of six languages are available, and texts in six languages are provided. Participants can download documents in their preferred language and attend conferences using their preferred language voice channels.

Table 2. Agenda items of WRC-19.

No.	Agenda item	Responsible group
1.1	Allocation of the frequency band 50–54 MHz to the amateur service in Region 1	WP 5A
1.2	Establishment of in-band power limits for earth stations operating in mobile-satellite service, the meteorological-satellite service and the Earth exploration-satellite service in the frequency bands 401–403 MHz and 399.9–400.05 MHz	WP 7B
1.3	Consideration of possible upgrading of the secondary allocation to the meteorological-satellite service (space-to-Earth) to primary status and a primary allocation to the Earth exploration-satellite service (space-to-Earth) in the frequency band 460–470 MHz	WP 7B
1.4	Consideration of possible revision of Annex 7 to Appendix 30 of the Radio Regulations	WP 4A
1.5	Use of the frequency bands 17.7–19.7 GHz (space-to-Earth) and 27.5–29.5 GHz (Earth-to-space) by earth stations in motion communicating with geostationary space stations in the fixed-satellite service	WP 4A
1.6	Studies of technical, operational issues and regulatory provisions for non geostationary fixed-satellite services satellite systems in the frequency bands 37.5–39.5 GHz (space-to-Earth), 39.5–42.5 GHz (space-to-Earth), 47.2–50.2 GHz (Earth-to-space) and 50.4–51.4 GHz (Earth-to-space)	WP 4A
1.7	Studies to accommodate requirements in the space operation service for non-geostationary satellites with short duration missions	WP 4A
1.8	Consideration of regulatory provisions for updating and modernization of the Global Maritime Distress and Safety System	WP 5B
1.9	1. Autonomous maritime radio devices operating in the frequency band 156–162.05 MHz	WP 5B
	2. Consideration of regulatory provisions and spectrum allocations to the maritime mobile-satellite service to enable the satellite component of the VHF Data Exchange System and enhanced maritime radiocommunication	WP 5B
1.10	Studies on spectrum needs and regulatory provisions for the introduction and use of the Global Aeronautical Distress and Safety System	WP 5B
1.11	Railway radiocommunication systems between train and trackside	WP 5A
1.12	Intelligent Transport Systems applications	WP 5A
1.13	Studies on frequency-related matters for International Mobile Telecommunications identification including possible additional allocations to the mobile services on a primary basis in portion(s) of the frequency range between 24.25 and 86 GHz for the future development of International Mobile Telecommunications for 2020 and beyond	TG 5/1
1.14	Facilitating access to broadband applications delivered by high-altitude platform stations	WP 5C
1.15	Studies towards an identification for use by administrations for land-mobile and fixed services applications operating in the frequency range 275–450 GHz	WP 1A
1.16	Studies concerning Wireless Access Systems including radio local area networks in the frequency bands between 5150 MHz and 5925 MHz	WP 5A
2	Revision of references to the text of ITU-R Recommendations incorporated by reference in the Radio Regulations /Use of incorporation by reference in the RR	CPM19-2
4	General review of the Resolutions and Recommendations of world administrative radio conferences and world radiocommunication conferences	CPM19-2
7	Implementation of Resolution 86 (Rev. Marrakesh, 2002) of the Plenipotentiary Conference	---
8	Footnotes to the Table of Frequency Allocations in Article 5 of the Radio Regulations	---
<AI 9*> 9.1	1. Implementation of International Mobile Telecommunications in the frequency bands 1885–2025 MHz and 2110–2200 MHz (Issue 9.1.1)	WP 4C/WP 5D
	2. Compatibility of International Mobile Telecommunications and broadcasting-satellite service (sound) in the frequency band 1452–1492 MHz in Regions 1 and 3 (Issue 9.1.2)	WP 4A/WP 5D
	3. Study of technical and operational issues and regulatory provisions for new non-geostationary-satellite orbit systems in the 3700–4200 MHz, 4500–4800 MHz, 5925–6425 MHz and 6725–7025 MHz frequency bands allocated to the fixed-satellite service (Issue 9.1.3)	WP 4A
	4. Stations on board sub-orbital vehicles (Issue 9.1.4)	WP 5B
	5. Consideration of the technical and regulatory impacts of referencing Recommendations ITU-R M.1638-1 and ITU-R M.1849-1 in Nos. 5.447F and 5.450A of the Radio Regulations (Issue 9.1.5)	WP 5A
	6. Studies concerning Wireless Power Transmission (WPT) for electric vehicles (Issue 9.1.6)	WP 1B
	7. Studies to examine: whether there is a need for possible additional measures in order to limit uplink transmissions of terminals to those authorized terminals, etc. (Issue 9.1.7)	WP 1B
	8. Studies on the technical and operational aspects of radio networks and systems for machine-type communication infrastructures (Issue 9.1.8)	WP 5D
	9. Studies relating to spectrum needs and possible allocation of the frequency band 51.4–52.4 GHz to the fixed-satellite service (Earth-to-space) (Issue 9.1.9)	WP 4A
9.2	Report of the Director on any difficulties or inconsistencies encountered in the application of the Radio Regulations and the comments from administrations	---
9.3	Action in response to Resolution 80 (Rev.WRC-07)	---
10	Preliminary agenda for the 2023 World Radiocommunication Conference	---

* Report of the Director of the Radiocommunication Bureau

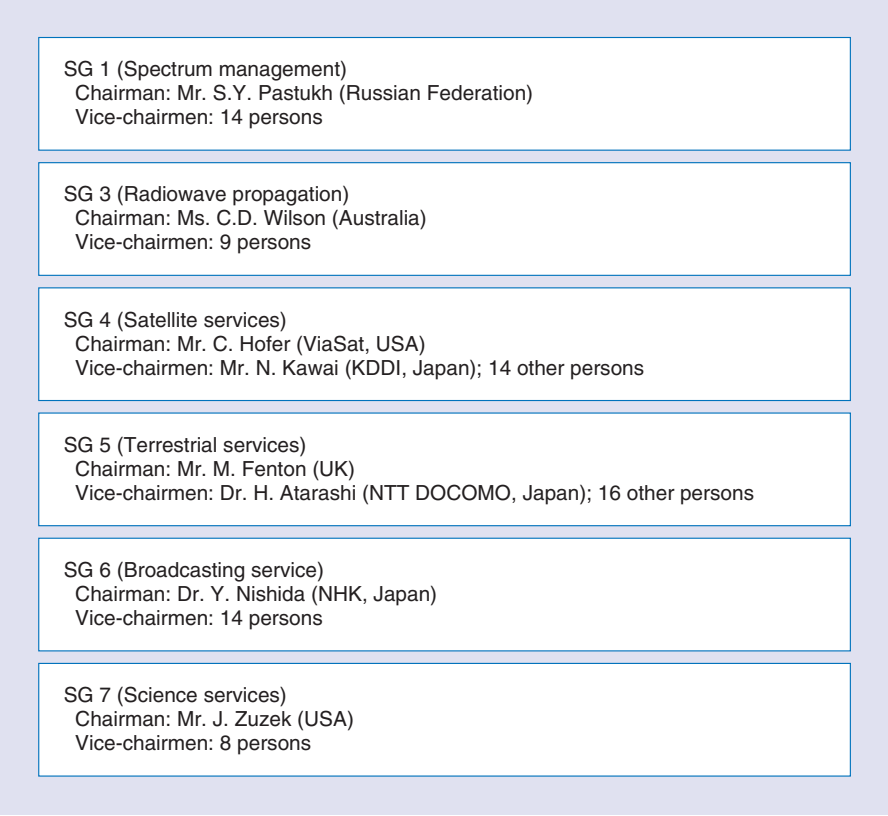

Fig. 4. ITU-R Study Group structure, and chairmen and vice-chairmen for 2016–2019.

delegates from Japan [3]. Dr. Hashimoto (NTT DOCOMO) was appointed chairman of the Plenary. RA-15 approved 7 Recommendations, 33 Resolutions, and 200 Questions proposed from ITU-R Study Groups and members. RA-15 approved a Resolution to name the 5G mobile systems "IMT-2020." It was also resolved at RA-15 to conduct studies on the Internet of Things in ITU-R, as well as in ITU-T SG 20. Additionally, RA-15 appointed the chairmen and vice-chairmen of the Study Groups. From Japan, Dr. Nishida of NHK was appointed chairman of SG 6, and Mr. Kawai of KDDI and Dr. Atarashi of NTT DOCOMO were appointed vice-chairmen of SG 4 and SG 5, respectively.

3. Future activities

The NTT Group will continue to participate and contribute to ITU-R and the relevant meetings towards WRC-19 in Japan and the Asia-Pacific region such as APT Conference Preparatory Group (APG) in order to promote the ongoing development and improvement of telecommunication services and guidelines throughout the world.

References

[1] Press release issued by MIC on November 30, 2015 (in Japanese). http://www.soumu.go.jp/menu_news/s-news/01kiban10_02000018.html
[2] Final Acts WRC-15, World Radiocommunication Conference. http://www.itu.int/pub/R-ACT-WRC.12-2015/en
[3] Press release issued by MIC on November 2, 2015 (in Japanese). http://www.soumu.go.jp/menu_news/s-news/01tsushin04_02000060.html

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Senior Manager, Radio Division, NTT Technology Planning Department.

He received a B.E. and M.E. in electronic engineering from Nagaoka University of Technology, Niigata, in 1988 and 1990. He joined NTT Radio Communication Systems Laboratories in 1990. Since then, he has been engaged in research and development (R&D) of compensation techniques for nonlinear distortion, implementation techniques of multi-input/output-port integrated circuits, subcarrier multiplexing transmission systems using fiber optics, fixed wireless access systems, and wireless local area network (WLAN) systems for hotspots and trains. From 2009 to 2012, he was involved in promotional and collaborative activities for R&D technologies at NTT Beijing Representative Office. He is currently involved in regulatory and standardization activities for wireless systems and their technologies and since 2014 has been serving as an expert member of the Information and Communications Council in the MIC and the Association of Radio Industries and Businesses. He is a member of the Institute of Electrical and Electronics Engineers (IEEE) and a senior member of the Institute of Electronics, Information and Communication Engineers (IEICE).

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Research Engineer, Wireless Access Systems Project, NTT Access Network Service Systems Laboratories.

He received a B.E., M.E., and Ph.D. in communication engineering from Osaka University in 1993, 1995, and 1997. He joined NTT in 1997. From 1997 to 2008, he studied wireless access systems, WLAN systems, and wireless systems for Internet services in trains. During 2008–2011, he was involved in international standardization efforts in evolved packet core and services using Internet protocol multimedia subsystems at NTT Service Integration Laboratories. He has been with NTT Access Network Service Systems Laboratories since 2011. He is a member of IEEE and IEICE.

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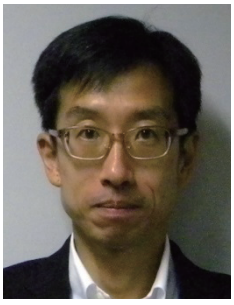
He received a B.E., M.E., and Ph.D. in electrical engineering from Kyoto University in 1996, 1998, and 2006. He joined NTT Wireless Systems Laboratories in 1998, where he worked on modulation and demodulation schemes for broadband mobile satellite communication systems. From 2010 to 2013, he was the Assistant General Manager of the NTT Research and Development Planning Department. He was transferred to NTT Access Network Service Systems Laboratories in 2013. He is currently working on the development of a new satellite communication system. He received the Excellent Paper Award of the 14th IEEE International Symposium on Personal Indoor Mobile Radio Communications (PIMRC) in 2003 and the Young Researcher's Award from IEICE in 2004. He is a member of IEICE.



Toshifumi Miyagi
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He received a B.E. and M.E. in electronic engineering from Shibaura Institute of Technology, Tokyo, in 1995 and 1997. He joined NTT Wireless Systems Laboratories in 1997. Since then, he has been engaged in R&D of WLAN access systems, fixed wireless access systems, and terrestrial fixed systems. He is currently involved in regulatory and standardization activities for wireless systems.

External Awards

Best Work-in-Progress Paper Award
Winner: Scinob Kuroki, Nobuhiro Hagura, Shin'ya Nishida, Patrick Haggard, and Junji Watanabe, NTT Communication Science Laboratories
Date: June 25, 2015
Organization: The Institute of Electrical and Electronics Engineers (IEEE) Technical Committee on Haptics

For "Asian Spice Sets Fingers Trembling."
Published as: S. Kuroki, N. Hagura, S. Nishida, P. Haggard, and J. Watanabe, "Asian Spice Sets Fingers Trembling," The 2015 IEEE World Haptics Conference, Poster: WIP-16, Chicago, USA, June 2015.

Kasami Award
Winner: Yuichi Sudo, NTT Secure Platform Laboratories
Date: October 6, 2015
Organization: Osaka University

For "A Study on Approaches for Stable Distributed Systems in Unstable Network Environments."
Published as: Y. Sudo, "A Study on Approaches for Stable Distributed Systems in Unstable Network Environments," Ph.D. thesis, Osaka University.

Innovative Technologies 2015
Winner: Takahiro Kawabe, Taiki Fukiage, Masataka Sawayama, and Shin'ya Nishida, NTT Communication Science Laboratories
Date: October 22, 2015
Organization: The Ministry of Economy, Trade and Industry (METI) of Japan

For the development of *HenGenTo*.
METI has selected 20 outstanding content technologies for Innovative Technologies 2015, which is part of the Program to Promote Innovation in Digital Content Technologies, aiming to promote their further utilization and development.
HenGenTo is a light projection technology that works by elucidating the principle of humans' liquid perception. Just by projecting a special light, you can make a still picture appear animated.

SCIS 2015 Innovation Paper Award
Winner: Mehdi Tibouchi, NTT Secure Platform Laboratories; Pierre-Alain Fouque, University of Rennes; and Tancrede Lepoint, CryptoExperts
Date: January 20, 2016
Organization: The Institute of Electronics, Information and Communication Engineers (IEICE) Engineering Sciences Society, Technical Committee on Information Security

For "Security Analysis of the Co-ACD Assumption and of Homomorphic Encryption Schemes Based on It."
Published as: M. Tibouchi, P. A. Fouque, and T. Lepoint, "Security Analysis of the Co-ACD Assumption and of Homomorphic Encryption Schemes Based on It," Proc. of SCIS2015 (the 32nd Symposium on Cryptography and Information Security), 3E4-4, Kokura, Fukuoka, Japan, Jan. 2015.

Kenjiro Takayanagi Achievement Award
Winner: Kunio Kashino, NTT Communication Science Laboratories
Date: January 20, 2016
Organization: The Takayanagi Kenjiro Foundation

For the research and development of audio, video, and other media analysis and search technologies.

Young Researcher's Award
Winner: Yasuhiro Teramoto, NTT Secure Platform Laboratories
Date: March 17, 2016
Organization: IEICE

For "Intrusion Path Prediction of Advanced Persistent Threat."
Published as: Y. Teramoto, B. Hu, T. Kishi, Y. Nagafuchi, T. Koyama, and H. Kitazume, "Intrusion Path Prediction of Advanced Persistent Threat," Proc. of Technical Committee on Information Networks, Osaka, Japan, Oct. 2015 (in Japanese).

Young Researcher's Award
Winner: Daisuke Kitayama, NTT Device Technology Laboratories
Date: March 17, 2016
Organization: IEICE

For "Study on Dependency of Hybridizing Modes on Structure of Layered-split-ring Resonators" and "Study on Split-ring-resonator-based Metamaterial Flat Lens at 120 GHz."
Published as: D. Kitayama, H.-J. Song, M. Yaita, and A. Hirata, "Study on Dependency of Hybridizing Modes on Structure of Layered-split-ring Resonators," Proc. of the 2015 IEICE General Conference, C-2-46, Kusatsu, Shiga, Japan, Mar. 2015 (in Japanese); D. Kitayama, H.-J. Song, M. Yaita, and A. Hirata, "Study on Split-ring-resonator-based Metamaterial Flat Lens at 120 GHz," Proc. of the 2015 IEICE Society Conference, C-2-25, Sendai, Miyagi, Japan, Sept. 2015 (in Japanese).

Young Researcher's Award
Winner: Hitoshi Wakita, NTT Device Technology Laboratories
Date: March 17, 2016
Organization: IEICE

For "Study on Compact Quad-channel Driver Module without Conical Coil."
Published as: H. Wakita, M. Nagatani, S. Yamanaka, H. Tanobe, and H. Nosaka, "Study on Compact Quad-channel Driver Module without Conical Coil," Proc. of the 2015 IEICE General Conference, C-10-5, Kusatsu, Shiga, Japan, Mar. 2015 (in Japanese).

IEEE James L. Flanagan Speech and Audio Processing Award
Winner: Takehiro Moriya, NTT Communication Science Laboratories
Date: March 21, 2016
Organization: IEEE

For contributions to speech and audio coding algorithms and standardization.

JSAP Silicon Technology Division Incentive Award
Winner: Jinichiro Noborisaka, NTT Basic Research Laboratories
Date: March 21, 2016
Organization: The Japan Society of Applied Physics (JSAP)

For "Electric Tuning of Direct-indirect Optical Transitions in Silicon."
Published as: J. Noborisaka, K. Nishiguchi, and A. Fujiwara, "Electric Tuning of Direct-indirect Optical Transitions in Silicon," Scientific Reports 4, Article no. 6950, 2014.

The Tingye Li Innovation Prize

Winner: Kohki Shibahara, NTT Network Innovation Laboratories
Date: March 22, 2016
Organization: Optical Society of America

For "Dense SDM (12-core × 3-mode) Transmission over 527 km with 33.2-ns Mode-dispersion Employing Low-complexity Parallel MIMO Frequency-domain Equalization."
Published as: K. Shibahara, T. Mizuno, H. Takara, A. Sano, H. Kawakami, D. Lee, Y. Miyamoto, H. Ono, M. Oguma, Y. Abe, T. Kobayashi, T. Matsui, R. Fukumoto, Y. Amma, T. Hosokawa, S. Matsuo, K. Saito, H. Nasu, and T. Morioka, "Dense SDM (12-core × 3-mode) Transmission over 527 km with 33.2-ns Mode-dispersion Employing Low-complexity Parallel MIMO Frequency-domain Equalization," Proc. of the 2015 Optical Fiber Communications Conference and Exhibition, Los Angeles, CA, USA, Mar. 2015.

2015 Technology of the Year Award

Winner: The METIS (Mobile and wireless communications Enablers for the Twenty-twenty Information Society) project
Date: March 22, 2016
Organization: Wireless Innovation Forum

For the development of 5G radio channel models.
The METIS is a European project whose objective is to lay the foundations for 5G, the fifth-generation mobile and wireless communications system, for 2020 and beyond. The METIS project's development of 5G radio channel models received the award due to its contribution to the future development of the next-generation mobile communications (5G) by developing a complete new set of radio channel models based on realistic end-user scenarios and requirements. These new models were studied by the METIS channel measurement and modelling group, which includes Anite (Chair), Ericsson, NTT DOCOMO, DOCOMO Euro-labs, Fraunhofer HHI, Nokia, Aalto University, University of Oulu, and Elektrobit.
Published as: V. Nurmela, A. Karttunen, A. Roivainen, L. Raschkowski, T. Imai, J. Järveläinen, J. Medbo, J. Vihriälä, J. Meinilä, K. Haneda, V. Hovinen, J. Ylitalo, N. Omaki, K. Kusume, P. Kyösti, T. Jämsä, A. Hekkala, R. Weiler, and M. Peter, "METIS Channel Models," METIS Deliverable D1.4, July 2015.

Excellent Woman Researcher Award of the Electrochemical Society of Japan

Winner: Nahoko Kasai, NTT Basic Research Laboratories
Date: March 30, 2016
Organization: The Electrochemical Society of Japan

For her research on nanobio-interfaces for detecting and controlling biological information.

Papers Published in Technical Journals and Conference Proceedings

Distributed Forests for MapReduce-based Machine Learning

R. Wakayama, R. Murata, A. Kimura, T. Yamashita, Y. Yamauchi, and H. Fujiyoshi

Proc. of ACPR 2015 (the 3rd IAPR Asian Conference on Pattern Recognition), Kuala Lumpur, Malaysia, November 2015.

This paper proposes a novel method for training random forests with big data on MapReduce clusters. Naive implementation of random forests on distributed systems easily overfits the training data, yielding poor classification performance. This is because each cluster node can have access to only a small fraction of the training data. The proposed method tackles this problem by introducing the following three steps. (1) Shared forests are built in advance on the master node and shared with all the cluster nodes. (2) With the help of transfer learning, the shared forests are adapted to the training data placed on each cluster node. (3) The adapted forests on every cluster node are returned to the master node, and irrelevant trees yielding poor classification performance are removed to form the final forests.

Experimental results show that our proposed method for MapReduce clusters can quickly learn random forests without any sacrifice of classification performance.

Neural Timing Signal for Precise Tactile Timing Judgments

S. Kuroki, J. Watanabe, and S. Nishida

Journal of Neurophysiology, Vol. 115, pp. 1620–1629, February 2016.

The brain can precisely encode the temporal relationship between tactile inputs. While behavioural studies have demonstrated precise interfinger temporal judgments, the underlying neural mechanism remains unknown. Computationally, two kinds of neural responses can act as the information source. One is the phase-locked response to the phase of relatively slow inputs, and the other is the response to the amplitude change of relatively fast inputs. To isolate the contributions

of these components, we measured performance of a synchrony judgment task for sine wave and amplitude-modulation (AM) wave stimuli. The sine wave stimulus was a low-frequency sinusoid, with the phase shifted in the asynchronous stimulus. The AM wave stimulus was a low-frequency sinusoidal AM of a 250-Hz carrier, with only the envelope shifted in the asynchronous stimulus. In the experiment, three stimulus pairs, two synchronous ones and one asynchronous one, were sequentially presented to neighboring fingers, and participants were asked to report which one was the asynchronous pair. We found that the asynchrony of AM waves could be detected as precisely as a single impulse pair, with the threshold asynchrony being ~20 ms. On the other hand, the asynchrony of sine waves could not be detected at all in the range from 5 to 30 Hz. Our results suggest that the timing signal for tactile judgments is provided not by the stimulus phase information but by the envelope of the response of the high-frequency-sensitive Pacini channel (PC), although they do not exclude a possible contribution of the envelope of non-PCs.

Mode and Polarization Division Multiplexed Signal Detection with Single Coherent Receiver Using Mode-selective Coherent Detection Technique

F. Hamaoka, S. Okamoto, K. Horikoshi, K. Yonenaga, A. Hirano, and Y. Miyamoto

Proc. of OFC (Optical Fiber Communication Conference and Exhibition) 2016, Th3A.6, Anaheim, CA, USA, March 2016.

We experimentally demonstrate that a single coherent receiver can successfully receive mode and polarization division multiplexed signals using the mode division multiplexed (MDM)-to-frequency division multiplexed signal conversion scheme based on our proposed mode-selective coherent detection technique to develop low-complexity MDM systems.

MineSpider: Extracting Hidden URLs behind Evasive Drive-by Download Attacks

Y. Takata, M. Akiyama, T. Yagi, T. Hariu, and S. Goto

IEICE Transactions on Information and Systems, Vol. E99-D, No. 4, pp. 860–872, April 2016.

Drive-by download attacks force users to automatically download and install malware by redirecting them to malicious URLs that exploit vulnerabilities of the user's web browser. In addition, several evasion techniques, such as code obfuscation and environment-dependent redirection, are used in combination with drive-by download attacks to prevent detection. In environment-dependent redirection, attackers profile the information on the user's environment, such as the name and version of the browser and browser plugins, and launch a drive-by download attack on only certain targets by changing the destination URL. When malicious content detection and collection techniques such as honeyclients are used that do not match the specific environment of the attack target, they cannot detect the attack because they are not redirected. Therefore, it is necessary to improve analysis coverage while countering these adversarial evasion techniques.

Millimeter-wave Close Proximity High-speed Data Transfer System

T. Nakagawa, H. Toshinaga, T. Tsubaki, T. Seki, and M. Shimizu

IEICE Communications Express, Vol. 5, No. 4, pp. 114–117, April 2016.

This paper presents the system concept, transceiver architecture, and control sequence for a millimeter-wave (60-GHz) band close proximity high-speed data transfer system. The communication range and the use cases are limited to achieve a fast link setup time and a stable point-to-point connection. Prototype equipment developed for the system includes three types of wireless transceivers; cooperative operation among them makes it possible to reduce the link setup time and limit the communication range. The system's control sequence enables the link setup time to be reduced from 7 seconds to 0.2 seconds.

A Strongly Coupled Λ-type Micromechanical System

H. Okamoto, R. Schilling, H. Schütz, V. Sudhir, D. J. Wilson, H. Yamaguchi, and T. J. Kippenberg

Applied Physics Letters, Vol. 108, p. 153105, April 2016.

We study a classical Λ-type three-level system based on three high-Q micromechanical beam resonators embedded in a gradient electric field. By modulating the strength of the field at the difference frequency between adjacent beam modes, we realize strong dynamic two-mode coupling, via the dielectric force. Driving adjacent pairs simultaneously, we observe the formation of a purely mechanical "dark" state and an all-phononic analog of coherent population trapping—signatures of strong three-mode coupling. The Λ-type micromechanical system is a natural extension of previously demonstrated "two-level" micromechanical systems and adds to the toolbox for engineering of all-phononic micromechanical circuits and arrays.
