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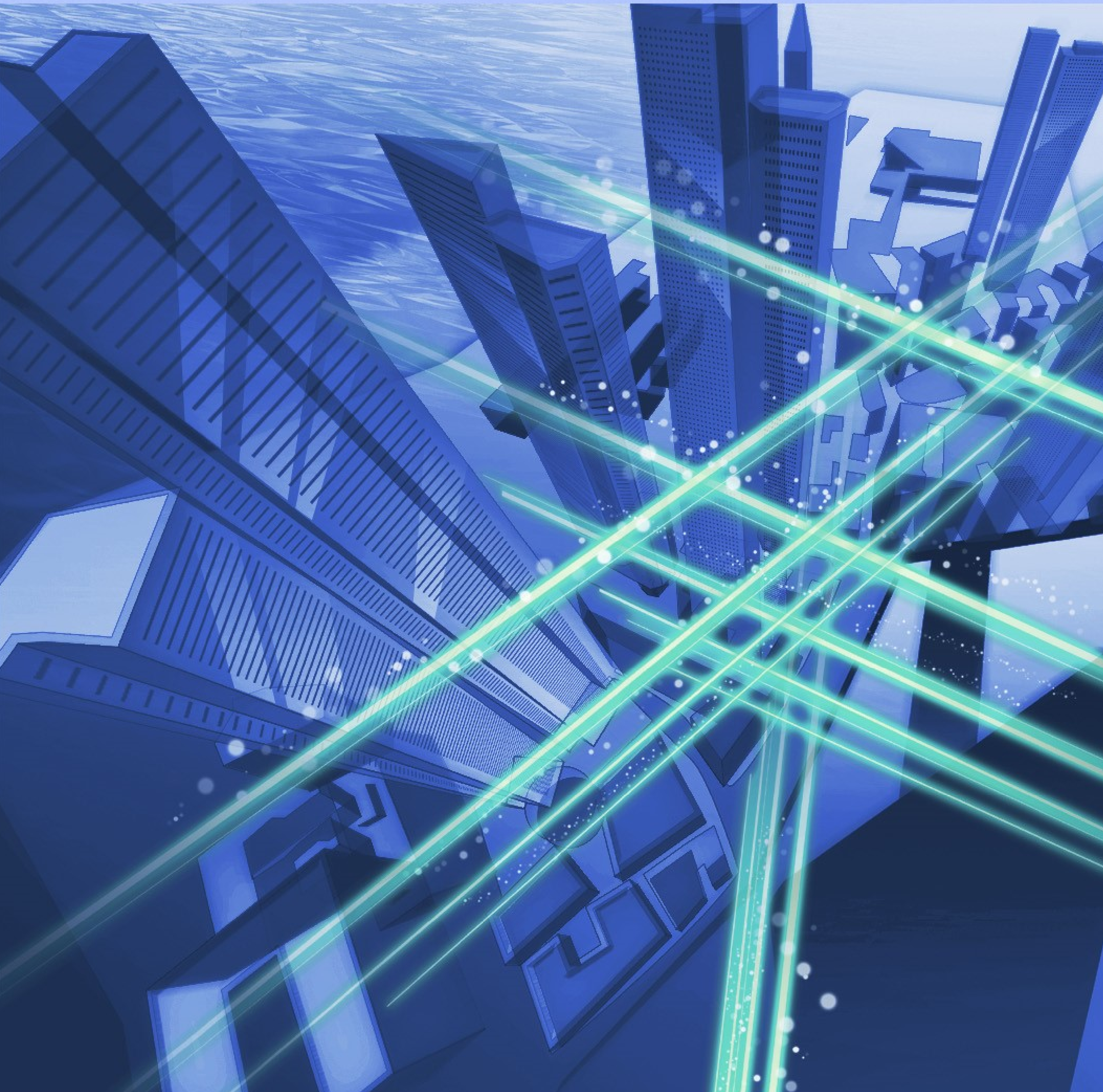

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Turning Crisis into Opportunity for Transformation: Understand the World and Discover Unknown Value

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Overview

NTT is promoting the Innovative Optical and Wireless Network (IOWN) to provide an information and communication technology infrastructure that brings about various benefits. The company is pursuing research and development of key technologies to implement IOWN in 2030. Now that the entire world has been hit by an unprecedented situation due to the coronavirus (COVID-19) pandemic, expectations for NTT's efforts based on its philosophy of contributing to society are growing. We talked with Katsuhiko Kawazoe, NTT Senior Vice President, Head of Research and Development Planning Department, about the attitude of his department—which ought to be called the "brain of NTT"—to tackle this crisis and the sense of value of NTT researchers.

Keywords: IOWN, social contribution, teleworking

No matter what happens, we must not use this crisis as an excuse for stagnant growth

—It has been more than two years since you were appointed head of Research and Developing Planning Department. How has the coronavirus (COVID-19) pandemic affected your initial plans?

I have been working for more than two years to strengthen our research laboratories and expand them globally. I think that we reached a major milestone when we announced the concept of the Innovative Optical and Wireless Network (IOWN) for continuous technological innovation. However, I never imagined that the whole world would be transformed in such a short term due to the coronavirus pandemic. In the midst of this whirlpool, people's values have changed drastically. Looking ahead to a society that has changed compared to before the pandemic, we are thinking about whether what we have planned should be changed and what we should prioritize.

At NTT, we are trying to ensure we do not use the effects of the coronavirus pandemic as an excuse, however, the global situation has changed completely in different ways such as economic stagnation and people participating in social activities at home. Under the current circumstances, we must consider the best contribution we can make to creating a new society in which people live happily. Depending on the theme, some research and development (R&D) might proceed toward its goal without influence from its surroundings, but since many research themes are for the sake of humanity, they are always influenced by the world in which we live.

After the 2011 Great East Japan Earthquake, we keenly sensed the powerlessness of humanity; however, the coronavirus pandemic has reminded us that humanity bears unknown risks. As you know, information and communication technology (ICT) is now an indispensable foundation of all industries; even so, current ICT is not always at its ultimate performance. The ability of ICT must be further improved so that it can confront unknown risks, including those in the medical field. I am currently asking all researchers at our laboratories to think what their research themes should be under the present situation and whether they should be changed. Now that society's values have changed, society is demanding change; accordingly, I want our researchers to think of the present situation as a time to reconsider the value of their research themes.

As one example of such changing values, in Japan, it has been said that we should reduce close contact with people by 80%. The important point is whether this effort can be proved to be effective and evaluated as a numerical value.

NTT DOCOMO's Mobile Spatial Statistics provides population dynamic statistics by region. Through this service, we can see daily changes in population surrounding major stations and other locations, and the service has been received positive feedback. However, it is preferable to provide not only statistical values but also information on the state of each population flow and the degree of closeness of people to one another. As a useful technology for navigation, NTT laboratories have developed a cloud-based GNSS (global navigation satellite system) that improves the accuracy of satellite-positioning systems by using cloud processing. Using this technology makes it possible to reduce positioning error, which used to be several meters, to the level of several dozen centimeters, which makes it possible to monitor the contact distance between people. Therefore, it is necessary to determine whether our technology can be extended to provide what society currently requires. However, such a reactive approach is not enough. As I mentioned earlier, the "after corona" era will bring new values. We must proactively consider how to grasp, understand, and respond to these values.

—You are promoting social contribution unique to NTT. Your mission is to carry on with your business under these difficult circumstances. What is your outlook?

We will surely see some fields in which we cannot succeed in the way we usually do business. An example of such a field is a business model involving understanding customer issues while engaging with them, and visiting customer premises to improve customer business or making new proposals. These activities will be reduced because it is difficult to create opportunities even during normal times. In contrast, the field of teleworking—which we are currently engaged in for this interview—is required by many people. However, a major issue is the rapid increase in traffic due to the sudden need for teleworking following the government's state-of-emergency declaration and stay-at-home request in Japan. Although the backbone network has sufficient capacity to withstand this need, it is sometimes the case that the quality of video and audio during important meetings temporarily deteriorates owing to processing limitations on servers. Under these circumstances, I believe that new business areas will be revealed to guarantee the quality of information communication infrastructure including video-distribution servers. In consideration of the pursuit of both convenience and economy, the most-important tool is the Internet, and the Internet of Things is a prerequisite for new fields. I also assume that many people have realized that the quality of the Internet is not uniform in this current situation. I strongly feel the need to tackle this issue as a business. I do not necessarily mean that NTT should make a profit; instead, I think the attitude of promoting social contribution is important.

The need for IOWN has accelerated

—In this social situation, how will the medium-term management strategy be implemented? In particular, tell us about NTT's initiative concerning IOWN and response to the sports events that have been postponed.

In May 2019, we proposed the concept of IOWN [1] for envisioning what society should be toward 2030 and promoting technological development within NTT to create that society. In April 2020, we announced a concrete roadmap [2]; however, society has rapidly changed since then, and technology that responds to this rapid change is being increasingly demanded. To meet that demand, the trend to develop technology for IOWN is accelerating. Recently, I have often been saying, "Let's aim for disruptive innovation." Since current technological development involves pursuing further upgrading of existing ICT, it has its limits. It is limited because the technology on which it is based—that is, an extension of conventional technology—is limited. Researchers have little courage to step up and change the base technology. In other words, they are conducting R&D only on the themes that are based on conventional technology. According to the concept of IOWN, in contrast, researchers are encouraged to disrupt conventional technology. We plan to promote many research themes that have been created to actualize IOWN.

Similarly, major changes will be required in response to the sports events that have been postponed. The needs of the audience and the feelings and expectations of society concerning these events will change significantly. If we consider our ultra-realistic communication technology called Kirari!, which enables you to experience the sense of being at a competition venue from a remote place in real time, the original premise of conveying that sense of presence will be broken unless the audience gathers at the venue. The key to suppressing the spread of the coronavirus is to disperse a group of people instead of having them gather. Accordingly, by developing technology to enable people to enjoy an event even if they are separated, we should be able to create new technology and value. It would be ideal if many international spectators will come to visit Japan next year; unfortunately, fear of the coronavirus may make people reluctant to visit. However, even under these circumstances, we must strive for success, and I think we must not misunderstand what we call "success." If we approach this event with conventional viewpoints, we may miss an opportunity for success.

—I understand that it is time to change our values in business. Do you have experience in transforming your values?

Yes, I do. Many events in my life have had a great impact on my values. For example, when I was a young child, I went with my parents to live in New York. There, I suddenly found myself at a school—surrounded by people who were non-Japanese—with a completely different culture to the one I knew. Looking back, I realize now that I was able to experience different cultures in a completely unknown world, learn about diversity, change my values, and learn ways to survive. Although that childhood experience caused the most significant change in my values, the most recent one is the present coronavirus pandemic. In this crisis, our top management encouraged us to find various possibilities for the company and employees. I feel that this crisis presents a great opportunity for our laboratories. However, we need a considerable amount of readiness in mind. To take advantage of this opportunity, we need to be prepared to throw away everything we have. Starting something new involves a lot of risk, so we are experiencing a major transformation during which we must proceed with determination to face that risk. People may be happy with the status quo, they may not like to take risks, or they may fear risk and avoid it. I think we can keep up with new transformations by turning risks into opportunities without fear.

If you draw the future, the past will be rewritten

—What is crucial when making an important decision?

If you climbed to the eighth station (of the ten) of Mt. Fuji, but you foresee a serious risk ahead, you will have to make a very difficult decision: either discard the hard work up to the eighth station or face the risk and carry on. When faced with such a situation, we would look back to learn from the past and think of ways to avoid risks wherever possible. However, I think we have entered an era in which such thinking alone does not work. Thinking chronologically, namely, about the past, present, and future (in that order) has limitations: new incidents are dealt with each time they occur and are connected in a piecemeal fashion, so situations in which the future cannot be fully predicted will continue. In the metaphor of climbing Mt. Fuji, being at the eighth station, you are in a situation in which you cannot make the best decision. This is converted from a chronological way of thinking into a non-chronological way of thinking, namely, considering the future, present, and past (in that order). In other words, we imagine the future, think about the present, and sometimes change our interpretation of the past. Perhaps some people imagine that it would be unfortunate to give up climbing the mountain and descend from the eighth station, which they struggled to reach. However, they might have been happy because they descended the mountain. Thinking non-chronologically can change our value judgments made in the past. I think this kind of thinking may bring happiness to people.

People tend to think of happiness as something instantaneous; in reality, however, I think that happiness is accumulated from the past into the future and that it is important to accumulate the moments of feeling happiness. I also think we should provide our research and technology to foster happiness.

—What do you think is required of the Research and Development Planning Department?

The R&D activity that I am in charge of does not make profit directly; in fact, it leads to costs. However, it is also true that R&D activities can cultivate the next growth engine for a company. Business activities are always focused on cost-effectiveness and efficiency. For example, Google is spending trillions of dollars to develop artificial intelligence, but cost efficiency and cost effectiveness are required in that development. In the same way, even though the NTT Group has different business domains for each company and department, it is necessary for the Group as a whole to consider cost-effectiveness, reduce waste, and efficiently engage in corporate activities.

In that sense, I think that the Research and Development Planning Department is one of the departments that thinks about efficiency most and bears the expectations concerning the future of technology that has been researched and developed with high cost. I feel a great responsibility for allowing us to continue R&D activities despite the fact that the NTT Group is facing a difficult situation in terms of profitability due to the coronavirus pandemic.

When I look at society as a whole, I wonder if the current research themes should be pursued. I think it is necessary for researchers to recognize this social situation fully and to seriously carry out their research in light of the values of the NTT Group as a whole. I am convinced that if we fully understand this situation and implement our R&D accordingly, we can contribute to society through our operating companies.

I think all our researchers should take this opportunity to remember why they became researchers in the first place and return to their starting point. In a sense, researchers are a “special” profession. I guess that when you first started your career as a researcher, you must have determined to contribute to society after receiving research funding. I want you to go back there. If there are people nearby who are only thinking about making money, you may be tempted. However, if you are true researchers, your determination and aspirations in your early days should not be altered.

If close contact between people must be reduced by 80%, increase online contact by 80%!

—You look at the positive side in everything. Tell us the positive aspects you found through teleworking.

I think that there are things we can do because we are being asked to refrain from going outside. As I said in a previous interview, one of my hobbies is cooking. I enjoy going to my favorite market and purchasing fresh fish to cook; however, I cannot go out freely now, so I am trying to devise recipes under limited conditions. I am enjoying using my imagination because I can use my time more efficiently than ever before. Many people are worrying about how long this situation will last and that most things will end up being done at home. As I feel with my cooking, people might be feeling their limit in doing things and may get stuck. In such a case, it is important to think positively about the situation in a manner like how to find the next challenge. Therefore, I thought that if we have to reduce close contact between people by 80%, let's increase online contact by 80%! At a time like this, I think we can take the opportunity to meet online people that we have not been able to meet easily. By finding many people we want to meet and meeting more and more of them online, we can exchange information and deepen our connections. In the past, it was sometimes necessary to meet people face-to-face, but that constrain has now been removed. There is no way we cannot take advantage of this opportunity. I think that possibilities will multiply if we change our perspective slightly in the way I described above.

References

[1] Website of NTT R&D, What's IOWN?, https://www.rd.ntt/e/iown/0001.html

[2] Press release issued by NTT, "Technology Development Roadmap for Realizing the IOWN Concept," Apr. 16, 2020. https://www.ntt.co.jp/news2020/2004e/200416a.html

Interviewee profile

■ Career highlights

Katsuhiko Kawazoe joined NTT in 1987. He became vice president of Research and Development Planning Department in 2008, head of NTT Service Evolution Laboratories in 2014, and head of NTT Service Innovation Laboratory Group in 2016. He became senior vice president, head of Research and Development Planning Department in June 2018. He has also served as director of NTT Research, Inc. since April 2019 and president and chairperson of IOWN Global Forum since January 2020. He received a Ph.D. in engineering.

Aiming to Be the World's Top Cryptography Laboratory

Tatsuaki Okamoto
NTT Fellow, Director, Cryptography & Information Security Laboratories, NTT Research, Inc.

Overview

Information and communication technology is used in all types of business activities, and expectations concerning security and reliability of cryptography—which is key to information security measures—are increasing. We asked Dr. Tatsuaki Okamoto, an NTT Fellow who spearheads the Cryptography and Information Security Laboratories (CIS Labs) of NTT Research, Inc., employing top scientists in cryptography and blockchains, about the progress of CIS Labs and his attitude toward being a distinguished researcher.

Keywords: cryptography, blockchain, attribute-based encryption

Forming a dream team in cryptography research that can be done only in the USA

—Please tell us what you are currently doing.

As the director of the Cryptography and Information Security Laboratories (CIS Labs) of NTT Research, Inc., I work mainly in management. The last time I appeared in this column, I was talking as a researcher; this time, I'm talking from a management perspective. That is, regarding themes such as cryptography and blockchain we are working on at CIS Labs and what kind of research institute NTT Research is.

Although NTT Research was launched in July 2019, we had been preparing long before that. Since we were starting from scratch, I was particularly focused on gathering people and building an organizational system during the six months before the opening of NTT Research. Prior to the launch, in 2018, when I was asked to work there in my research field of cryptography, I wanted to do something that could not be done in Japan and could only be done in the USA. First of all, we needed to recruit human resources, and the Bay Area attracts many well-known and outstanding people from around the world. Taking advantage of this, our goal is to establish the world's top cryptographic laboratory by gathering people who are active in cryptography to create a "dream team."

—What was your plan for forming a dream team?

What we should focus on in this research field is an important strategic issue. I chose core cryptography and blockchain as research themes and decided to promote them at a respective ratio of 7:3. Starting around the end of 2018 with a focus on those themes, we began to recruit researchers, and as of February 2020, ten people have joined. In cryptography, we have six prominent researchers, led by Dr. Brent Waters, and in blockchain, we have four outstanding researchers, led by Dr. Shinichiro Matsuo, who is also researching at Georgetown University. However, there are many places to work such as startups and venture companies regarding blockchain. People are inevitably attracted to those places, and few want to do basic research. As a result, we have some difficulty in securing human resources in that field.

Although the laboratories have opened, our recruitment activities are ongoing. A new top researcher in cryptography joined us in March 2020. Taking a long-term perspective, we plan to hire more human resources. Many outstanding researchers are not in a situation where they can immediately join us when we invite them. For example, if they work at a university, they cannot retire immediately and enter our laboratories, even if they want to. In consideration of the circumstances of each researcher, we are making arrangements for researchers working at universities to be affiliated with CIS Labs concurrently. Then, as soon as their situation allows, they can pivot towards our laboratory.

We are in an era in which we can work remotely from anywhere in the world; even so, our colleagues are gradually settling here in the Bay Area. NTT Research will reach its first year of operation in the summer of 2020 and it is evolving considerably. We are making steady progress toward achieving my plan.

Take on big strategic challenges

—What are your goals in cryptography research?

The conventional encryption method is based on the concept of putting something that would be troublesome if seen by other people into a kind of 'safe' (encryption), sending it in this manner, then removing it from the safe on the receiver side by using a key (decryption). However, if you try to delete spam mail from the encrypted mail you want to receive, for example, it is necessary to detect and delete the spam mail on the server when it is on its way to you. For that reason, the server decrypts the encrypted email (opens the lock with the key), checks the content of the email, detects and deletes any spam mail, and re-encrypts the email (i.e., puts the messages back in the safe and locks it). In other words, the server (a third party) has a duplicate key for the safe, so in that sense, the role of encryption between the sender and receiver is lost. To put that the other way around, the security of such encryption systems faces various restrictions (including usage).

In contrast to the conventional method described above, the concept known as attribute-based encryption (ABE), or more generally, functional encryption, was pioneered by CIS Labs' Dr. Waters about 15 years ago (**Fig. 1**). As a result, in the above-described example, only the information necessary for detecting and deleting spam mail can be extracted from the encrypted email, without decrypting the encrypted data on the server, and it is possible to detect and delete the spam mail based on that information.

As this new concept of cryptography emerges, to develop highly functional cryptography that has been proven secure under standard assumptions, we are conducting research on (i) methods of conversion from weaker security to desirable security; (ii) design of various cryptographic protocols and security proofs; and (iii) encryption methods based on the learning with errors (LWE) assumption.

I'll now introduce some of our efforts. The chosen-ciphertext security (indistinguishability under chosen-ciphertext attack: IND-CCA) is a class of the strongest security for ciphers with a higher level of security than that of chosen-plaintext security (indistinguishability under chosen-plaintext attack: IND-CPA), which is easier to achieve. For ABE, we recently showed that any IND-CPA-secure ABE can be converted to an IND-CCA-secure ABE by using a new method called hinting pseudorandom generator (PRG). As a result of this finding, we aim to (i) create a faster and more compact hinting PRG by using number-theory techniques and (ii) establish an IND-CCA conversion method that can be applied to general functional cryptography and re-randomized cryptography (**Fig. 2**).

The LWE assumption has been widely accepted as a strong assumption in cryptography in relation to, for example, quantum-resistant security and the worst-case lattice problem, and has seeded many methods for creating new cryptographic functions. Accordingly, we have a new ambitious goal of constructing cryptosystems based on the LWE assumption. We first consider a new concept, that is, obfuscating a pseudo-random function (PRF), and its application. We then show how to build witness encryption from the LWE assumption. As an intermediate step between those two steps, we are constructing a 'restricted PRF,' and in that process, we are trying to find new methods (and their limitations) for

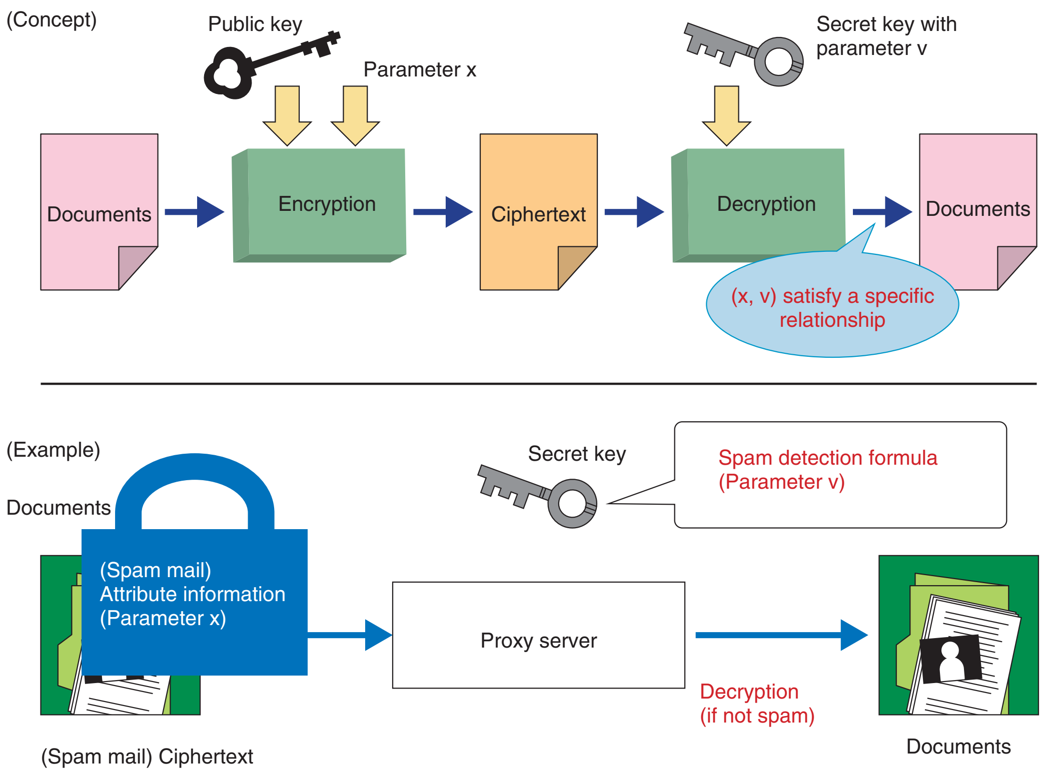


Fig. 1. Attribute-based encryption (functional encryption).

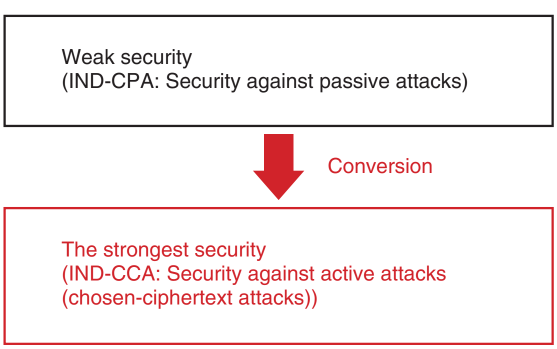


Fig. 2. Converting weak security into desirable security.

achieving adaptive security with LWE-based ABE.

—What about in the blockchain field?

We are focusing on fundamental research to achieve a major goal of research and development (R&D) on blockchain, namely, create an environment in which anyone can freely develop applications that use programmable and shared ledgers (**Fig. 3**).

Bitcoin and blockchain have become hot topics, so it may seem that the time of their widespread adoption is coming soon. However, achieving the above goals is a huge challenge and requires long-term basic and theoretical R&D. To meet that challenge, we are researching (i) secure and more-scalable distributed consensus algorithms, (ii) creation of a secure programming environment for programmable ledgers, and (iii) implementation of privacy protection when information is processed on the blockchain.

Because theoretical research on blockchain requires exquisite combinations of research fields, it is necessary to form a team of researchers with different specialties. Moreover, research on blockchain must be conducted strategically. As I mentioned before, it is difficult to secure outstanding researchers because they tend to flow towards ventures and startups. My team has just started up, so we need to strengthen our human resources. Although my team is composed of researchers with expertise in security of cryptographic protocols, software engineering, formal verification, game theory, and economics, I plan to recruit more researchers with different specialties.

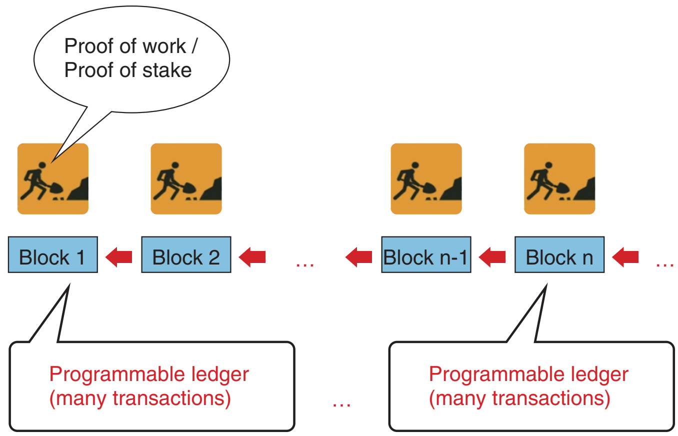


Fig. 3. Programmable public ledger by blockchain.

The only way to be recognized is to achieve results as a researcher

—Where do you look when identifying talented people? In other words, could you tell us how to impress you from the applicant's viewpoint?

I don't think researchers need to impress us by any means other than their achievements. In academic societies in which professional researchers in certain fields gather, outstanding researchers evaluate each other. For example, Dr. Waters of the cryptography team is a world-leading researcher, and he knows a lot of excellent researchers in all aspects of the field, including key figures and young researchers. Current team members were also recommended by him. Although some researchers have heard rumors about us and promoted themselves during the six months since our establishment, we basically do not take on self-recommended people; instead, we hire people who have outstanding achievements and abilities in certain research fields. Dr. Matsuo of our blockchain team is also familiar with talented people in that field, and we welcome researchers on his recommendation. Even in the case of young student researchers about to receive a doctorate, their research achievements have something that shines differently from those of others, so we can find them. In other words, I don't think there is any other way to attract us other than achieving results as a researcher.

—What are you aware of when searching for research issues or themes?

I'd like to make the most-important issues in my field of study into research themes. Those issues should determine the direction of the research field as well as interest me. When involved in discussions while collaborating in research with various people, we may discover new themes together. At such times, even if someone rates a topic as interesting, I don't necessarily want to make it a research theme if I don't find it important. However, there are many different cases, and topics that did not seem so important at first consideration can later become central themes. Although selecting themes can be difficult, basically, a good researcher has a good sense, so I think that you can often select themes based on that sense. As I said in my interview ten years ago, in a nutshell, these themes are the tastes of the researchers. In the case of the arts, taste is like an aesthetic sense, and what we are waiting for in our research is a kind of intuition that determines whether we are in a fruitful place or the wilderness.

No matter where you are, aim for something original, not an imitation

—What is your vision for the future?

As a team, we aim to be a world-class group of researchers recognized by both ourselves and others. I think we are pretty close to the top, but I want to make sure we are. I want us to receive accolades such as a major award that proves the achievements of each researcher. Since cryptography is a field of computer science, it is not subject to the Nobel Prize. Therefore, one of our goals is to win the Turing Award, which has been declared the Nobel Prize of computer science. I want us to win this award to build our reputation to make it clear that NTT Research is a research institute with globally prestigious award-winning researchers.

As an individual, I'm working on something as my lifework. The world is complicated. For example, life forms are very complex. It is also known that the universe has evolved from a simple form immediately after the Big Bang to its present complex form. In regard to things that are said to be complicated in this world, I want to take a unified perspective as a kind of science. Although the research field of complexity science has been around more than 30 years, as an extension of that field, I want to put out something that is theoretically exact. I'm 67 years old. I don't think that my management job can go on for much longer, but I want to continue working as a researcher for a little longer.

—Please say a few words to our young researchers.

Working outside of Japan, I have the image that Japan is shrinking slightly. In the 1980s, Japan experienced an economic bubble, so "Japan as number one" was often heard; however, Japan today has less presence in the world. Companies like the GAFA (Google, Apple, Facebook, and Amazon) in the information technology (IT) industry spend more than 10 times more on R&D than NTT. Under such circumstances, if Japanese companies simply repeat the way of doing things that has been successful in the past, it may not be possible for them to make their presence felt much globally. Currently, even the most successful IT companies in Japan have little presence around the world. Therefore, how can we make our presence felt? We are just running around in small circles if we just focus our activities in Japan, so we are taking the initiative through global endeavors at NTT Research. It is important to create something original, not an imitation. I feel that Japanese venture companies often imitate others. You have to have the spirit to create something unique. In this era, since we are all online, you ought to be able to do what can be done in Silicon Valley or Tokyo (or in any region of Japan). I want you to turn your perspective toward the world and create original ideas with the spirit that this is second to none.

■ **Interviewee profile**

Tatsuaki Okamoto

Director, Cryptography & Information Security Laboratories, NTT Research, Inc.

He received a B.E., M.E., and Ph.D. from the University of Tokyo in 1976, 1978, and 1988. He has been working for NTT since 1978 and is an NTT Fellow. He has been a director of NTT Research in USA since 2019 and engaged in research on cryptography and information security. He served as president of the Japan Society for Industrial and Applied Mathematics (JSIAM), director of International Association of Cryptology Research (IACR), and a program chair of many international conferences. He received the best and life-time achievement awards from the Institute of Electronics, Information and Communication Engineers (IEICE), the distinguished lecturer award from the IACR, the Purple Ribbon Award from the Japanese government, the RSA Conference Award, and the Asahi Prize.

Approach to Cognitive Foundation® for the Innovative Optical and Wireless Network (IOWN)

Katsuyuki Hasebe, Daisuke Aoki, Yusuke Kusakabe, Makoto Kanzaki, Ichiro Kudo, and Takashi Ikebe

Abstract

There is an urgent demand for information and communication technology (ICT) to meet the needs of industrial and social systems. These systems include the management of rapidly increasing devices and diverse digital services. In this article, we introduce NTT Group's approach to fully automated, autonomous, and self-evolving life-cycle management of ICT resources, including the deployment and optimization of such resources, to provide applications and solutions.

Keywords: Cognitive Foundation, Multi Orchestrator, IOWN

1. Introduction

In the era of fifth-generation mobile communication systems (5G) and the Internet of Things (IoT), almost any device can be connected to the Internet. This means that not only will it soon be possible to efficiently collect and store large volumes of digital data, but through artificial intelligence (AI), advanced analysis and prediction contributing to work efficiency and productivity will also become possible.

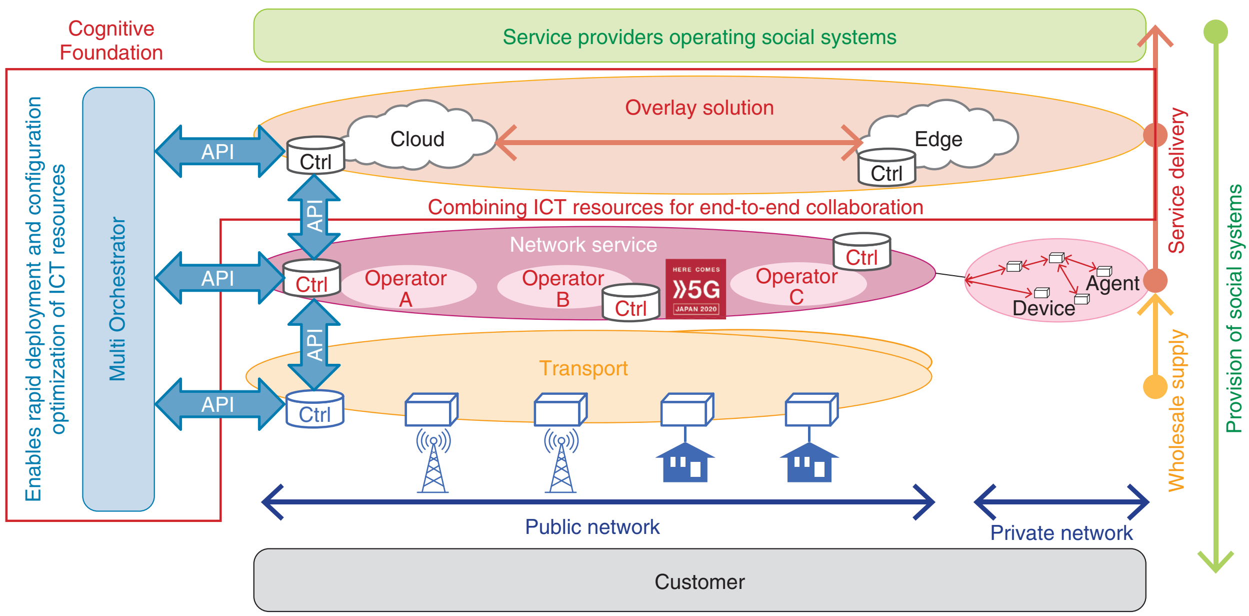
There are high expectations for digital transformation (DX) to resolve social issues such as the reduction in birth rates, aging society, shrinking working population, and increase in natural disasters. The NTT Group is promoting the business-to-business-to-X (B2B2X) model, which will create new value for end users by supporting service providers (second B in B2B2X) in a variety of fields to meet the demands of those users.

In these Feature Articles, we introduce the concepts promoted by the NTT Group, the technology that enables these concepts, and the current approaches to achieve these concepts.

2. Cognitive Foundation®

Cognitive Foundation® (CF) is a concept for integrally optimizing deployment and configuration—such as building, configuration, management, and operation—of information and communication technology (ICT) resources[*1] to provide applications and solutions. ICT resources include not only cloud and network services, such as platform as a service (PaaS), infrastructure as a service (IaaS), and software-defined network (SDN), but also ICT resources owned by the second B. In the past, ICT resources have been siloed by each application and solution, requiring separate life-cycle management for optimizing deployment and configuration of such resources. Recently, use cases requiring advanced distributed collaboration in edge computing and hybrid cloud have increased. ICT resource life-cycle management tends to be continuous and complex and is a huge burden for the second B, which provide social systems, to focus on developing and providing

*1 ICT resources: Computing resources in multiple domains and multiple layers supporting applications and solutions provided by the second B. This includes central processing units, graphics processing units, and memory comprising various services.



API: application programming interface
Ctrl: controller

Fig. 1. Cognitive Foundation® and three-layer network model.

applications and solutions. CF enables the second B to focus on their core businesses by rapidly optimizing deployment and configuration of ICT resources in a multi-domain*2, multi-layer*3, and multi-service/vendor environment. It will also make such optimization fully automated, autonomous, and self-evolving in the future (**Fig. 1**).

3. Multi Orchestrator

CF is composed of two elements. The first is ICT resources, as described in the previous section. The second is the Multi Orchestrator (MO), the key technology of CF. The MO, requested by the second B, provides integrated optimized deployment and configuration of a wide variety of ICT resources, thus achieving CF.

The MO is composed of the following three function groups that can communicate via an application programming interface (API).

(1) Orchestration function group: An adaptor group that can convert commands that are suitable for the workflow engine and for each ICT resource.

(2) Management function group: A group that includes configuration and design information based on the standard model.

(3) Intelligent function group: An AI group that continually optimizes ICT resources, from design, configuration, and testing to operation, independently.

According to our research, there are currently no comparable products that incorporate all three function groups. Regarding groups (2) and (3), in-house development is progressing together with applications for technical patents as a source of competitiveness to differentiate from other companies' products. Basic development of the three function groups will be completed in FY 2019. NTT Communications will continue to enhance and advance the functionality of the MO to make CF concept a reality.

There are currently smart city initiatives in Las Vegas City, USA, to represent CF. There are several other proofs of concept (PoCs) going on in parallel. We will continue to work on initiatives to create a smart world such as smart factories, smart healthcare, and smart sports.

*2 Multi-domains: Physically distributed locations such as cloud services, own/other company datacenters, and network edge servers.

*3 Multi-layers: Virtualized ICT resources such as IaaS, PaaS, and SDN, in overlay solutions, as well as wired and wireless network services and transport networks that support them.

4. IOWN

CF is also an important initiative in terms of the innovative optical and wireless network (IOWN). IOWN is an initiative for future communications infrastructure introduced by the NTT Group in 2019. IOWN is aimed at resolving technical issues to facilitate sustainable growth. One such issue is the stagnation in the evolution of semiconductors. Another issue involves the increase in power consumption due to the vast volume of data processed with IoT, big data, and AI. The NTT Group is addressing these issues through research initiatives, changing from existing signal processing using electronics technologies to processing using photonics-electronics convergence technologies with which optical technology is incorporated on-chip. In April 2019, NTT announced the development of a highly efficient optical transistor [1]. This transistor consumes the least amount of energy during operation when compared to any other type of transistor. Additionally, Intel, Sony, and NTT have established the IOWN Global Forum [2] in the United States. This forum is an international initiative to promote photonics-related research and development (R&D), specifically, technologies that use photonics-electronics convergence. Optical semiconductors using photonics-electronics convergence technologies are the basis of IOWN and are expanding the capabilities of applications that support terminals, devices, and networks.

IOWN consists of three elements: 1) The All-Photonics Network, in which photonics technology is deployed in all areas, from the network to terminals; 2) Digital Twin Computing, which enables future predictions by combining information gathered from the real world and digital world; and 3) CF, in which all things/devices are connected and controlled.

CF, as previously described, is a framework for the centralized execution of the construction, configuration, and operation/management of ICT resources, which includes user resources. With CF, it is possible to optimize the rapid allocation of ICT resources and ICT resource allocation in a multi-domain, multi-layer, and multi-service/vendor environment. Toward the realization of IOWN, we are evolving CF into a platform on which further automated, autonomous, and self-evolving network management and AI platform and data management are possible. In terms of the former, we are engaged in R&D to evolve from the level of predictive maintenance of a single system for abnormality detection based on deep learning toward an optimized wireless connection through multi-wireless control technology, automated operation of wireless systems, and self-evolving operation of systems. In terms of the latter, there are initiatives with regard to AI platforms to support the estimation, prediction, and optimization of vast quantities of data in real time. These initiatives also support low latency and safe distribution of sporadic data. CF must also combine a variety of resources safely, so we are researching and developing security technology to support that.

5. Public safety solution initiative in the City of Las Vegas, United States

Based on the B2B2X model, the NTT Group is working to create a smart world that includes smart cities, factories, healthcare, and sports. We now introduce the smart city (public safety solution) initiative implemented as CF in Las Vegas.

5.1 Social issues required for public safety solution

With the recent increase in the number of situations associated with crime and disasters in urban areas, it has become increasingly important for local government, police, fire departments, and other relevant authorities to understand the crowd movements, traffic status, and emergencies occurring in downtown districts of urban areas and event venues where people gather and protect the safety of citizens.

To achieve a shorter initial response time from the relevant authorities, in addition to rapidly grasping the current status through the allocation of multiple sensors, there is a necessity to establish a public safety solution to assist with predicting and analyzing incidents with a high occurrence rate in advance.

5.2 Public safety solution in the City of Las Vegas

Concerning such social issues, starting from September 2018, the NTT Group along with the Dell Technologies Group deployed high-definition video cameras, acoustic sensors, and IoT devices in the Innovation District in the downtown district of Las Vegas and collected and analyzed the information for relevant authorities of Las Vegas to recognize situations on the field. To create economic opportunities, verification of a data-management platform for traffic management is being conducted jointly with Las Vegas. The three main points related to these joint smart city PoCs (**Figs. 2, 3**) are outlined below:

(1) CF: Enable rapid and optimized deployment and configuration of ICT resources in a

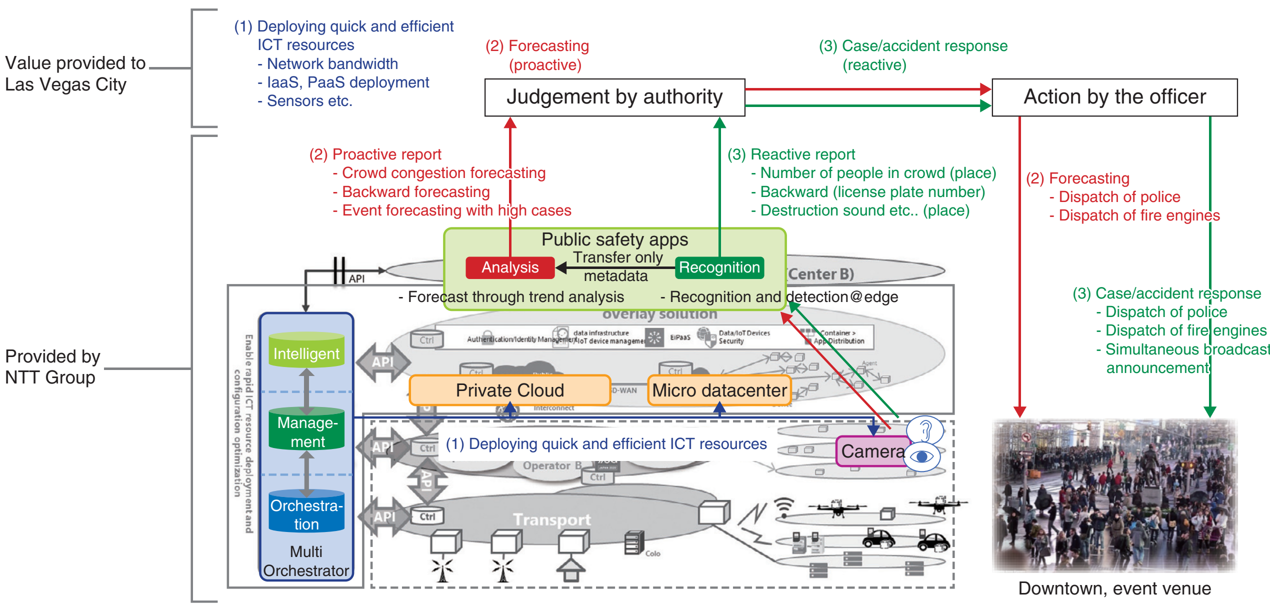


Fig. 2. Public safety solution in Las Vegas.

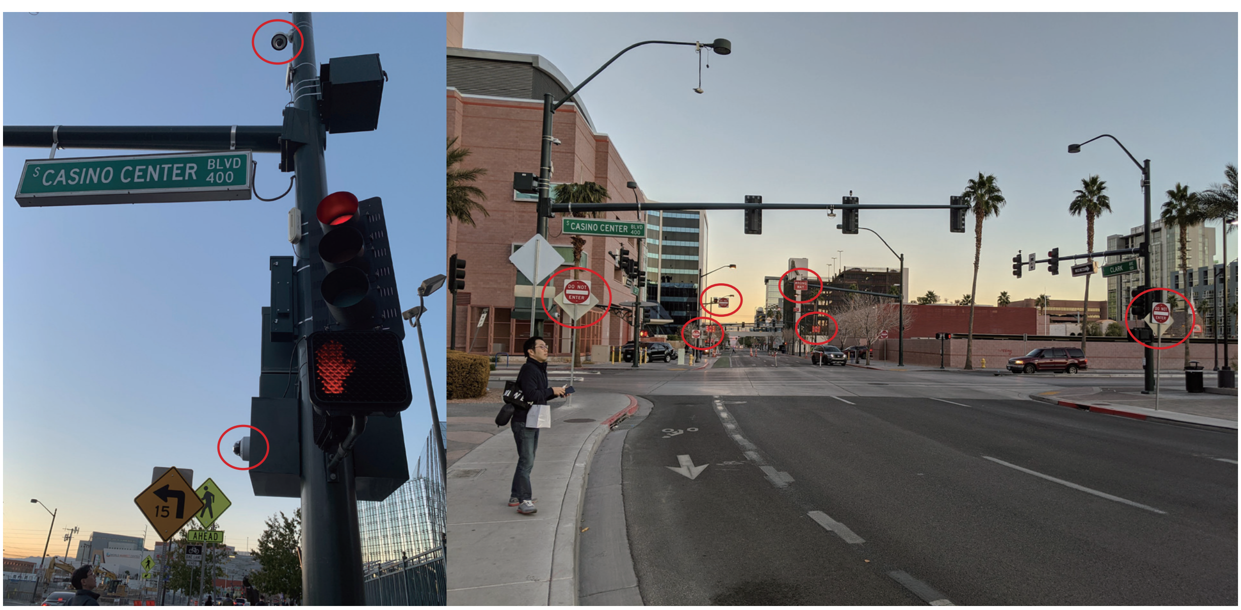


Fig. 3. Video cameras and road signs in the Innovation District of downtown Las Vegas.

multi-domain environment. We distributed the analysis environment in a micro datacenter (Edge) near the sensor and in the customer datacenter (Core). We promptly and remotely created and deployed ICT resource configuration in which only the results obtained through the analysis in the Edge and the data required for further analyses are transferred to the Core.

(2) Proactive reports (trend analysis): Predict the seriousness of a situation and its potential as an even more serious incident. We collected

the data obtained from different types of sensors, comprehensively used information such as movement and volume of crowds, traffic conditions, and sounds associated with incidents with high occurrence rates, such as gunfire and screams, in the vicinity, as well as climate data and social-networking-service (SNS) information, to carry out advanced trend analysis through the "corevo®" AI technology developed by the NTT Group.

(3) Reactive reports (edge detection): Enable prompt recognition and reporting of the relevant information to the authorities after an incident occurs. Specifically, we used the aforementioned AI technology in the Edge near the sensors to constantly monitor crowd movements and volume, as well as movements of dangerous vehicles, to identify known criminals and stolen vehicles through facial recognition and image analysis and analyze the surrounding situation, including sounds associated with incidents with high occurrence rates by detecting these sounds in the Edge.

As a result of these PoCs, by monitoring and analyzing roads, such as one-way roads where reverse driving frequently occurred, the reasons of such behavior were elucidated such as road signs being difficult to view or the paint on a road beginning to disappear. In Las Vegas, a wide variety of preventative measures have been undertaken based on the results of such analysis.

5.3 Future developments

In December 2018, based on the results of these PoCs, NTT, the State of Nevada, and City of Las Vegas agreed to advance and accelerate the smart city solution. In February 2019, the NTT Group (NTT, NTT DATA, Dimension Data, NTT Communications, NTT Comware, and NTT Security) started a commercial provision of the smart city solution in Las Vegas, and the solution has been further expanded by using The International Innovation Center @ Vegas (IIC@V) [3], which is located in the downtown area. The NTT Group is also cooperating with the city to expand the functions of the solution and provide it to other cities. Moving forward, we plan to collaborate further with our partners to globally distribute smart world solutions based on CF to achieve promote the smart world in other states and cities in the United States, as well as the Asia-Pacific and EMEA (Europe, the Middle East, and Africa) regions.

6. "Cradio" for Optimizing Wireless Access

CF is also closely related to wireless access, which corresponds to the "W" in IOWN. Various access systems are currently used. The situation will become even more complex by using not only 4G/LTE (Long Term Evolution), but also using satellite communications, Wi-Fi, WiMAX, low power wide area (LPWA) for IoT, 5G, and local 5G. We are engaged in R&D on Cradio technology, which is intended to optimize wireless access in a variety of usage scenarios without regard to the type of wireless communication method or particular network service. This can be done based not only on location but also on quality and congestion predictions. For example, if a person urgently needs to send information to another person in an area with low Wi-Fi throughput, Cradio selects the optimal wireless access with regard to the network side and controls the connection. With CF, we plan to incorporate a wireless technology that can be used to establish wireless access according to the location, application, and environment without the necessity to consider a system or business operator. For further details, refer to the article "Quality-prediction Technology for Optimal Use of Multiple Wireless Access Networks" in this issue [4].

7. Evolution into a self-evolving operation

The considerable damage caused by typhoons in 2019 that hit Japan resulted in extensive damage to telecommunication services. To provide a reliable telecommunication infrastructure, the NTT Group has been engaged in R&D focused on developing a technology for predicting damage by using AI on the basis of the logs issued by devices and taking appropriate preventative measures. The information that cannot be perceived simply by monitoring network devices, including meteorological information, such as ferocity of a typhoon and its path and event hosting information, can also be incorporated into CF to enhance preventive measures. For example, we plan to develop a system that is able to analyze and optimize the current situation based on the newly collected information, so that preventative measures can be defined and executed before the damage occurs. As a result of evolving the system used for future predictions, self-evolving operation can be incorporated into CF. The details are provided in the article "Intelligent Zero-touch Operations" in this issue [5].

References

[1] Press release issued by NTT, "Realization of an Ultra-energy-saving Electro-optic Modulator and Highly-efficient Optical Transistor," Apr. 16, 2019.
http://www.brl.ntt.co.jp/E/2019/04/latest_topics_201904161802.html

[2] IOWN Global Forum, https://iowngf.org/

[3] International Innovation Center @ Vegas, https://innovate.vegas/IIC-Vegas

[4] K. Wakao, K. Kawamura, and T. Moriyama, "Quality-prediction Technology for Optimal Use of Multiple Wireless Access Networks," NTT Technical Review, Vol. 18, No. 6, pp. 17–20, 2020.
https://www.ntt-review.jp/archive/ntttechnical.php?contents=ntr202006fa2.html

[5] K. Yamagoe, M. Nishio, M. Kobayashi, S. Harada, and H. Nozue, "Intelligent Zero-touch Operation," NTT Technical Review, Vol. 18, No. 6, pp. 21–25, 2020.
https://www.ntt-review.jp/archive/ntttechnical.php?contents=ntr202006fa3.html

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Quality-prediction Technology for Optimal Use of Multiple Wireless Access Networks

Keisuke Wakao, Kenichi Kawamura, and Takatsune Moriyama

Abstract

Amid changes brought on by digitalization, wireless communications for connecting people and things are increasing in importance while available frequency bands and wireless access standards are becoming increasingly diversified. At the same time, the quality of wireless communications can change from moment to moment depending on user conditions, so there are times when the user has to consciously select the most appropriate means of wireless access. Against this background, our goal is to achieve a world in which wireless communications can be automatically and naturally used without a person or thing having to select and connect to a wireless access network. To this end, we are developing technology for proactively controlling the wireless environment based on wireless-quality-prediction technology using machine learning.

Keywords: wireless communications, quality prediction, AI

1. Introduction

As social changes brought on by digitalization increase, wireless communications are taking on an even greater role in many aspects of daily life, including increasing the communications capacity of smartphones and interconnecting all manner of things as the Internet of Things continues to expand. At the same time, a variety of wireless communications standards have appeared to support an increasing variety of wireless communications applications. In addition, the frequency bands available for wireless communications have expanded from several 100 MHz to several 10 GHz, so it has become necessary to select from a variety of frequency bands with radio waves that differ in their characteristics and from various wireless standards depending on the situation. In such a complicated heterogeneous wireless environment, we can envision an ideal world in which users can use the most suitable wireless standard at all times automatically and naturally.

The quality of wireless communications can change from moment to moment depending on user conditions and can lack stability due to interference from surrounding systems. To enable optimal use of wireless access under such conditions according to the purpose of use, there is a need for technology that can control the quality of wireless communications. Recognizing the importance of such technology, NTT has undertaken research and development (R&D) for controlling wireless quality through technologies that can proactively form communication areas and link multiple means of wireless access according to the user's situation. The aim is to create a communications environment in which the user need not be conscious of the actual wireless network being used. This group of wireless-access-control technologies is called "Cradio" [1] as an element of NTT's Innovative Optical and Wireless Network (IOWN). NTT is now accelerating the R&D of Cradio.

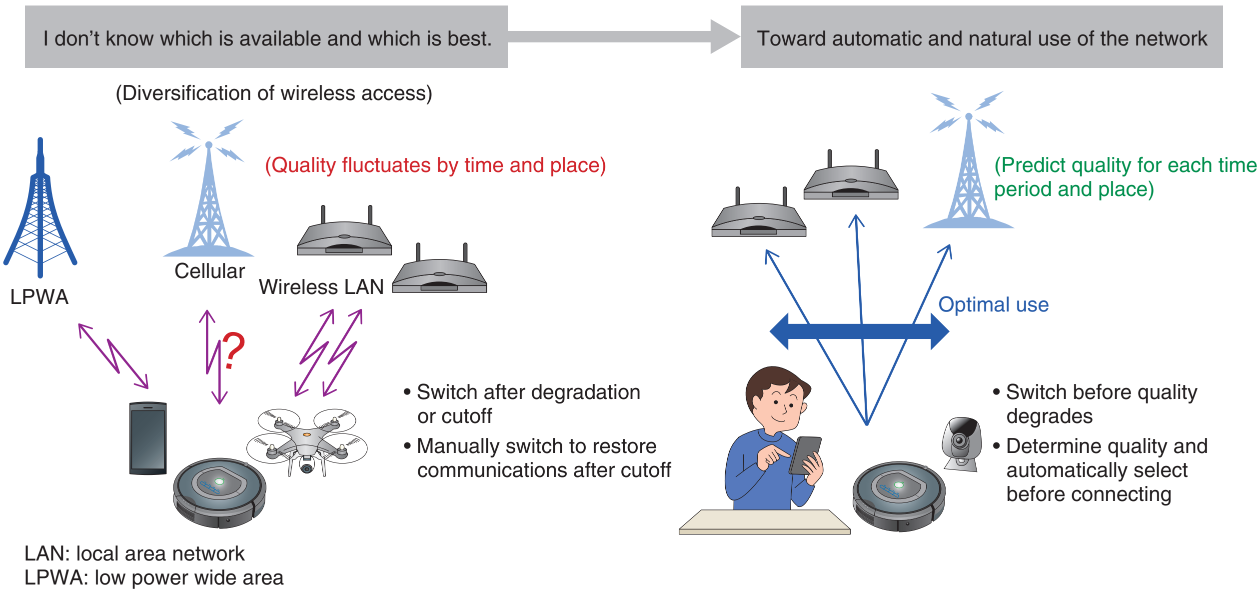

Fig. 1. Wireless-quality-prediction technology for optimal use of multiple means of wireless access.

2. Wireless-quality-prediction technology

One of the technologies in the Cradio wireless-access-control technologies is wireless-quality-prediction technology for proactively predicting changes in wireless quality. This technology uses machine-learning techniques [2], the application of which to wireless communications has been actively investigated in recent years. Wireless-quality-prediction technology improves quality by flexibly changing the configuration of a communications area and switching the radio base station or type of wireless access that the terminal is connected to before quality deteriorates (**Fig. 1**).

The base station that a wireless terminal uses has been selected based mainly on the strength of received signals from various base stations. However, in an environment in which the number of wireless communications users has jumped dramatically, increasingly diversified conditions such as the degree of congestion, model-specific terminal conditions, and application characteristics are making this an unrealistic approach. With the technology we are developing, however, a server collects detailed information continuously measured at the terminal, analyzes that information by machine learning*, calculates the predicted throughput, latency, jitter, and packet-loss values in the wireless communications of that terminal, and passes those results to the terminal side. This technology will enable switching to an optimal wireless base station for each terminal or application and select the wireless access method to be used. An overview of this technology is shown in **Fig. 2**. The wireless-quality-prediction engine runs on a network server installed on the cloud or within the management network. The detailed information measured at the terminal—such as location information, terminal model, wireless access method, wireless-environment scan data, and actual values of communications quality—is regularly uploaded to the wireless-quality-prediction engine to become history information accumulated in a database. The machine-learning algorithm is trained at this engine based on the content of this database. The terminal engaged in wireless access sends an inquiry to the wireless-quality-prediction engine affixing location information, wireless-environment information, etc. and receives, in turn, predicted values on the quality (throughput, latency, jitter, packet loss) that can be expected when connecting to a base station in the peripheral area. Based on these predicted values and taking into account application characteristics, the terminal selects the base station to be connected to. This approach achieves a means of optimally selecting

* Machine learning: A mechanism that enables a computer to learn useful decision-making criteria through statistical processing of sample data.

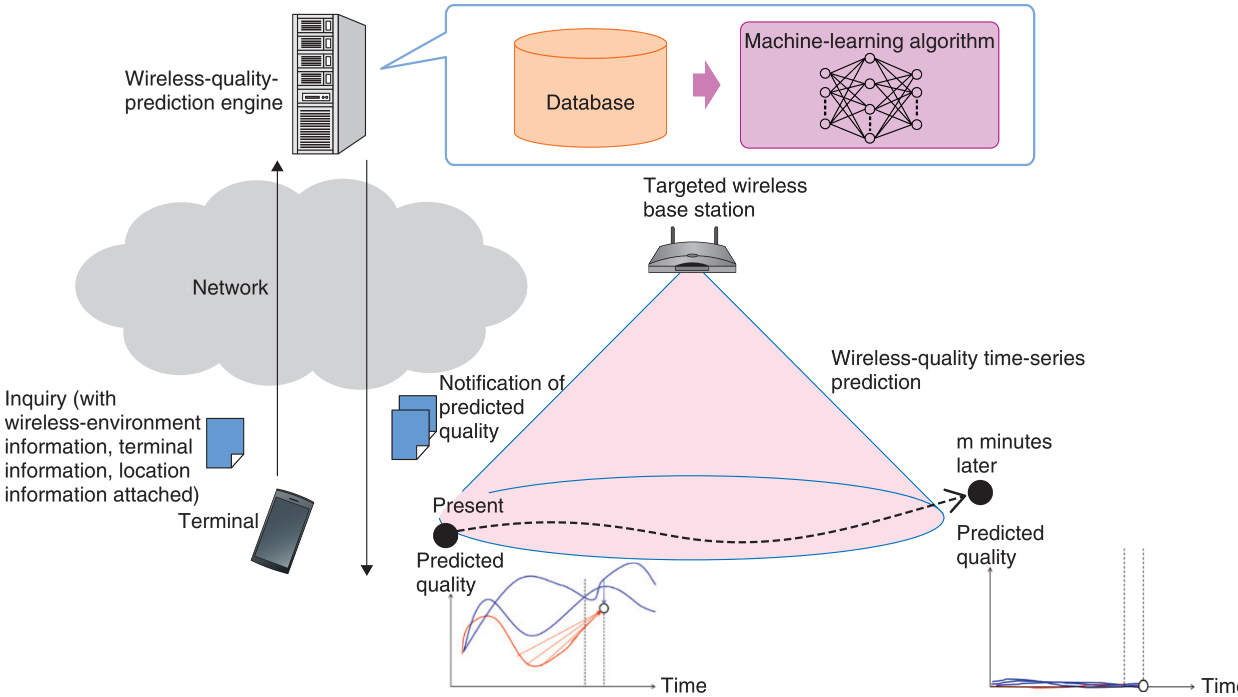

Fig. 2. Overview of wireless-quality-prediction engine.

the type of wireless access to use from predicted values of quality based on past results.

One benefit of using a wireless-quality-prediction engine is that it enables the efficient collection of data while shortening processing time in machine learning. As described above, carrying out quality prediction from certain types of input information in machine learning requires that such input information as well as past predicted values be collected beforehand, but doing so only at the terminal targeted for prediction would take considerable time. In contrast, deploying a wireless-quality-prediction engine and using it to collect data not only from the target terminal but also from many other terminals makes it possible to efficiently collect a sufficient amount of data and quickly carry out the processing required for machine learning. Nevertheless, this technique presents other issues. For example, simply integrating the data collected from all terminals and applying them blindly to machine learning does not promote useful learning since terminal performance differs from one model to another. Moreover, since the types, definitions, etc. of information that a terminal can collect depend on the model and area in question, there is also the problem that such information cannot be input as-is into a common machine-learning algorithm. In the R&D on the wireless-quality-prediction engine of Cradio, we are stepping up studies of a machine-learning algorithm that can overcome this issue and use the data collected from many and varied terminals in common. Our goal is to establish wireless-quality-prediction technology that enables the user to automatically and naturally use the wireless access network.

We envision one application example of this technology as communication control for maintaining stable wireless communications in automatic guided vehicles commonly used today in large-scale warehouses. This would be needed in such an environment because of the many structures and obstacles that hinder wireless communications and significant fluctuation in signal congestion due to the effects of various types of office equipment.

3. Future outlook

We plan to improve wireless-quality-prediction technology through the use of various types of environmental data and enhancing machine-learning algorithms. Our ultimate goal is technology that enables people to use wireless communications more naturally and intuitively.

References

[1] J. Sawada, M. Ii, and K. Kawazoe, “IOWN—Beyond the Internet,” NTT Publishing, pp. 41–42, 2019 (in Japanese).

[2] C. Jiang, H. Zhang, Y. Ren, Z. Han, K. C. Chen, and L. Hanzo, “Machine Learning Paradigms for Next-generation Wireless Networks,” IEEE Wireless Communications, Vol. 24, No. 2, pp. 98–105, Apr. 2017.

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Intelligent Zero-touch Operation

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Abstract

NTT laboratories have been researching and developing zero-touch operation technology to reduce and level out maintenance operations for network services. This article describes use cases of intelligent zero-touch operation incorporating artificial intelligence (AI) and introduces three elemental AI technologies used in these use cases.

Keywords: zero-touch operation, AI, maintenance automation

1. Introduction

As part of NTT's Innovative Optical and Wireless Network (IOWN), NTT laboratories aim to develop Cognitive Foundation® for coordinating the collection, processing, recording, and communication of data dispersed around a variety of hubs in multiple domains while providing a functional group essential to service deployment and operation. This article introduces our efforts in developing the technologies essential to Cognitive Foundation.

In current network operations, alarms occurring due to a failure or quality degradation require operation personnel to analyze and decide on a response such as changing the configuration and replacing defunct network equipment. Services and their required quality are becoming increasingly diversified, leading to increasingly complex operations, even though the number of experienced operation personnel is decreasing. Under such circumstances, reducing the workload is a pressing issue.

Against this background, with an eye to the IOWN era, NTT laboratories have undertaken research and development of intelligent zero-touch operation with which artificial intelligence (AI) takes over the analysis and decision-making tasks traditionally carried out by operation personnel then automatically executes a range of processes from information collection to failure response (**Fig. 1**). As elemental technologies for intelligent zero-touch operation, NTT laboratories have thus far established network resource management technology [1], which can be used with various AI technologies, and federation engine technology [2], which coordinates the processes of information collection, analysis, decision-making, and response. We are also focusing on various AI technologies that perform advanced analysis and decision-making to automate more complex failure response.

2. Traffic classification and prediction technology

The recent diversification of user terminals and services is creating fluctuations in network traffic all the more complicated. Because of this, traffic prediction has become increasingly difficult. The traffic classification and prediction technology [3] developed by NTT laboratories classifies traffic having similar features into clusters and predicts with high accuracy complex fluctuations in traffic based on the features of each cluster. Clustering traffic with similar features into clusters based on transmission source, transmission destination, transmission time, and amount of transferred data using non-negative tensor factorization—a time-series clustering technique—is a key feature of this technology. It can be used to accurately predict the occurrence of congestion on each link and mount a proactive response.

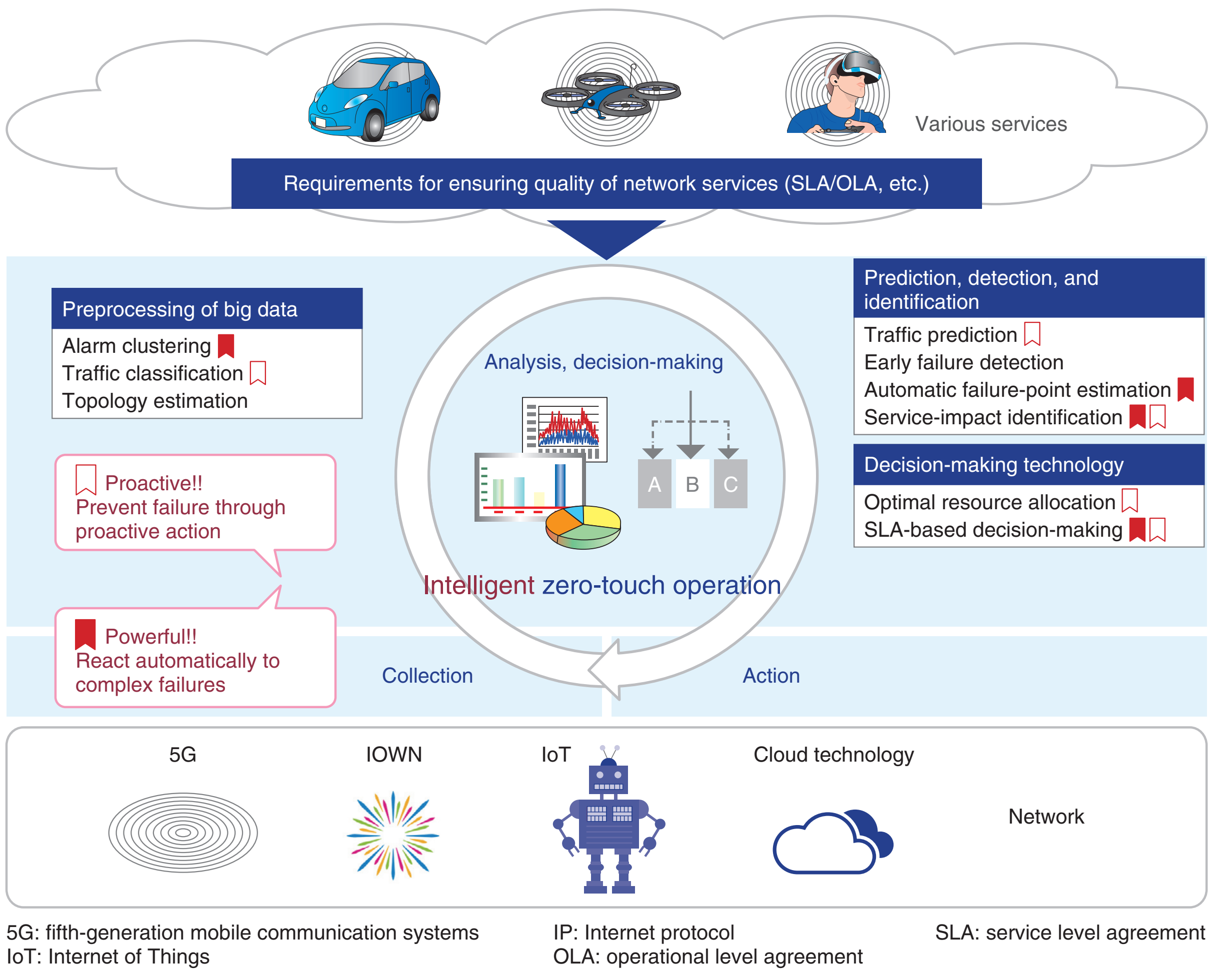

Fig. 1. Intelligent zero-touch operation.

3. SLA-based decision-making technology

In addition to advanced data-analysis technology, zero-touch operation requires technology for automating the decisions that have to be made for mounting a problem response. Some examples are whether a response is needed at the time of quality degradation, what failure should be prioritized, when the response should be scheduled, and which response method and by whom are optimal from the point of view of response costs.

Service level agreement (SLA)*1-based decision-making technology focuses on the fact that the fundamental objective of network operations is to maintain service quality. This technology automatically makes decisions for mounting a response by evaluating the information indicating service quality (failure duration, average traffic latency, jitter, loss, etc. for each service and user) based on the service quality that must be satisfied (values specified in the user SLA and in-house operational level agreement (OLA)*2 by stakeholders). Application examples of this technology include (1) automatic decision-making on the need for taking action based on predictions regarding service/user SLA violations at a bottleneck point, and (2) automatic decision-making on optimal dispatch timing by comparing the cost of dispatching maintenance personnel to the failure site according to a time slot with increase in losses incurred by SLA violations when delaying response time [4].

*1 SLA: An agreement negotiated between a service provider and service contractor (user) on items related to service quality such as indicators, target values, and violation handling.

*2 OLA: An agreement negotiated between the operation department and operation management department on operation-related items such as indicators, target values, and violation handling.

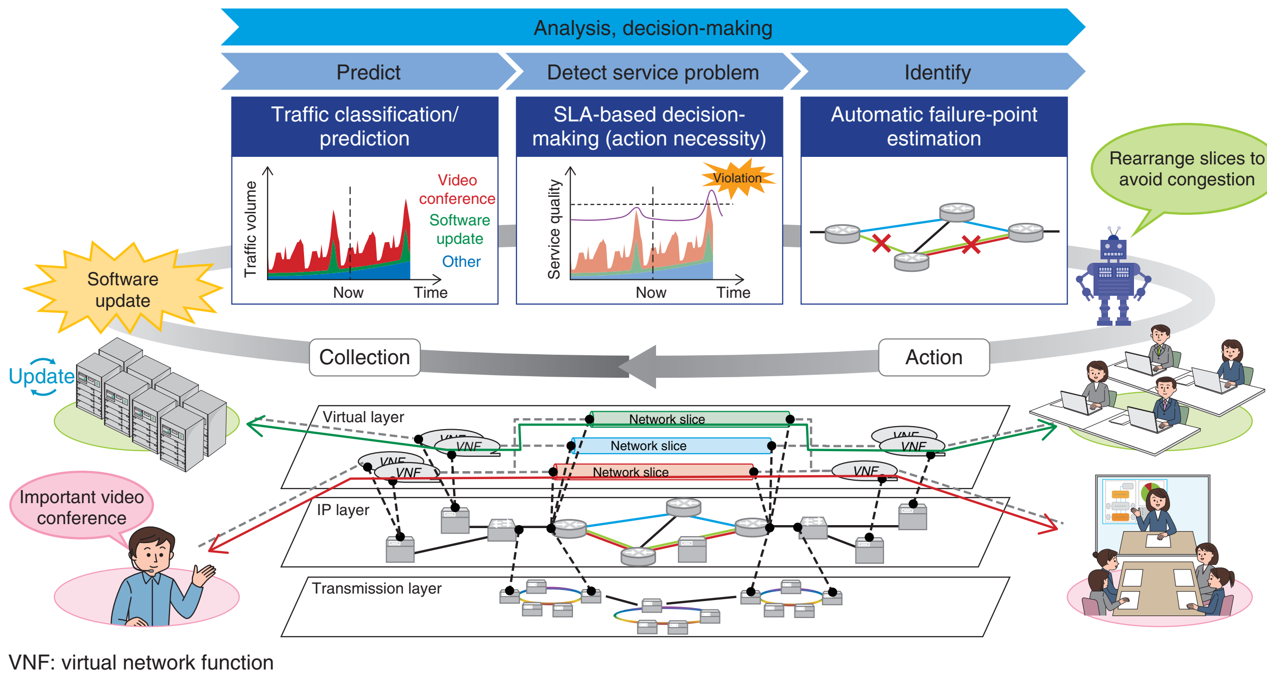

Fig. 2. Proactive response to service quality degradation caused by congestion.

4. Automatic failure-point-estimation technology

The occurrence of a failure in a large-scale network triggers a large number of and various alarms that make the troubleshooting of failure points workload-intensive. Failure-point-estimation technology [5] infers failure points using rules automatically generated beforehand and visualizes the candidates on a topology map, thereby speeding up network maintenance tasks and reducing workload (and operating costs). Specifically, this technology collects alarms and other events generated at the time of past failures plus their failure points and root causes, derives associations beforehand based on the degree of similarity in combinations of the above, and automatically learns and generates appropriate failure-point-estimation rules. This makes for immediate estimation of failure points even in the case of complex failures. The automatic generation of rule conditions contributes to the formalization of failure-troubleshooting rules that have traditionally relied upon the skills and experience of operation personnel.

5. Use case: proactive response

Figure 2 shows a use case of combining the three elemental technologies described above to mount a proactive response to degradation in service quality caused by congestion. This case involves a time slot for making a major software update that overlaps the time of an important video conference. If no responses are to be taken, the quality of each service would degrade due to congestion, and this important video conference would suffer transmission interruptions.

In this use case, our traffic classification and prediction technology predicts with high accuracy traffic fluctuation for each service. Next, SLA-based decision-making technology first predicts the quality of each service and estimates SLA violations in the video conference, then determines the necessity of maintenance responses and issues alarms if needed. Finally, automatic failure-point-estimation technology infers failure points and causes from all the alarms generated during this period. In this case, no failure alarms other than SLA violation alarms would have been generated, so this technology would use rules formulated beforehand to estimate the root cause as a simple congestion (not congestion due to a failure) and to estimate the failure points associated with the (inferred) root cause. Finally, quality degradation in the video conferencing service can be avoided by proactively changing the network route of the software-update service to prevent SLA violations. This type of proactive response can be carried out without

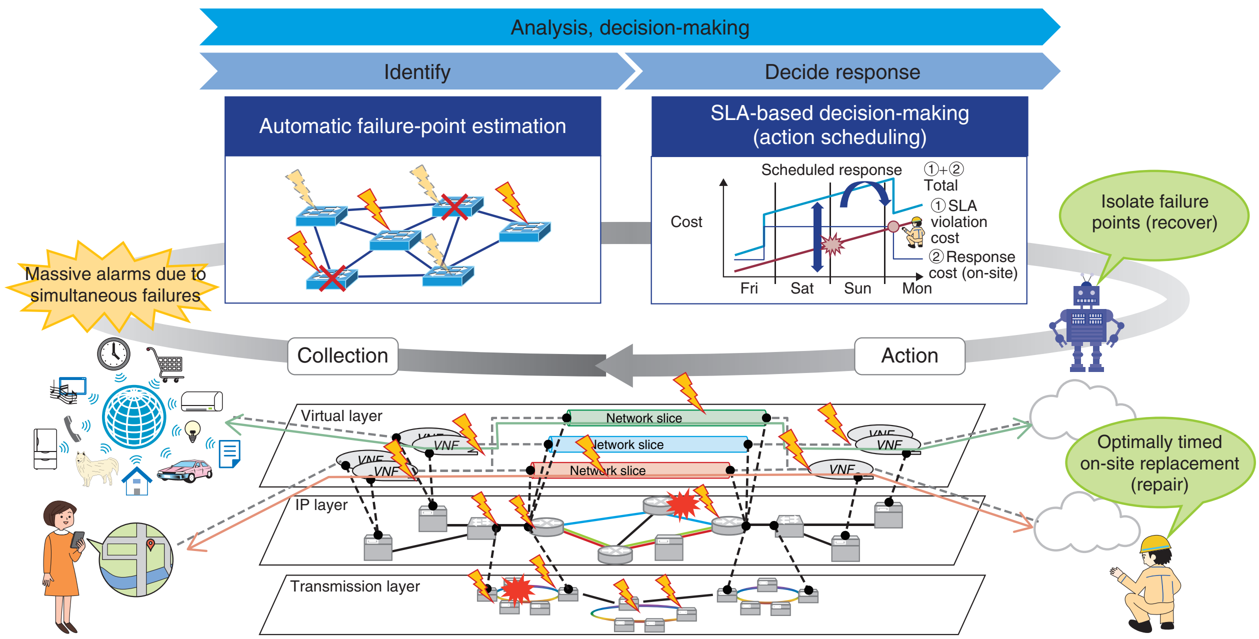

Fig. 3. Automatic response to complex failure.

human interaction and without users noticing any degradation in service quality.

6. Use case: response to complex failure

Figure 3 shows a use case of a response to a complex failure that generates a large number of alarms from multiple layers on the network due to the simultaneous occurrence of multiple failures. In this case, information related to these failures on different layers would be displayed together on a monitoring screen, which increases the workload of operation personnel since they would have to analyze these data.

In this case, automatic failure-point-estimation technology would first learn about the alarms that characterize failures from past cases and immediately estimate failure points and root causes using the generated alarm group. This technology can visualize the effects of failures spanning different layers by performing data management using network resource management technology [6]. Next, a traffic route is diverted to avoid failure points. This would recover services, but in the event of equipment failure, the entire system would not be recovered until maintenance personnel arrive at the site and replace the defunct equipment. For this reason, SLA-based decision-making technology would evaluate work costs and losses incurred by SLA violations using common indices to decide on the optimal on-site work period (for example, "Should this work be done immediately?" "Can it be done tomorrow or later without upsetting the customer?"). This technology automates the work of responding to a complex failure that requires a heavy workload, reduces that workload, and improves service quality.

7. Future outlook

This article introduced three elemental AI technologies for achieving intelligent zero-touch operation and use cases of proactive response to complex failures applying these technologies. NTT laboratories will continue to work on researching and developing various AI technologies, expand the automation domain, coordinate various AI technologies, and enable practical use of intelligent zero-touch operation.

References

[1] S. Horiuchi, K. Akashi, M. Sato, and T. Kotani, "Network Resource Management Technology," NTT Technical Review, Vol. 15, No. 10, Oct. 2017.
https://www.ntt-review.jp/archive/ntttechnical.php?contents=ntr201710ra2.html

[2] A. Oi, A. Takada, K. Sakata, and M. Nakajima, "A Study of Assurance Automation for Zero-Touch Operations," IEICE Technical Report,

Vol. 119, No. 111, ICM2019-14, pp. 47–52, 2019 (in Japanese).

[3] Y. Komai, T. Kimura, M. Kobayashi, and S. Harada, "Traffic Prediction by Extracting Users' Access Patterns," IEICE Technical Report, Vol. 119, No. 158, IN2019-22, pp. 43–46, 2019 (in Japanese).

[4] A. Takada, N. Tanji, T. Seki, K. Yamagoe, Y. Snejima, and M. Tahara, "SLA Driven Operation – Optimizing Telecom Operation Based on SLA," Asia-Pacific Network Operations and Management Symposium, Shimane, Japan, Sept. 2019.

[5] N. Murata, F. Asai, T. Yakawa, S. Suzuki, H. Oishi, and A. Inoue, "Failure Point Estimation Using Rule-based Learning," NTT Technical Review, Vol. 17, No. 7, July 2019. https://www.ntt-review.jp/archive/ntttechnical.php?contents=ntr201907fa2.html

[6] K. Fukami, K. Musase, M. Sato, and K. Tayama, "Study on Method of Identifying Service Influence Occurred by Network Fault," IEICE Technical Report, Vol. 118, No .483, ICM2018-51, pp. 13–18, 2019 (in Japanese).

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NTT Group's Initiatives Regarding Food and Agriculture

Yoshikazu Kusumi, Takuya Murayama, and Kanji Yoshitake

Abstract

Agriculture is a key industry in rural areas of Japan; however, it faces various problems such as long-term decline in the working-age population, aging of the population, natural disasters due to climate change, and securing sales channels. To solve these problems, *AgriTech*—which uses biotechnology, the Internet of Things, big-data analysis, artificial intelligence, and robots in the field of agriculture—is attracting attention. Since its privatization in 1985, NTT has been required to have a mission with both public and corporate aspects. In consideration of this dual mission, NTT is striving to create a *smart world* to solve social issues through its business activities. With agriculture positioned as a priority, we are working to create *Smart Agri* by using information and communication technology developed for telecommunications business to solve problems faced by the agricultural industry through cooperation with leading partners. The direction of initiatives by the NTT Group, specific examples, and future plans are introduced in this article.

Keywords: food and agriculture, food value chain, global

1. Issues being faced regarding food and agriculture

In agriculture, the working population is declining and aging simultaneously. Specifically, the number of workers decreased about 60% in 30 years and more than 60% of them are over 65 years old. Moreover, new farmers are not significantly increasing in number owing to unstable income due to fluctuations in yield and quality (which depend on the weather) and uncertainties regarding disasters, damage due to wildlife, etc. Accordingly, the area of agricultural land is decreasing [1]. Another issue is securing transportation and sales destinations (sales channels) after agricultural production. After farming, it is necessary to not only produce agricultural products but also sell them at a profit. To meet these requirements, it is effective to understand the needs and trends of consumers in a timely manner and devise *market-in* agriculture that reflects those needs in production. In the meantime, it is said that given the current state of the world, a population explosion would lead to competition for food and water. To develop Japanese agriculture from now onwards, it is necessary to (i) increase the number of younger people employed in agriculture, (ii) expand the scale and improve the productivity of food and agriculture as a whole (including distribution, sales, and consumption), and (iii) develop agriculture with the global market in mind. Under these circumstances, given the aim of transforming Japan into Society 5.0 and a data-driven society, the Council on Investments for the Future of the Japanese government has heralded an offensive agriculture, forestry, and fisheries industry focusing on creating world-class *smart agriculture* and *smart food chain* using information and communication technology (ICT) [2].

2. NTT Group's initiatives: "Food and Agriculture × ICT"

The NTT Group has also positioned agriculture as a priority, and the Research and Development Planning Department of NTT took the lead in launching a

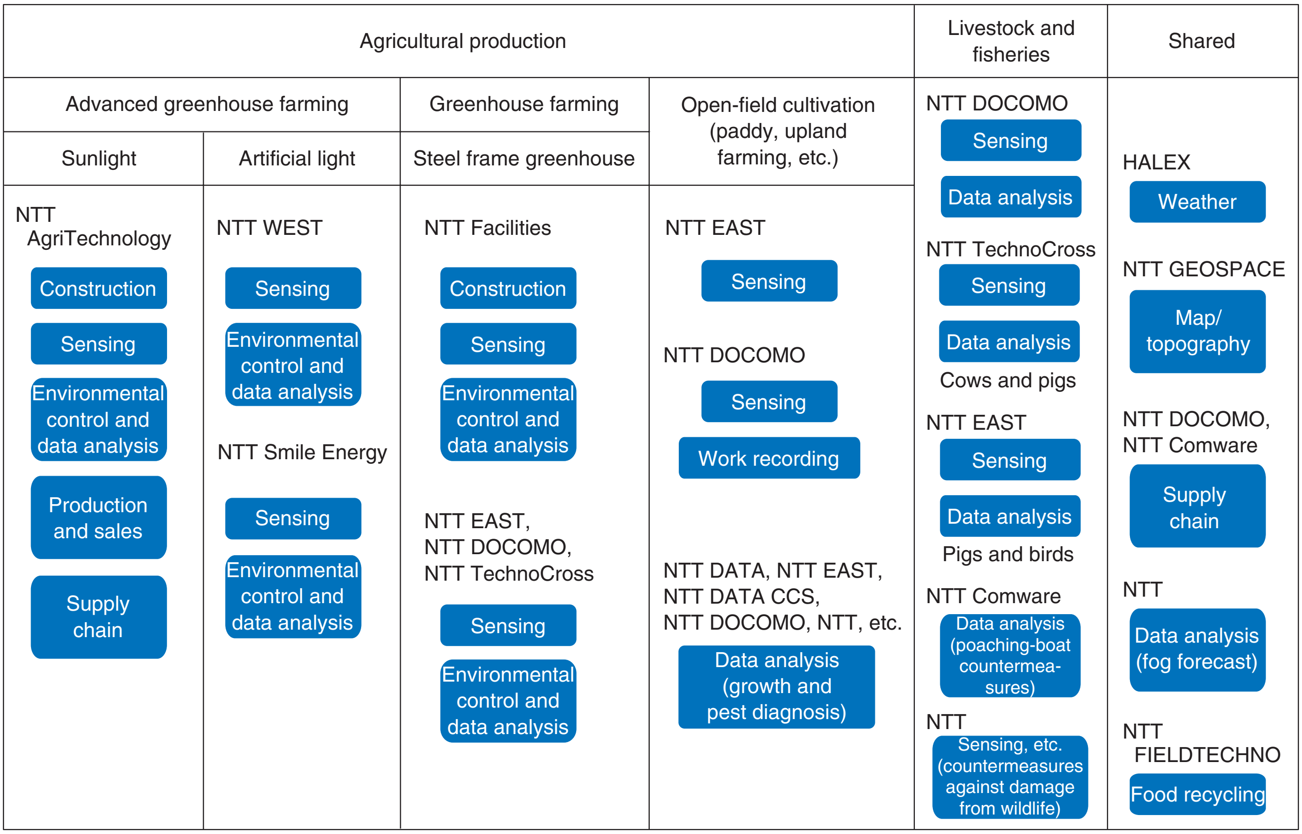


Fig. 1. Solution map.

cross-group project called "Agriculture Working." In addition to working with the major operating companies of the NTT Group (namely, NTT EAST, NTT WEST, NTT DOCOMO, NTT DATA, and NTT Communications), we are cooperating with about 30 other group companies with outstanding services and research laboratories to work on a wide range of activities from formulation of overall strategy, creating services, research and development (R&D), etc. in agricultural production, distribution, sales, consumption, food, and globalization. We are providing customers with technologies and solutions concerning the food and agriculture sector, in which we plan to use the nationwide telecommunications infrastructure and assets held by each group company, network services, artificial intelligence (AI) technology, and the Innovative Optical and Wireless Network (IOWN)* (**Fig. 1**). Our lineup of services and technologies encompasses greenhouse farming (sunlight type and artificial-light type), open-field cultivation, raising livestock, shared weather information, maps and distribution, sales, and food and food-loss reduction, which contribute to the United Nations' Sustainable Development Goals (SDGs). By combining these services and technologies, for example, large-scale and distributed farmland and facilities (greenhouses) can be integrated as one virtual farm, and farming can be simulated (by Digital Twin Computing) in a manner that makes it possible to centrally manage and coordinate various types of digital data about the environment and soil, growth status, weather information, etc. Based on the simulation results, an optimal cultivation plan is drawn up for each item (vegetable, animal, etc.), and farming is efficiently carried out according to that plan while remotely controlling robotics such as agricultural machines, drones, mowers, and harvesters. The results of these research laboratories and group-company initiatives are strategically disseminated through various exhibitions and external lectures (**Fig. 2**).

* IOWN: A next-generation communication infrastructure that NTT is promoting toward practical application around 2030.

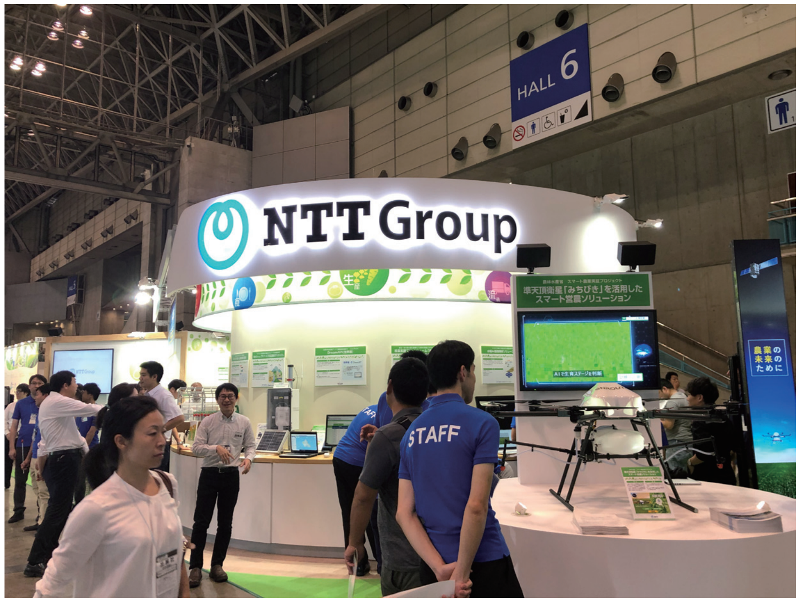


Fig. 2. Exhibition booth of the NTT Group.

3. Specific initiatives with leading partners

The NTT Group has a short history of participating in the agricultural business, so it lacks specialized knowledge and know-how. Therefore, we are strategically promoting collaboration with leading partners in industry, government, and academia (**Fig. 3**). For example, NTT Group, Hokkaido University, and Iwamizawa City in Hokkaido have concluded an industry-government-academia collaboration agreement and initiated a joint study to apply innovative technologies to agriculture. We are aiming to (i) create and implement world-class smart agriculture by using self-driving robotics technology (including cutting-edge agricultural machinery), high-precision location information, fifth-generation mobile communication system (5G), and data-analysis technology such as AI; (ii) develop models for sustainable regional revitalization and smart-city solutions centered on smart agriculture; and (iii) study the application of future innovative technologies, including IOWN, to smart agriculture.

We are currently in the demonstration phase of fully self-driving (unmanned) agricultural machinery (level 3) with the world's first "cooperative-work" system using multiple agricultural machines and remote monitoring. To achieve the next stage (commercialization), it is necessary to (i) acquire accurate positioning information and automatically generate farm-work plans based on understanding and forecasting of the states of agricultural machinery, weather, and crop growth and (ii) transmit video information from cameras mounted on agricultural machinery to monitoring sites while ensuring low delay and reliability. To satisfy these needs, 5G and local 5G will be used and IOWN will be used in the future. For example, a large number of agricultural machines, drones, robot mowers, and others are monitored and controlled over a wide area of a farm from a remote location such as a monitoring center in Iwamizawa City by a member of Japan Agricultural Cooperatives (JA) or a contractor of agricultural work. Therefore, we aim to create a world that enables technological innovation and the accompanying industrialization of agriculture in cooperation with universities, local governments, JA, manufacturers of agricultural machinery, and others. It is said that like Japan, emerging countries are becoming more urbanized and the population of farmers is decreasing. For this reason, to contribute to alleviating global food shortage through automation and boosting efficiency of agriculture, we will model and systematize our smart agriculture technology and solutions and expand them globally (**Fig. 4**).

4. Future directions

The NTT Group has been expanding its activities

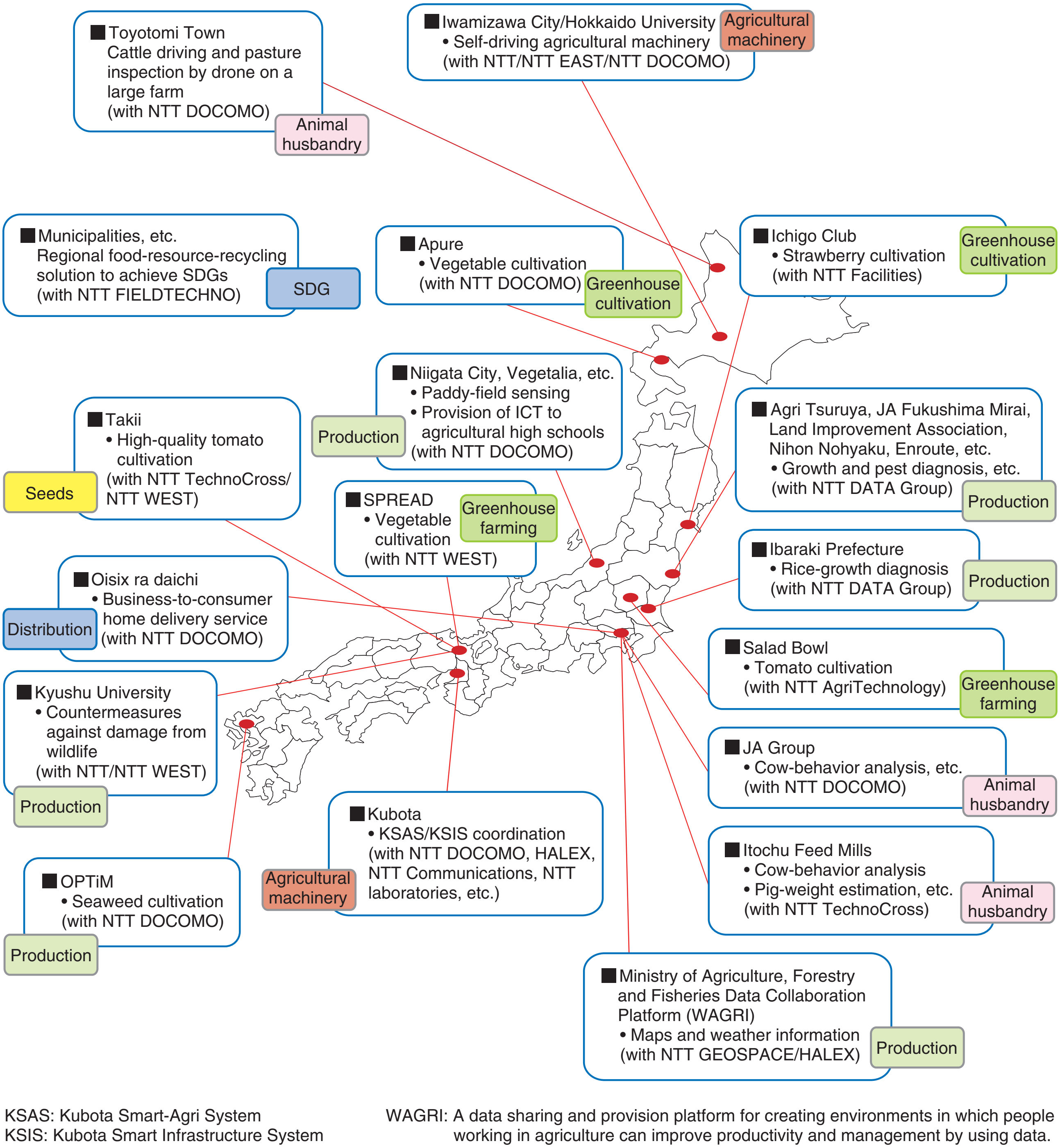


Fig. 3. Collaborations with partners.

into the so-called smart food chain, which is a larger market covering agricultural production to distribution, processing, sales, food, and exports. For example, through a mechanism called "digital food value chain," which connects producers and customers/consumers with digital data, and market-in agriculture, which produces crops on demand from consumers, we aim to ensure planned and stable production and procurement and implement a system that enables people involved in food and agriculture to

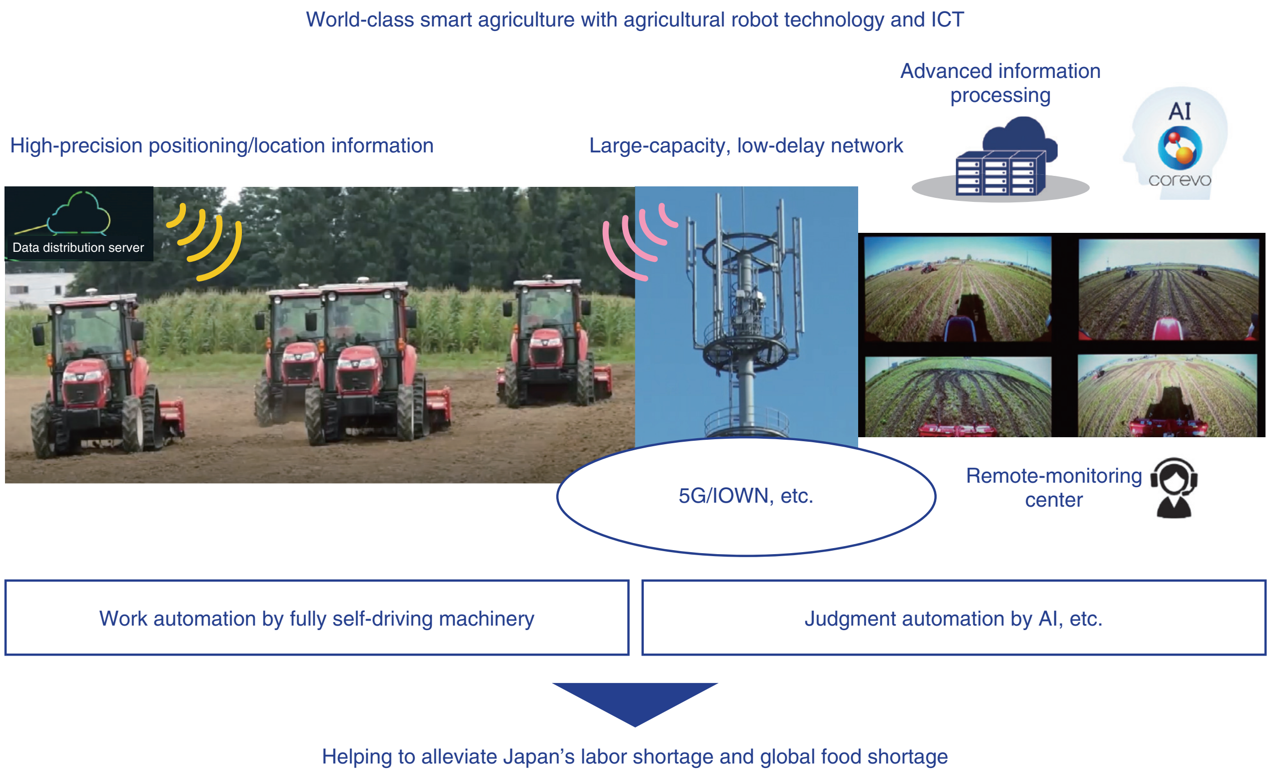
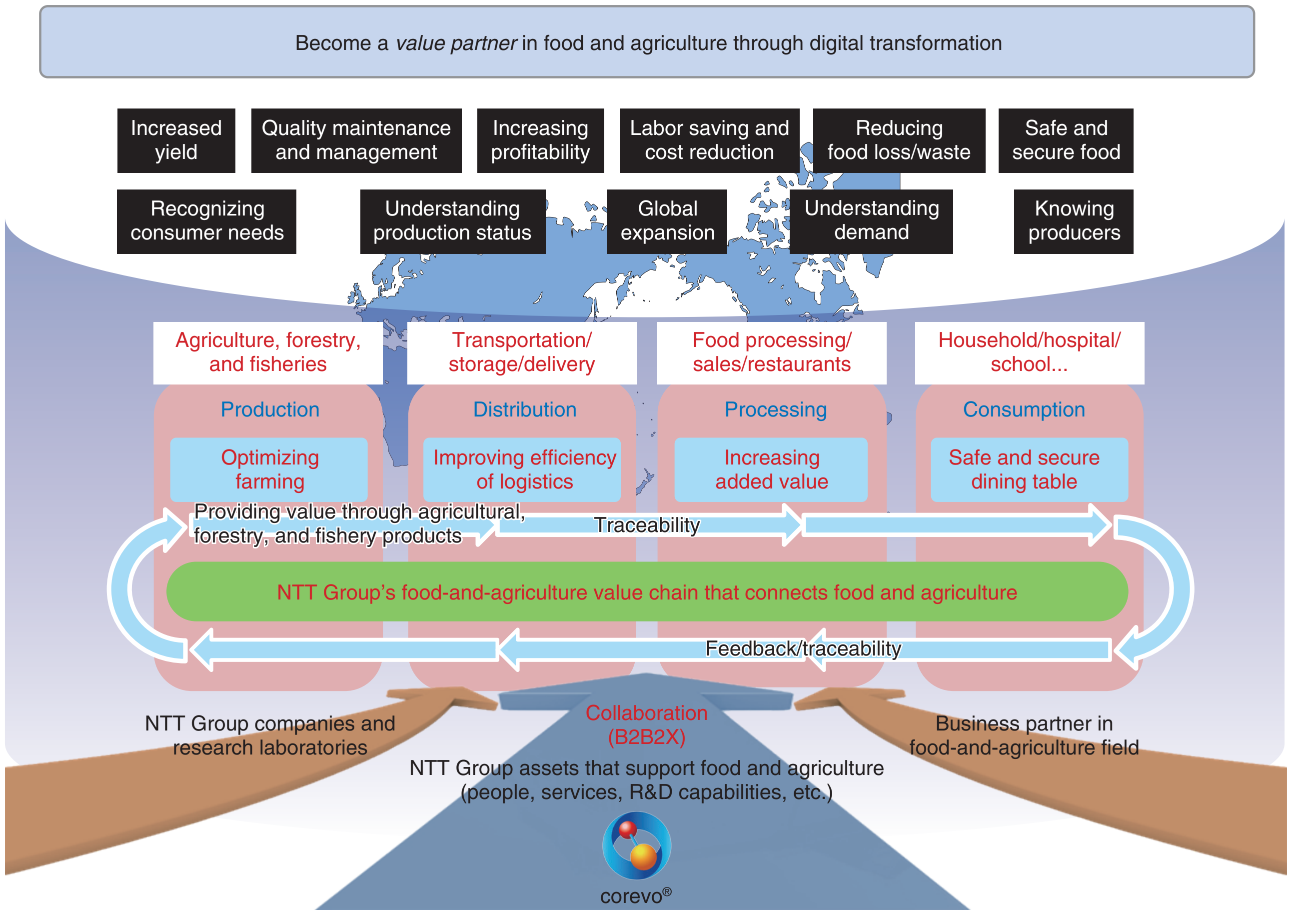


Fig. 4.   Collaboration with Hokkaido University and Iwamizawa City.

enjoy benefits of such value chain without waste. We will also strive to address SDGs by reducing food waste/loss through improved distribution efficiency while expanding the scope of our efforts to global agriculture. We first plan to promote our initiatives in Southeast Asia, the Middle East, and Africa, where growth is expected, as well as in Europe, which is an advanced agricultural region, through specific projects with local companies, organizations, and universities. We then plan to expand our efforts to forestry and cooperate with partners necessary for that expansion at an early stage. To become a value partner of choice, we will continue to contribute to the development of primary industries as a whole (**Fig. 5**).



B2B2X: business-to-business-to-X

Fig. 5. Vision.

References

[1] Handout of the fourth meeting of the 2030 Outlook and Reform Task Force, pp. 14–16, Nov. 2016 (in Japanese).
https://www5.cao.go.jp/keizai-shimon/kaigi/special/2030tf/281114/shiryou1_2.pdf

[2] "Council on Investments for the Future 2018," June 2018 (in Japanese).
https://www.kantei.go.jp/jp/singi/keizaisaisei/pdf/miraitousi2018_zentai.pdf

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Community Revitalization by Utilizing ICT and Agriculture

Taiga Sakai, Daiki Endo, Masaki Hiizumi, and Shingo Maehara

Abstract

NTT AgriTechnology is the only agricultural company in the NTT Group and is implementing advanced technology in the food and agriculture supply chain as an agricultural-production corporation. In cooperation with domestic and overseas producers, Japan Agricultural Cooperatives (JA), local governments, the National Agriculture and Food Research Organization, agricultural-related companies, and other organizations, we are creating a new form of agriculture, which is a major industry in rural Japan, by operating a large-scale greenhouse using the latest technology. Our dedicated efforts to promote profitable agriculture as well as develop communities and nurture human resources through the food and agriculture business are introduced in this article.

Keywords: high-tech greenhouse, data-driven horticulture, food value chain

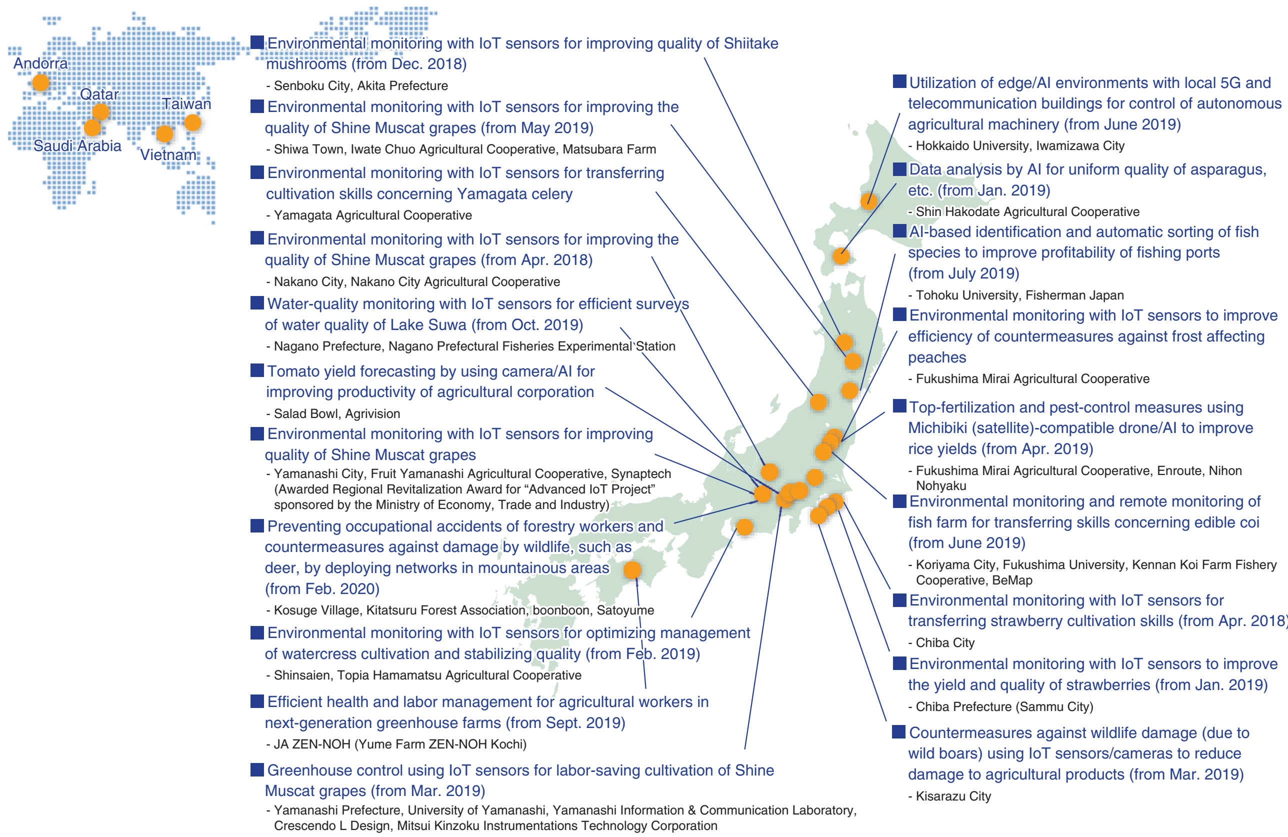
1. Projects that spread nationwide

Thanks to being the sole agricultural corporation of the NTT Group, NTT AgriTechnology is receiving inquiries from both domestic and overseas producers, all types of businesses, and NTT Group companies [1–3]. We believe that food and agriculture are the backbone of our society and a major industry that supports the Japanese regional economy and community. Against this backdrop, an increasing number of producers and regions are practicing profitable agriculture to address issues such as a declining birthrate, aging population, improving productivity, and adding value (i.e., increasing income) (**Fig. 1**).

When it comes to agriculture, we tend to focus on production sites. However, it is important to accurately grasp the *flow of information* from production to consumption and manage the agriculture process on the basis of that information while adding value at each point such as distribution, processing, and sales. In this process, when information (data) is connected and forms a *circle*, that is, when it functions as a *food value chain*, many things become possible. The projects introduced in this article are not examples of individual solutions; on the contrary, they are all organically connected. We are responding to social needs through our efforts of effectively using our three approaches, "value chain from production to sales," "large-scale to small-medium-scale farmers," and "demonstration to implementation."

2. Initiatives with Salad Bowl Group

Salad Bowl has attracted attention as a pioneering agricultural corporation. AgriVision, a group company of Salad Bowl, produces and sells high-quality tomatoes cultivated in a vast greenhouse covering about 3 ha by using advanced technologies such as automatic environmental control. The bottleneck in that process is the fluctuation in yield prediction. Up until now, yield predictions depended on grower's observations and empirical rules, so there was fluctuation between each grower in charge at a particular time. To solve this problem, we developed and introduced a yield-prediction system. With this system, a smartphone is fixed on a trolley used for harvesting work, the tomatoes to be harvested are photographed, and the images are stored on the cloud via an optical fiber line connected to Wi-Fi in the greenhouse. The data are used to analyze the color, size, and number



AI: artificial intelligence
5G: fifth-generation mobile communication
IoT: Internet of Things
JA: Japan Agricultural Cooperatives
ZEN-NOH: National Federation of Agricultural Cooperative Associations

Fig. 1. Examples of projects around Japan (NTT EAST Group).

of tomatoes, select those that are ready for harvesting the next day, and predict the yield (**Figs. 2(a), (b)**).

The predicted (i.e., calculated) yield is then used for suitable allocation of harvesting and packing workers for the next day's work, arranging logistics trucks, and providing information to buyers. This initiative represents the first place to connect the value chain from the field to the shipping destination and customers. This system will greatly reduce shipment adjustments, opportunity loss, and food loss due to sudden out-of-stock items and excess items on the day. By connecting the food value chain in this manner, it becomes possible to deliver high-quality agricultural products to more people while maintaining freshness and reach more consumers. As a result, we can create more profitable agriculture.

3. Initiatives with ZEN-NOH

While the number of farmers is decreasing due to the declining birthrate and aging population in Japan, agricultural management is becoming larger scale and more incorporated (**Fig. 3**). Under these circumstances, the importance of labor management will increase along with that of securing human resources, especially during the transition from family management to corporate-organization management. In agriculture, job sharing and acceptance of foreign technical interns are increasing. Moreover, a recent trend is to have disabled people play an active part through cooperating with social welfare organizations. We are in an era that necessitates an environment for accepting diverse workers and flexible working practices to secure human resources, and agriculture is no exception. It is therefore important to ensure the health and safety of farm workers through proper communication

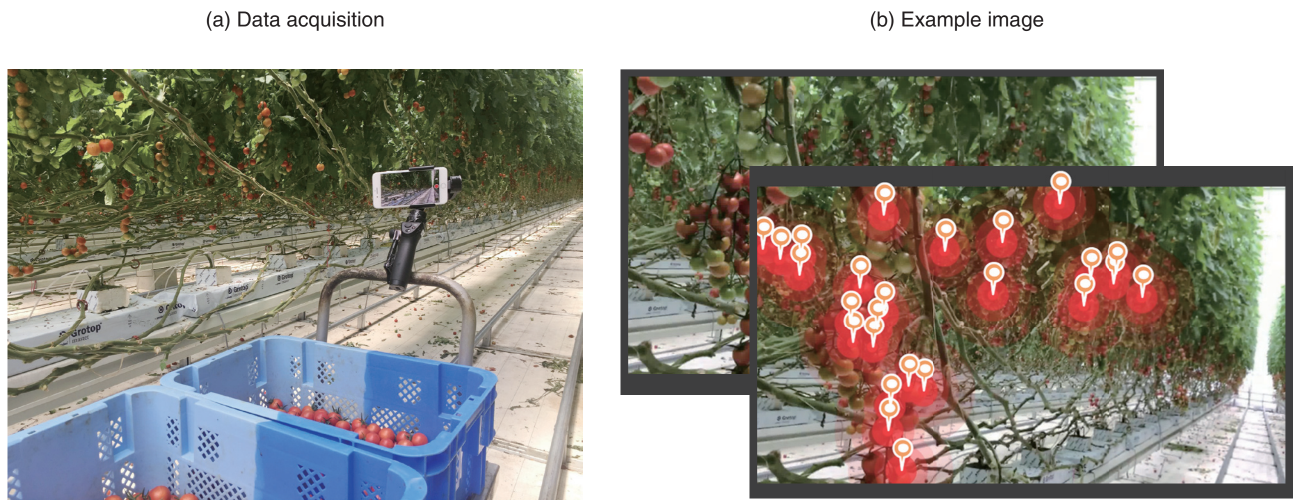


Fig. 2. Yield forecasting.

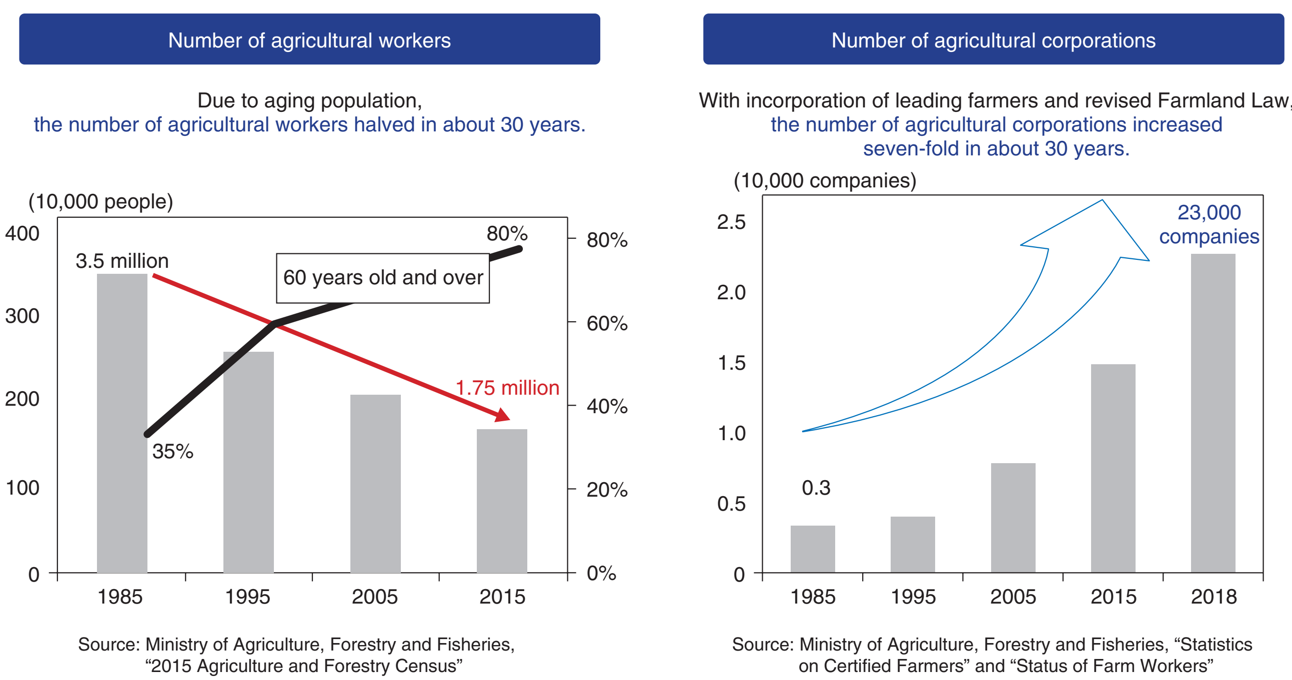


Fig. 3. Changes in number of agricultural workers and agricultural corporations in Japan.

and formulate and review work plans, suitably allocate workers, and manage labor through standardization of work, etc. Therefore, working in cooperation with the National Federation of Agricultural Cooperative Associations (ZEN-NOH) at a large-scale greenhouse facility called Yume Farm ZEN-NOH NEXT Kochi operated by ZEN-NOH in cooperation with local Japan Agricultural Cooperatives (JA) bodies, local governments, and producers, we launched a project that implements safe, secure, and efficient agricultural management through health and labor management of farm workers by using Internet of Things (IoT).

In this project, we started off with an effort to protect the health of workers as well as the acceptance of technical interns from Vietnam. Vital data (heart rate, etc.) of the farm workers are acquired via a wristwatch-type wearable device, and those data are combined with the data acquired from temperature and humidity sensors installed in greenhouses for environmental control. The data are used to visualize the effects of workload on the body, and if preset conditions for such effects are exceeded, an alert is sent to the administrator of the farm. Even if a foreign worker or disabled person has a communication problem, the administrator can encourage them to take a break (**Fig. 4**).

Combining location information with such data makes it possible to fully understand the work content and working hours of each farm worker; consequently, it will be possible to improve the work environment (review work-flow lines, etc.) and manage labor to achieve, for example, appropriate staffing. We aim to implement this scheme in each region where securing a sufficient number of workers is an issue by cooperating with ZEN-NOH, which is deeply involved in such regions and supports producers.

Fig. 4. Working with a wearable device.

4. Collaboration with National Agriculture and Food Research Organization

As the number of agricultural workers decreases, interest in smart agriculture for saving labor and improving productivity is increasing. The Japanese government has also declared the goal of "almost all agricultural workers will practice data-driven agriculture by 2025" (Integrated Innovation Strategy 2019). To implement agriculture using data, a system that benefits producers and local communities is required. For example, we received feedback from producers who expect a system that can stably produce high-price agricultural products and new competitive varieties without relying on experience. Therefore, income increases and local governments can expect a system that can maintain and grow agriculture as a sustainable industry by passing down technology for cultivating agricultural products and improving brand power.

Under these circumstances, with the aim of improving agricultural productivity and income of producers, we signed a collaboration agreement with the National Agriculture and Food Research Organization (NARO) to promote regional implementation of data-driven agriculture. As the first step, we will cooperate with NARO and public agricultural testing and research centers to digitize the paper-based cultivation manuals currently owned by both parties and store them in the cloud. We will also provide a mechanism for automatically linking the digitized cultivation manuals and the environmental data (temperature, etc.) acquired from the IoT sensing devices installed in the field. As a result, growers with little experience in cultivation can effectively obtain information and learn cultivation methods that enable optimal management of fields. For example, we will support the stable production by producers who have newly entered into the agriculture business and those who are new to the cultivation of high-added-value varieties. In addition, temperature and other standards required for optimal management of field environments for each region and type of agricultural product will be automatically displayed on terminals such as tablets for producers. This information can be used easily without any specialized knowledge of information and communication technology (ICT), so data-driven agriculture will become familiar in many regions.

Digitized cultivation manuals facilitate the transfer of technology and are expected to help maintain and grow agriculture as a sustainable regional industry. By incorporating environmental data accumulated from IoT sensing devices installed in the field and open data, such as weather data, in the digitized cultivation manuals, it will be possible to improve brands and enhance added value of all production

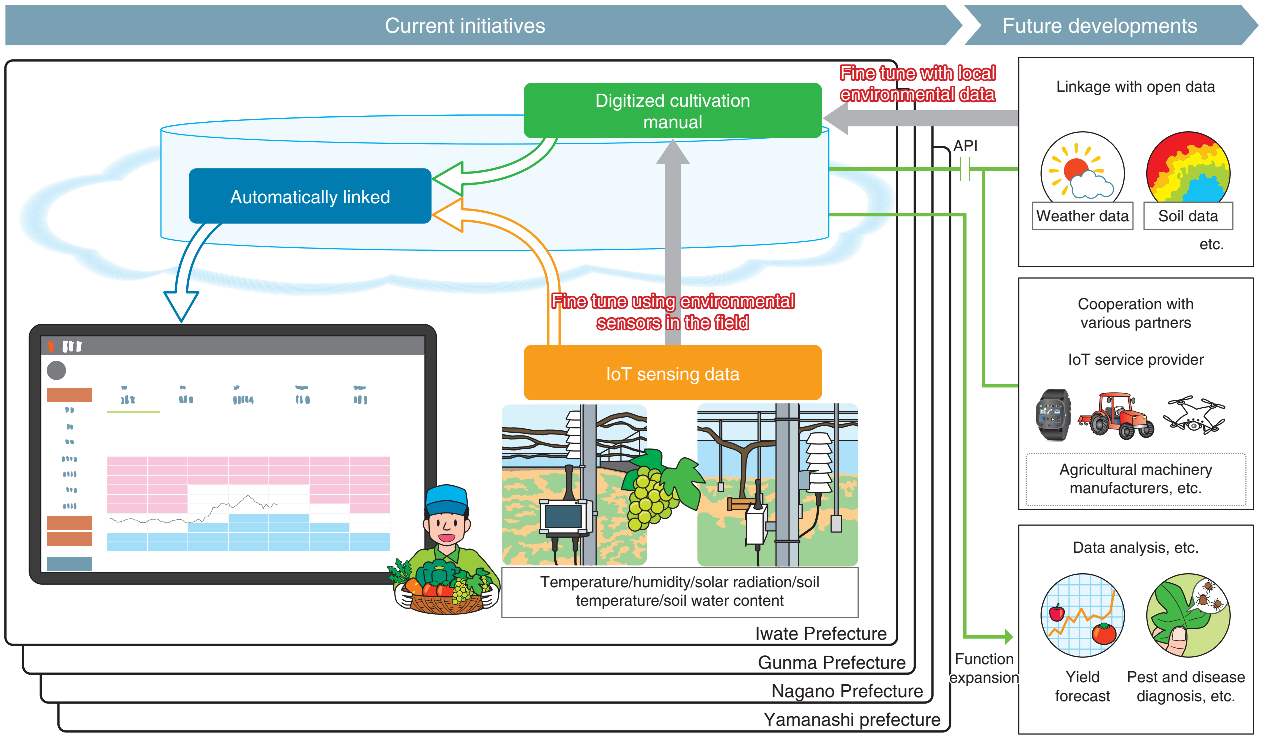


Fig. 5. Illustration of initiatives with NARO.

regions (**Fig. 5**).

5. Production and sales through high-tech greenhouse farming by NTT AgriTechnology

To demonstrate technology that effectively adapts techniques to the unique environment of Japan and demonstrate agricultural management that attains high productivity and practices profitable agriculture, we will establish our high-tech greenhouse facility to produce and sell the products that will be cultivated there.

Before the start of the construction of our greenhouse, we conducted technical research in various countries, mainly in Europe, and repeatedly discussed greenhouse design suitable to Japan's environment for several months. As a result, a very high strategic nature is reflected in our greenhouse. Automation through mechanization is essential to achieve high productivity. However, automation cannot be effective unless it works properly in a series of production activities. Therefore, we first determine the sales destination and market. On the basis of the determined needs, we then decide the final shipment form of the production item, set target values for size and shipping amount of one packaged product, and calculate the required daily production. After that, we specifically trace back to intermediate management (such as harvesting, irrigation, and spraying), planting, raising seedlings, germination, and sowing, and calculate the amount of work and required space for each process. Through simulating production activities, we can thoroughly identify bottlenecks and preferentially mechanize such activities to improve the overall process flow. After confirming that significant effects can be anticipated, we will select automation equipment and robots to be introduced. Some of this equipment will be introduced in Japan for the first time. By introducing such equipment, we expect cultivation efficiency to increase 50% and the number of workers to be halved. As a producer ourselves, by quantitatively demonstrating the effects of introducing technology and improving return on investment, we will gain the ability to provide producers around the world with confidence and certainty (**Figs. 6(a), (b)**).

(a) Planned construction site (construction started in January 2020 on a site of approximately 1 ha in Yamanashi Prefecture)

(b) Illustration of our farm

Fig. 6. High-tech greenhouse facility.

6. Future developments

According to the way the word “agricultural-community culture” is used in Japan, agriculture is closely related to community and human-resource development. When it comes to smart agriculture, we tend to focus on using ICT at production sites. However, this is not what we are aiming for. The role that we should play is to be involved in community development. Agriculture is an important industry that can serve as a starting point of community development. Inquiries from some local governments revealed that they want to rejuvenate their regions by providing an *ecosystem* to producers. That is, centered around agriculture, they want to create a food cluster of related industries such as physical distribution, warehouses, energy, processing, and environments necessary for workers (daycare centers, etc.). We cannot make half-hearted effort to meet their expectations. The projects described above will take several years to complete. Even so, we are committed to responding to local sentiment. We aim for highly productive agriculture in Japan, which has been negatively affected by an aging society with a low birthrate, to reach a high enough level to help the world’s agriculture cope with future explosive population growth.

References

[1] “Local IoT to Solve Problems in Primary Industry—Challenging Urban Development Starting from Agriculture, Forestry, Livestock, and Fisheries,” Supervised by NTT EAST and NTT AgriTechnology, Rick Telecom, 2020 (in Japanese).

[2] “Practical IoT that Makes a Difference in the Region—Examples of Utilization of Local Government, Agriculture, and Warehouses and Factories,” Supervised by NTT EAST, Rick Telecom, 2018 (in Japanese).

[3] “Group Company Visit: NTT AgriTechnology Corporation,” NTT Technical Journal, Vol. 31, No. 11, pp. 48–51, 2019 (in Japanese).

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Development of the Food and Agriculture Value Chain by Using "Tsunagu" Distribution Platform

Chizuko Kawano and Mayumi Kanehira

Abstract

NTT DOCOMO conducted a field experiment of the Let's Eat Local Food Project in February 2019. In this experiment, we demonstrated a mechanism that enables the purchaser to purchase agricultural products at a lower price, even if the seller of the products sells at a higher price than before, by reducing the logistics cost and time involved in collection and delivery of agricultural products. Until now, our *smart agriculture* initiatives have been focused on improving productivity throughout the production process. Going forward, we will support Japan's agricultural industry from production to distribution and sales by developing the food and agriculture value chain.

Keywords: food and agriculture value chain, smart agriculture, food loss

1. Smart agriculture initiatives by NTT DOCOMO

NTT DOCOMO has been striving to improve the efficiency of production processes for agricultural products as part of the initiatives of *regional co-creation* and *solving social issues*. In particular, we have been working on environmental sensors—which enable remote monitoring of conditions in fields, cowsheds, and fishing grounds—as well as remote monitoring and image analysis using drones. These efforts have made it possible to improve efficiency and save labor in the production process and boost production volume. However, the income of farmers is determined by a formula given as *price of agricultural products* × *quantity*. If the total amount of agricultural products becomes large, an oversupply will occur, and the price of products will tend to fall. Thus, even if the use of information and communication technology spreads across the industry and production volume of agricultural products overall increases, the agricultural products produced will be traded at low prices. This situation will not increase the income of farmers and further accelerate the shortage of workers. Feeling a sense of urgency about this situation, we collaborated with the software development company Tsunagu Co., Ltd., to study a distribution platform that makes it possible to trade agricultural products at an appropriate price and conducted a field experiment of the Let's Eat Local Food Project.

2. Overview of field experiment

To optimize the price of agricultural products, three requirements must be met: (i) streamline the current commercial distribution, (ii) trade at a price commensurate with value, and (iii) produce according to demand. In the case of normal market distribution, as shown on the left side of **Fig. 1**, agricultural products after being harvested incur significant cost and time through repeatedly assembling and transporting. To improve the conventional model whereby many intermediate players intervene, we established the food and agriculture platform called Tsunagu, which enables sellers and buyers to directly connect to one another and buy and sell agricultural products. In the field experiment, the seller was Japan Agricultural Cooperatives (JA) Yokohama and the buyers were corporations including restaurants (**Fig. 2**). This

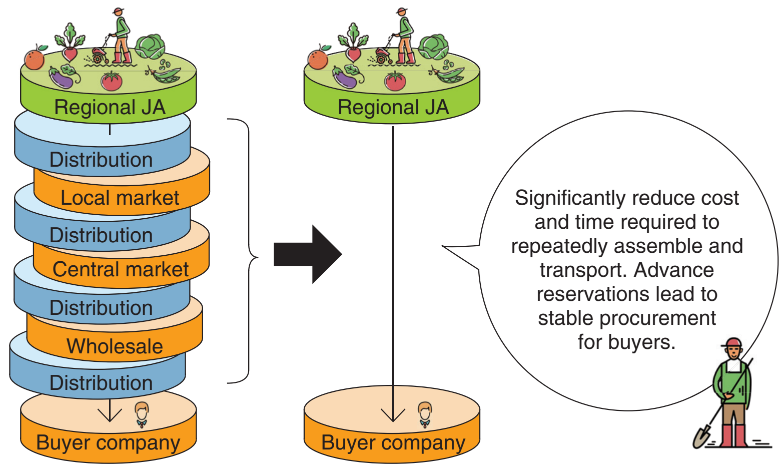

Fig. 1. Current distribution (left) and distribution with Tsunagu (right).

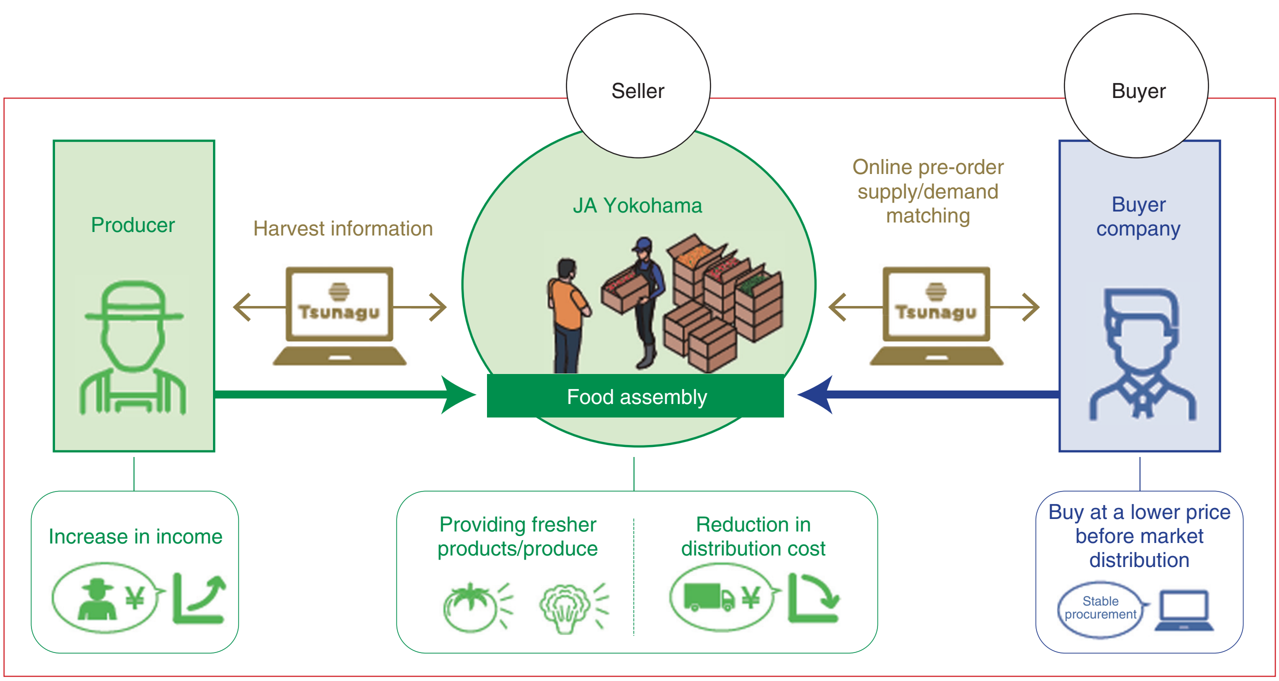

Fig. 2. Players in the Let's Eat Local Food Project.

platform differs from other such buyer-seller matching platforms in that the buyer and seller were both corporations (i.e., the "Bs" in business-to-business (B2B) model).

2.1 Significance of implementing a matching platform under the B2B model

To reduce the number of intermediate players as much as possible, the customer-to-business (C2B) and customer-to-consumer (C2C) models (where the first "C" is the producer), whereby products are sold directly by the producer to the buyer, are the most effective. Many other matching platforms take this approach; however, if the buyer is B, their business activity will be affected if the yield of agricultural products cannot be secured. In this initiative, therefore,

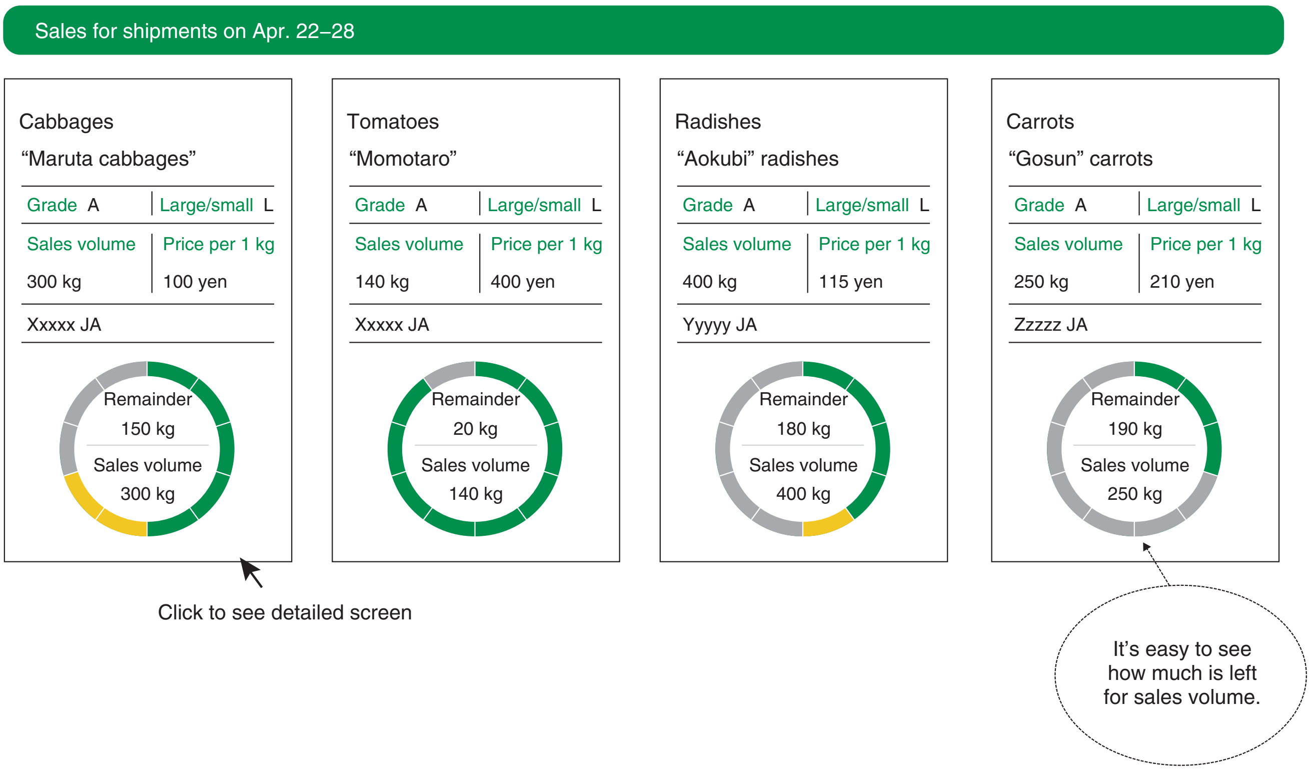

Fig. 3. Sales of agricultural products from the buyer’s perspective.

with a view to the following advantage, we implemented a B2B model in which the seller is JA.

- Agricultural products can be secured with a certain standard and quality set by JA.
- Yield for B can be secured by creating a producer group consisting of multiple producers of JA.

2.2 Matching method

The triggers for matching sellers and buyers used on Tsunagu consist of two pieces of information: *sales information provided by the seller* and *request from the buyer*. Regarding *sales information provided by the seller*, JA registers sales information about agricultural products, such as grades, quantity in one box (e.g., number of items/bundles/etc. and weight), and unit price, on Tsunagu about two weeks before the products are harvested. The buyer side views the information (**Fig. 3**) and makes a reservation for the desired products. By making advance reservations, buyers can reduce uncertainty about procurement and prepare fresh agricultural products at direct-sales prices in units of boxes. Distribution of sales via Tsunagu is not done by individual items, but by the box. In the event that supply and demand cannot be matched, products can be distributed to the market as before. One advantage of this supply-demand matching method is that the sales strategy can be flexibly set up, that is, if the matching is successful, the product is sold via Tsunagu; however, if the matching is not successful, the product is put on the market as usual.

For the other piece of trigger information, *request from buyer*, Tsunagu provides a function with which the buyer can show JA the information about the desired agricultural product when there is no such product in the sales information. For example, when *komatsuna* (Japanese mustard spinach) is not being sold, it is possible to make requests like “Request for *komatsuna*” or “2L-sized carrots instead of M-sized carrots.” The buyer side specifies the desired delivery date, grade, desired price, required amount, etc., and the seller accepts the request only when it can respond to the request. At that time, a request can be accepted even without satisfying all the conditions presented by the buyer. When each JA producer enters the amount, grade, size, desired price, etc. that it can provide, the buyer side can comprehensively judge the

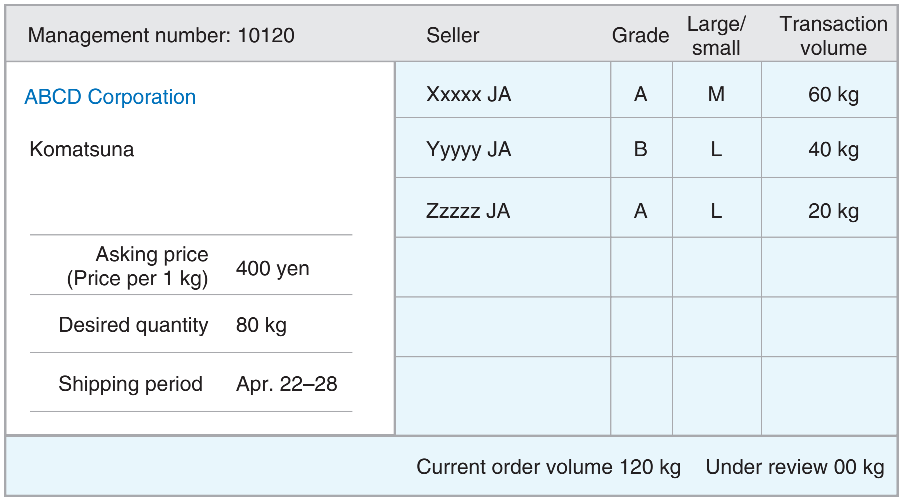

Fig. 4. Example of request application.

situation of each JA producer (**Fig. 4**) and makes a formal order for each producer. At that time, it is possible to buy from multiple JA producers instead of buying from only one. Doing so will broaden the range of transactions and enable more efficient purchases.

The *request from the buyer* is also advantageous for the JA side. Most agricultural products in Japan are produced based on farmer-oriented production systems, so-called product-out approach. As a result, sometimes not enough agricultural products are available, and sometimes their yield is too high, so products are discarded at the production site[*1] to maintain prices. On the contrary, if a market-in approach—whereby the production system is tailored to *request from the buyer*—is adopted, food loss is less likely to occur. Moreover, farmers can produce agricultural products while ensuring buyers for stable income, thus allowing them to continue farming with peace of mind.

2.3 Means of logistics

In this field experiment, the assembly and pickup method was adopted as a form of matching seller and buyer to reduce logistics, and the harvested agricultural products were picked up by the buyer at the JA collection point. In this manner, it is possible to reduce extra costs related to logistics and provide agricultural products with assured freshness. The price of one box of agricultural products is relatively low, so if the buyer's transport or those of other companies are used for the distribution, the shipping fee will account for a considerable percentage of the total cost of the product. The buyer may have to come and pick up the product themselves; even so, the assembly and pickup method gives a sense of security because the buyer can confirm the product at a single collection point.

3. Future developments

In this field experiment, in which it was assumed that the seller was JA, the agricultural products produced by each producer were collected by the buyer at the collection point. On the basis of the request from the buyer, it is possible to give guidance to growers while addressing the above-mentioned standards and quality issues and yield issues, thereby enhancing the benefit of a producer joining JA.

The Let's Eat Local Food Project was completed at the end of March 2020, after which commercialization of the proposed Tsunagu supply-demand matching platform will be considered. Agricultural products have an off-season[*2]; accordingly, to constantly acquire agricultural products, it is necessary to obtain them from different production areas according to the season. To that end, we will comprehensively verify

*1 Discarded at production site: If agricultural products are overharvested in various places, their prices are lowered, and shipping costs are increased even if they are shipped to market. Thus, to maintain the market price, the harvested products (e.g., vegetables) are disposed of at the production site.

*2 Off-season: The period during which agricultural products cannot be harvested. It depends on the place of origin and the crop.

how to introduce logistics and which features should be strengthened to more efficiently establish the matching between buyer and seller in collaboration with Tsunagu Co., Ltd. to provide a highly convenient platform. We will strive to expand this initiative to cover the whole process for sales of agricultural products to reduce food loss by producing agricultural products according to demand and maintain and stabilize agricultural products to revitalize Japan's agricultural industry.

Authors (from left): Mayumi Kanehira and Chizuko Kawano, NTT DOCOMO

Radio Frequency Equipment for High Maintainability and Availability in Remote Island Satellite and Disaster Relief Satellite Communications

Munehiro Matsui, Akira Matsushita, Mitsuru Nishino, and Fumihiro Yamashita

Abstract

The NTT Group uses satellite communications as a means of providing communications services to areas where deploying optical fiber or other communication facilities is infeasible such as remote islands or regions stricken by a natural disaster where residents are forced to take temporary refuge at evacuation centers. Against this background, NTT Access Network Service Systems Laboratories has been researching and developing a satellite communications system with the aim of making more efficient use of facilities and improving operability. This article introduces radio frequency equipment developed to achieve high maintainability and availability of remote island satellite and disaster relief satellite communications.

Keywords: power amplifier, maintainability, availability

1. Highly Efficient Satellite Communications System

The NTT Group uses satellite communications known for wide-area coverage and ease of network construction to provide communications services to areas where deploying a communication infrastructure made up of optical fiber, etc. is difficult. Such areas include remote islands and areas stricken by natural disasters where residents are forced to take temporary refuge at evacuation centers. NTT Access Network Service Systems Laboratories has been researching and developing the Highly Efficient Satellite Communications System (HESCS) for more efficient use and enhanced operability of satellite communications facilities. The NTT Group has been using this system to provide remote island satellite communications and disaster relief satellite communications services. A conceptual diagram of these services provided with the HESCS is shown in **Fig. 1**. Remote island satellite communications provides communications between a mainland station and island station if deployment of a submarine optical cable to that island is impractical, or it can serve as a backup circuit to a previously deployed submarine optical cable. Disaster relief satellite communications provides communications between a base station and terminal stations installed in a disaster-stricken area. It can rapidly deploy provisional circuits to evacuation centers in that area and provide special public telephones and Internet-connection services.

The basic configuration of the HESCS for such services is shown in **Fig. 2**. This system consists of satellite circuit-terminating equipment called the

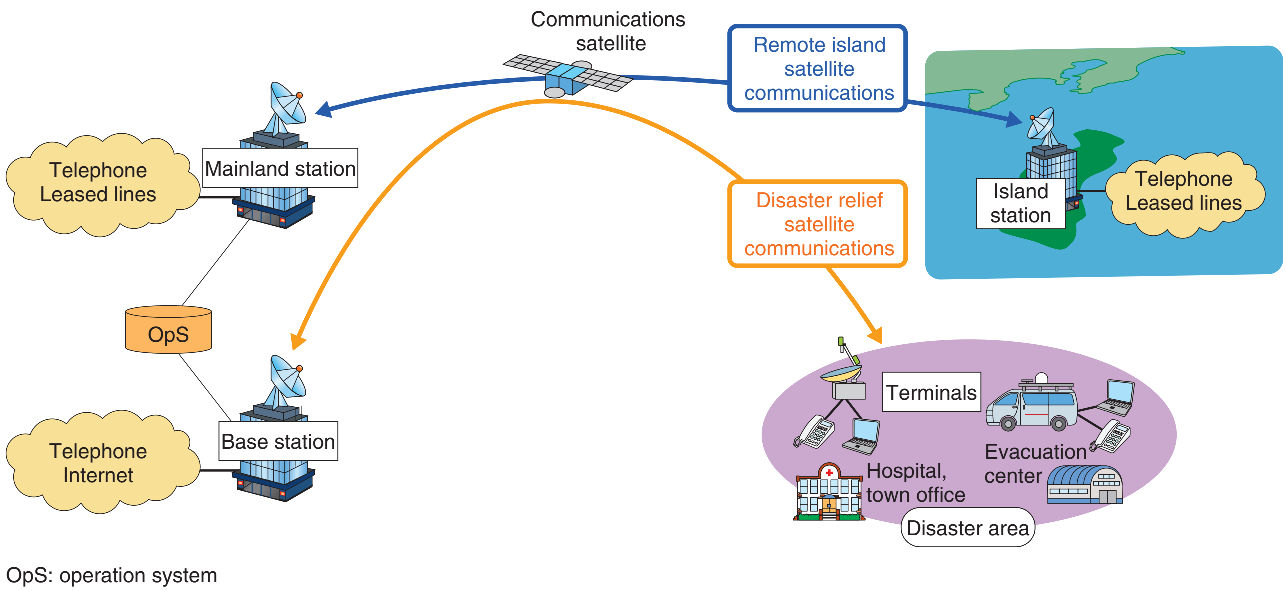

Fig. 1. Services provided with Highly Efficient Satellite Communications System (HESCS).

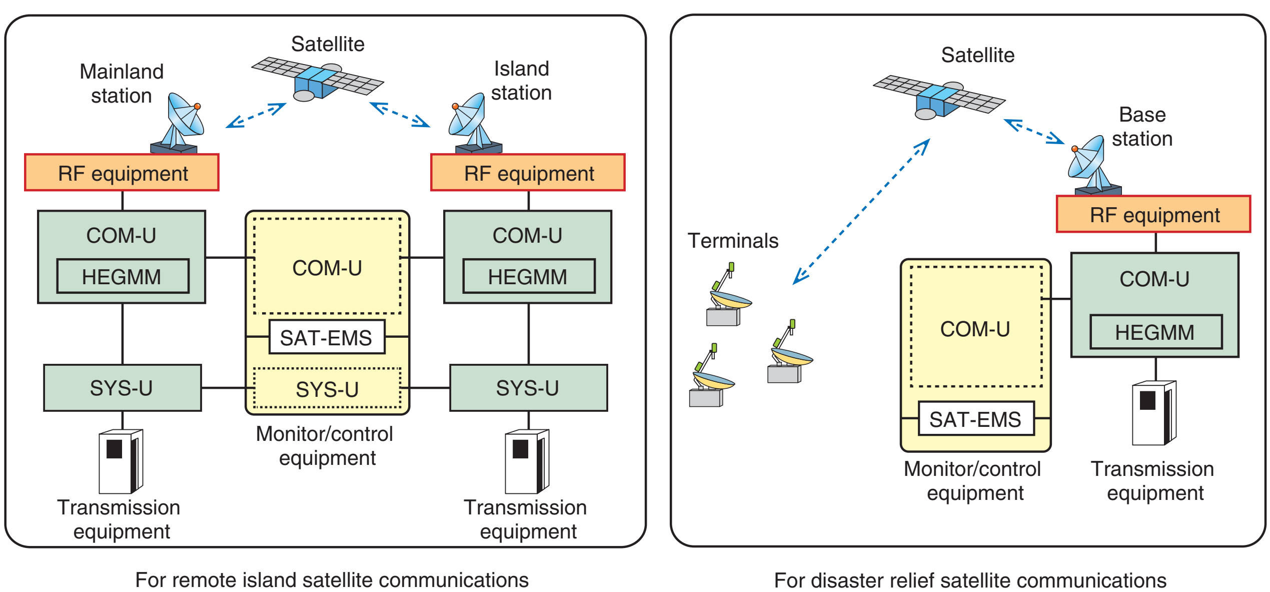

Fig. 2. Configuration of HESCS.

Common Unit (COM-U) equipped with the Highly Efficient Group Modem Module (HEGMM), satellite circuit-terminating equipment called the System Unit (SYS-U) that connects the COM-U to transmission equipment, the Satellite-Element Management System (SAT-EMS) that monitors and controls the above units, and radio frequency (RF) equipment, the focus of this article. The COM-U is a satellite communications modem that makes efficient use of satellite transponders by incorporating the HEGMM [1]. The SYS-U, meanwhile, links the mainland with a remote island for remote island satellite communications and makes circuit connections via satellite circuits. In addition, the RF equipment converts the intermediate

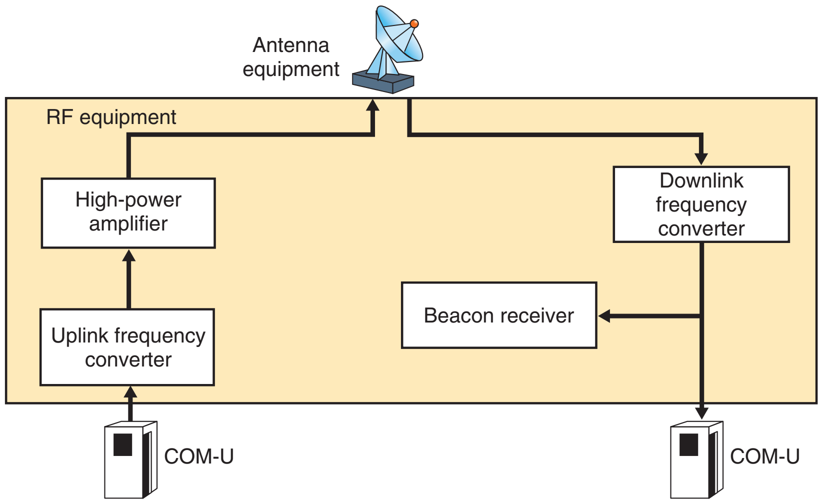

Fig. 3. Configuration of RF equipment.

frequency (IF) signals output by the COM-U to high-frequency radio signals (RF signals) for output via antenna equipment. The same RF equipment converts incoming RF signals to IF signals and outputs them to the COM-U. Finally, the SAT-EMS monitors and controls the various types of equipment making up the HESCS such as the SYS-U, COM-U, and RF equipment.

2. Development of RF equipment

The configuration of the RF equipment is shown in **Fig. 3**. The RF equipment consists of an uplink frequency converter, high-power amplifier, downlink frequency converter, and beacon receiver. The uplink frequency converter converts IF signals output from the COM-U to RF signals, and the high-power amplifier amplifies the power of those RF signals before outputting them to the antenna equipment. The downlink frequency converter, on the other hand, converts the RF signals received by the antenna equipment to IF signals. The beacon receiver controls transmission power and antenna direction based on the received beacon signals. The high-power amplifier, which uses large amounts of power, requires periodic maintenance to prevent failures and must therefore have high maintainability. It must also be able to provide a stable level of communications quality at all times through uplink power control that matches the current conditions such as the number of connected terminal stations. It must therefore have high availability. In the face of these requirements, NTT Access Network Service Systems Laboratories has developed a high-power amplifier for the HESCS to improve maintainability in remote island satellite communications and high-power-amplifier module for the HESCS to improve availability in disaster relief satellite communications.

(1) High-power amplifier for improving maintainability

Remote island satellite communications provides communications between a mainland station and remote island station via a satellite in geostationary orbit (at an altitude of approximately 36,000 km). A frequently used high-power amplifier in satellite communications is a traveling wave tube amplifier (TWTA). The TWTA, while capable of achieving high-output amplification at low cost, requires that the traveling tube be periodically replaced resulting in high maintenance costs. The maintenance of remote island station facilities, in particular, can increase maintenance costs due to travel expenses of maintenance personnel, shipping costs of parts and components, etc. On the other hand, technology for achieving a solid state power amplifier (SSPA), which requires no periodic replacement, has been progressing toward high-output capabilities.

Against this background, NTT Access Network Service Systems Laboratories developed an SSPA with a maximum output of 200 W for remote island satellite communications. A view of the interior section of this SSPA is shown in **Fig. 4**. The developed SSPA is equipped with four gallium nitride field effect transistors (GaN-FETs) enabling a maximum

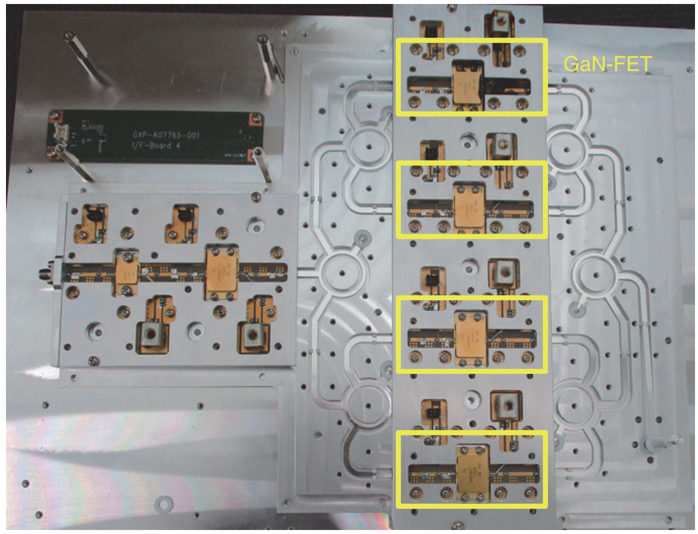

Fig. 4. Photograph of SSPA interior.

output of 200 W. A linearizer is also installed in the SSPA pre-stage to suppress interference that propagates outside the amplifier's own band and that arises during signal amplification in the nonlinear region of a power amplifier. The linearizer processes the signal prior to SSPA input, thereby suppressing the interference generated after SSPA output. Using a technique developed by NTT Access Network Service Systems Laboratories, linearizer parameters are adjusted so that the power ratio between the SSPA's own signal and outside-band interference reaches the required value [2]. Parameter adjustment originally had to be carried out using a multicarrier signal consisting of a maximum of about 30 carriers used during service operation. The developed technique, however, enables parameter adjustment to be completed with the signals of only two carriers.

(2) High-power amplifier for improving availability

Disaster relief satellite communications provides communications between a terrestrial base station and terminal stations via a satellite in geostationary orbit. For this service, a decision is made as to the number of connected terminal stations accommodated by a single carrier in a multicarrier signal as well as required transmission power per carrier. In the case of many terminal-station connections, the number of operating carriers increases, which requires the base station to have high transmission power. Base station operation takes on a redundant configuration to ensure that communications services are provided as usual even during a disaster. That is, the service uses one base station installed in eastern Japan and one in western Japan, and in normal conditions, each base station can cover all of Japan with the ability to connect to terminal stations anywhere in the country. These base stations function as a backup to each other, and in the event that either stops operating during a major disaster, the other will cover the entire country to enable communications with terminal stations. In the case of operation by a single base station, there will be many terminal stations to be connected to that base station, requiring high transmission power compared with normal conditions. At such a time, transmission power from a single high-power amplifier may not be sufficient and communications quality may drop, impeding communications services.

To mitigate this concern, NTT Access Network Service Systems Laboratories developed a high-power-amplifier module equipped with two high-power amplifier units. The equipment configuration and external view of this high-power-amplifier module are shown in **Figs. 5** and **6**, respectively. The module consists of two TWTA units as the high-power amplifiers plus a switch/power-divider unit and power-combiner/phase-synthesizer unit. The controller controls the operation of the two TWTA units and switch/power-divider unit and controls two modes. The first of these two modes is simple output mode, which is used during normal operation of the two base stations. At this time, only one TWTA in the module is operating while the other serves as a backup

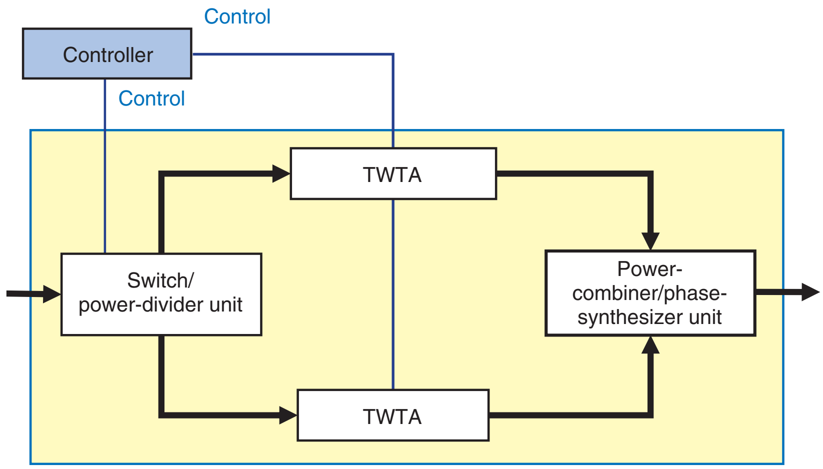

Fig. 5. Configuration of high-power-amplifier module for disaster relief satellite communications.

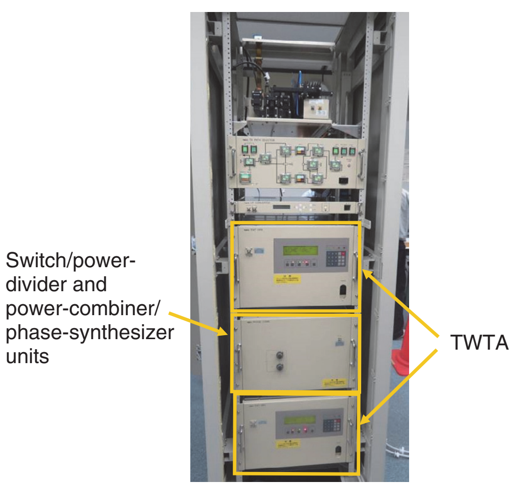

Fig. 6. External view of high-power-amplifier module for disaster relief satellite communications.

in the event of a failure. The second is combined output mode, which is used when only one base station is operating. At this time, both TWTA units of that module are put into operation, and the output from each are combined and output. This scheme prevents transmission power from becoming insufficient even when many terminal stations are connected during operation of only one base station, thereby maintaining communications quality.

3. Future plans

This article introduced RF equipment developed as part of NTT's HESCS with the aim of improving system maintainability and availability. Looking to the future, NTT laboratories are committed to researching and developing satellite communications systems including the development of advanced terminal stations with an eye to reducing costs and improving usability.

References

[1] H. Shibayama, K. Yano, I. Urata, J. Abe, A. Matsushita, and F. Yamashita, "Satellite Communications Modem Unit *COM-U*—Enhanced Maintenance, Operations, and Spectrum Utilization Efficiency of Satellite Transponders for Remote Island Satellite Communications and Disaster Relief Satellite Communications," NTT Technical Review, Vol. 16, No. 5, 2018. https://www.ntt-review.jp/archive/ntttechnical.php?contents=ntr201805ra2.html

[2] Y. Suzuki, K. Suzaki, M. Matsui, A. Matsushita, and F. Yamashita, "A Linearizer Adjustment Method to Reduce Intermodulation Distortion in Multi-carrier Amplification," Proc. of the 2018 IEICE Gen. Conf., B-3-8, Tokyo, Japan, Mar. 2018 (in Japanese).

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Activities to Revise the Radio Regulations on 5-GHz-band Wireless LANs at WRC-19 and ITU-R

Junichi Iwatani, Shinya Otsuki, Yusuke Asai, and Hideo Imanaka

Abstract

The World Radiocommunication Conference 2019 (WRC-19) organized by the International Telecommunication Union (ITU) was held from October 28 to November 22, 2019 in Egypt to discuss the revision of the Radio Regulations (RR). The RR specifies international rules for using radio worldwide. At this conference regarding the agenda item on 5-GHz-band wireless local area networks (LANs), especially for outdoor use and higher transmission power of the 5.2-GHz band (5150–5250 MHz), an agreement was successfully reached to revise the RR with conditions consistent with the national regulations in Japan. NTT had been engaged in activities on technical studies, proposal for the revision of the RR, and building consensus for the revision. NTT has also been responsible for this agenda item at WRC-19, ITU-R (ITU Radiocommunication Sector) and the related meetings as delegation members of Japan for three years. This article describes the process and results of the activities to revise the RR on 5-GHz-band wireless LANs and the revised RR.

Keywords: wireless LAN (WLAN), Radio Regulations (RR), WRC

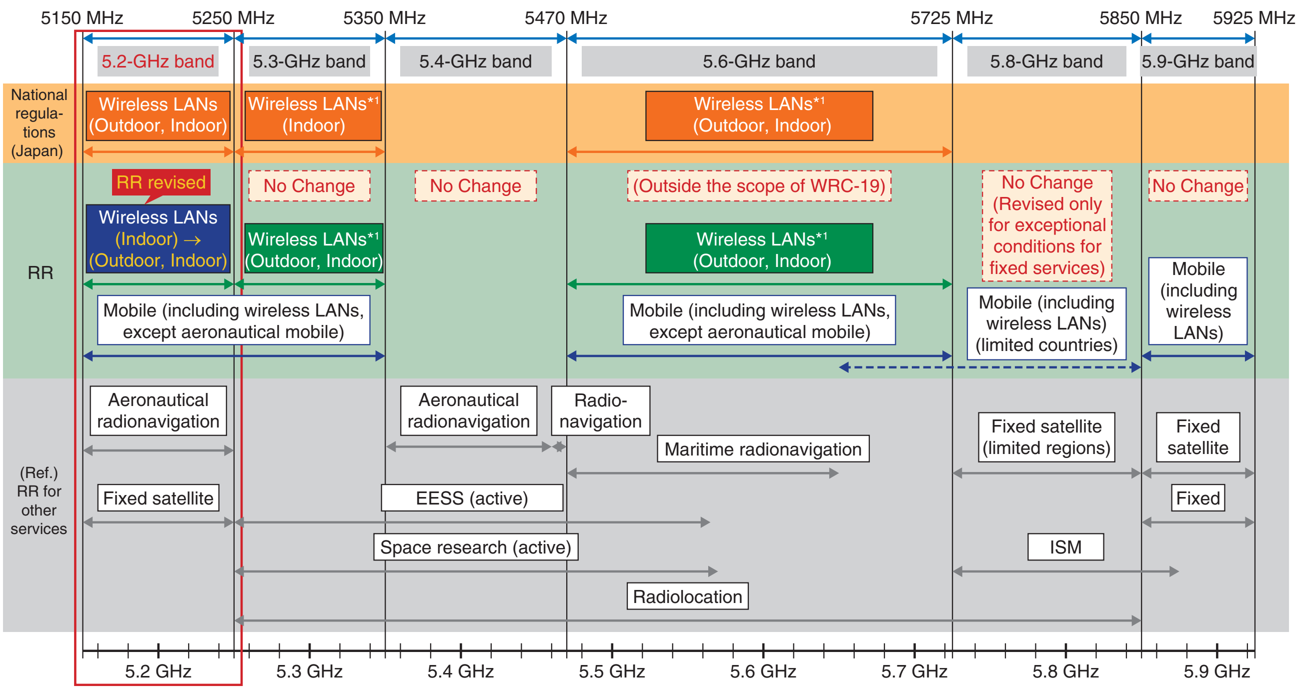
1. Modification of the Radio Regulations (RR) on 5-GHz-band wireless local area networks (LANs)

1.1 Regulations on 5-GHz-band wireless LANs

There had been concerns about the lack of frequency resources for wireless LANs due to the rapid increase in demand for them as a result of the widespread use of smartphones and tablet terminals. The results of studies in the International Telecommunication Union - Radiocommunication Sector (ITU-R) towards the World Radiocommunication Conference 2015 (WRC-15) showed that an additional 300–425 MHz frequency bandwidth was needed for 5-GHz-band wireless LANs. **Figure 1** shows the available frequency bands for 5-GHz-band wireless LANs.

Under the previous RR, for the 5.3-GHz band (5250–5350 MHz) and 5.6-GHz band (5470–5725 MHz), outdoor use is allowed with higher transmission power with the maximum equivalent isotropically radiated power (EIRP) of 1 W. However, for these frequency bands, the restriction of dynamic frequency selection (DFS) is required which changes the frequency band of wireless LANs when a radar signal was detected. This causes termination of data transmission when a radar system is used. For the 5.3-GHz band, national governments are required to ensure that predominant use is limited to indoors. For the 5.2-GHz band, while DFS is not applied, only indoor use is allowed with lower transmission power with the maximum EIRP of 200 mW.

With regard to Japan's national regulations, outdoor use is allowed only in the 5.6-GHz band with DFS, and only indoor use is allowed in the 5.3-GHz band with DFS. Outdoor use in the 5.2-GHz band is allowed only provisionally. For these reasons, relaxation of the conditions for 5-GHz-band wireless LANs is required, especially for outdoor use of the



*1 Restrictions of DFS (to detect and avoid radar signals) are applied to 5250–5350 MHz and 5470–5725 MHz. For 5250–5350 MHz, predominant use is limited to indoors.

EESS: earth exploration-satellite service
ISM: industry science and medical

Fig. 1. Frequency bands for 5-GHz-band wireless LANs.

5.2-GHz band since this frequency band is available without the restriction of DFS.

Based on this background, as agenda item 1.16 of WRC-19, revision of the RR was discussed in ITU-R and related meetings from 2016 to 2019 for (1) relaxation of the conditions of the 5.2-GHz and 5.3-GHz bands, and (2) additional frequencies of the 5.4-GHz band (5350–5470 MHz), 5.8-GHz band (5725–5850 MHz), and 5.9-GHz band (5850–5925 MHz) for wireless LANs.

1.2 National regulations in Japan and the activities of NTT

This section explains the relationship between the RR and national regulations. Usually, national regulations, such as the Radio Law in each country, are modified based on the revision of the RR. However, with regard to 5.2-GHz-band wireless LANs in Japan, the national regulations were provisionally modified to allow outdoor use with higher transmission power, which was led by NTT in 2018 prior to the revision of the RR. The modified regulations were planned to be reviewed based on the results of WRC-19. Therefore, to ensure that the 5.2-GHz band is available for outdoor use under the modified national regulations, it was necessary to revise the RR to have the conditions be consistent with these national regulations.

One of the NTT Group companies, NTT Broadband Platform, has been deploying wireless LANs to stadiums after the modification of the national regulations in 2018, and it has been imperative that the national regulations be maintained to allow outdoor use in the 5.2-GHz band. For these reasons, NTT has been engaged in WRC-19, ITU-R, and the APG (Asia-Pacific Telecommunity (APT) Conference Preparatory Group for WRC) meetings to revise the RR to maintain consistency with national regulations. These activities are coordinated with the Ministry of Internal Affairs and Communications (MIC) and the Association of Radio Industries and Businesses (ARIB) to collect opinions from the relevant companies in Japan.

2. Discussions at ITU-R and APG meetings

2.1 Plan for revision of the RR

From 2016 to 2019, the authors on behalf of Japan

Table 1. Options for the revision of the RR in the preparatory document for WRC-19 (February 2019).

Frequency band	Options	Proposal for the revision of the RR	Remarks
5150–5250 MHz	Method A1	No Change	
	Method A2	Outdoor use is allowed with the maximum EIRP of 4 W and a relaxed EIRP mask with an antenna elevation angle. Conditions for unwanted emissions are added.	Proposed by the US
	Method A3	Outdoor use is allowed with the same conditions as specified for 5250–5350 MHz (maximum EIRP of 1 W and the same EIRP mask with an antenna elevation angle with a limited number of wireless LAN devices).	Proposed by Japan
	Method A4	In-car use with the maximum EIRP of 40 mW, in-train use with the maximum EIRP of 200 mW, and use within unmanned systems (e.g. drones) with the maximum EIRP of 200 mW are allowed.	Proposed by France
	Method A5	In-car use with the maximum EIRP of 40 mW is allowed if an additional propagation loss of a car hull is at least 15 dB.	Proposed by Russia
	Method A6	More specified conditions on unwanted emissions are added to Method A2.	Proposed by Canada
5250–5350 MHz	Method B	No Change	
5350–5470 MHz	Method C	No Change	
5725–5850 MHz	Method D1	No Change	
	Method D2	Mobile use (including wireless LANs) is allowed except in North and South America (wireless LAN use is limited to indoor only with DFS).	Proposed by the UK
	Method D3	Countries are added where mobile use (including wireless LANs) is allowed exceptionally.	Proposed by the UK
5850–5925 MHz	Method E	No Change	

focused on the following three activities, (1) technical studies at ITU-R, (2) making a proposal in the preparatory document for WRC-19, and (3) building consensus at APG meetings.

In Japan's national regulations, in addition to outdoor use and high transmission power (maximum EIRP of 1 W), the conditions of an EIRP mask with an antenna elevation angle (the same conditions specified for 5250–5350 MHz) and the registration procedures for outdoor access points are included to reduce interference to other services [1]. Therefore, Japan focused on building consensus for the revision of the RR with the same or more relaxed conditions compared with the national regulations in Japan.

2.2 Technical studies at ITU-R

The discussions at the ITU-R meeting were mainly on whether more relaxed conditions are feasible for the 5.2-GHz band. Since outdoor use or higher transmission power may increase interference to other services, such as satellite feeder links or aeronautical radionavigation services, the discussions focused on the effect of increased interference and how to reduce it. The discussions were based on the results of technical studies for three years from several countries, such as Japan, the United States, China, France, Russia, and Globalstar (a satellite company in the US). However, no consensus was reached on the conclusions of the discussions, and several of these technical studies were included in the technical report. NTT on behalf of Japan presented the results of technical studies that show sharing is feasible under conditions consistent with the national regulations in Japan, which were also included in the technical report. This technical report was not finalized as an ITU-R Report for publication as initially planned, and it was to be referred to as a temporary version at WRC-19.

2.3 Making a proposal in the preparatory document for WRC-19

The preparatory document for WRC-19 (CPM Report: Conference Preparatory Meeting Report) was created at ITU-R in 2019 and was intended to be referred to at WRC-19, in which several options for the revision of the RR are included. The authors on behalf of Japan successfully added an option that is consistent with the national regulations in Japan. This document contains six options for the revision of the RR for the 5.2-GHz band (5150–5250 MHz) including Method A3 from Japan, as shown in **Table 1**.

2.4 Building consensus at APG meetings

The purpose of APG is to discuss the common proposals and views of APT for WRC, and five APG meetings were held towards WRC-19. The goal for Japan at the APG meetings was to complete an APT

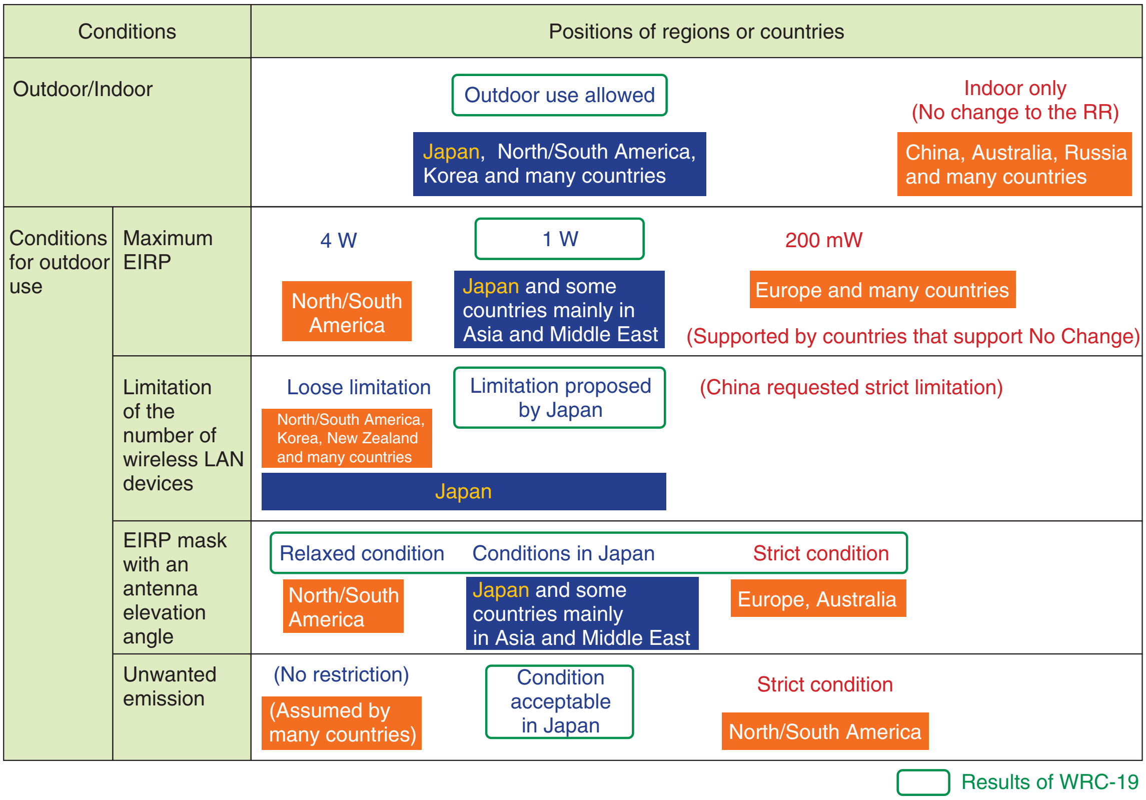


Fig. 2. Positions of regions or major countries for 5.2-GHz-band wireless LANs before WRC-19.

Common Proposal based on Method A3 it proposed. However, China and Australia supported No Change to the RR and strongly opposed the proposal due to concerns about interference to satellite services. Finally, neither any revision of the RR nor No Change was agreed as an APT Common Proposal. However, among the five options for the revision of the RR for the 5.2-GHz band, except No Change, the APT members agreed that the possible option should be limited to Method A3 proposed by Japan, and this agreement was included in the output document of the last APG meeting as an APT Common View. After the APG meetings, Japan took the lead to draft a multi-country proposal by nine APT countries for WRC-19 based on Method A3 and submitted a contribution to WRC-19.

3. Discussions at WRC-19

3.1 Situations before WRC-19

WRC-19 was held from October 28 to November 22, 2019 at Sharm el-Sheikh in Egypt to discuss the revision of the RR [2]. Thirty-one contributions were submitted regarding 5-GHz-band wireless LANs. **Figure 2** shows region or major country positions on the 5.2-GHz band based on the contributions. Many countries, such as China, Australia, and Russia, opposed to allow outdoor use, and the acceptable conditions among countries that support outdoor use, such as Japan, North and South America, Europe, and the Republic of Korea, significantly differed. As mentioned above, the ITU-R technical report was not finalized, and the common proposal was not agreed in several regions including APT. Accordingly, it was quite difficult to reach a unanimous agreement with regard to the revisions of the RR based on any proposal from Japan or other countries including the proposal for No Change.

The authors have coordinated with the MIC on the plan for the discussions on the 5.2-GHz band and set the primary goal of revising the RR for all regions under the conditions that cover Method A3 proposed by Japan or the conditions that are equivalent to Method A3 without any concern on implementation. However, the authors and the MIC realized that this primary goal was extremely difficult to achieve after analyzing the contributions from other countries or regions. The authors also coordinated with the MIC and prepared several plans on compromise before and during the conference.

3.2 Discussions at WRC-19

The discussions on 5.2-GHz-band wireless LANs, which started at the beginning of the conference, had been complicated and continued until the last day of the conference including weekends and late evenings.

During the first and second weeks, the countries or regions repeatedly argued their proposals, and there was no progress in the discussions with no prospect for consensus. The authors considered a compromise solution that allows outdoor use with the maximum EIRP of 1 W only for APT regions and had discussions with China and Australia as APT members since they opposed the revision of the RR. However, their position did not accept the maximum EIRP over 200 mW; thus, no consensus was reached during these discussions.

In the third week, as a result of tough negotiations, Japan and China reached a consensus to allow outdoor use with the maximum EIRP of 1 W under the condition that limits the number of wireless LAN devices with a certain outdoor use ratio. However, the Republic of Korea and New Zealand, who supported Method A3 proposed by Japan, were concerned about the limitation of the number of wireless LAN devices since it was difficult for them to implement such a limitation in their countries. This means that it was difficult to include the compromise solution between Japan and China in the revised RR even as an exceptional condition applied only in the APT region.

In the last week, a compromise proposal to allow outdoor use with the maximum EIRP of 200 mW was presented by the countries that supported No Change to the RR, and many countries supported this proposal. However, Japan did not agree to it since the condition was not consistent with the national regulations in Japan. The authors explained that outdoor use with the maximum EIRP of 1 W was already implemented for operation in several countries including Japan and that the interference to satellite services is less compared with the case of 200 mW if an EIRP mask with an antenna elevation angle is used. The authors continued to persuade the countries that did not accept the maximum EIRP of 1 W to accept the proposals from Japan.

On the second-to-last day of the conference, the chair of this agenda item determined that there was no prospect for consensus at the official sessions, and an unofficial meeting was held among the delegates from the regions and major countries including Japan to discuss and finalize the draft of the revised RR. At this unofficial meeting, no consensus was reached with regard to more relaxed conditions, such as Method A2 proposed by the US, due to concerns about increased interference to other services. With regard to Method A3 proposed by Japan, however, there was a discussion that interference would be less than that of Method A2 and the results of technical studies for the proposal, which were continuously discussed in ITU-R meetings, would be reliable. Accordingly, a consensus was successfully reached on the final draft of the revision of the RR, which was slightly modified from Method A3 proposed by Japan.

On the last day of the conference, at the plenary session of WRC-19, this agenda item was discussed as the last agenda item, and the revision of the RR was approved without any explicit objection. While several countries, such as the US and the Republic of Korea, made reservations since they may use more relaxed conditions than the revised RR, this does not affect the revision of the RR or the national regulations in Japan.

3.3 Results of WRC-19

The results of the revision of the RR for 5-GHz-band wireless LANs are as follows [3]:

- 5.2-GHz band: The revision of the RR was approved with the conditions consistent with the national regulations in Japan, as shown in **Table 2.**
- 5.8-GHz band: No change to the RR with regard to wireless LANs (The current RR allows the use of mobile services—including wireless LANs—in limited countries, and there were proposals to add several countries to the list of the limited countries. However, they were added only for fixed services under the revised RR.).
- 5.3-GHz, 5.4-GHz, and 5.9-GHz bands: No change to the RR (There was no proposal to revise the RR for these frequency bands).
- 5.6-GHz band: No change to the RR (This frequency band was outside the scope of the agenda item of WRC-19).

4. Future plans

The revision of the RR at WRC-19 expands the frequency band for outdoor use of wireless LANs globally not only for Japan, and this enables deployment

Table 2. The revised RR for 5.2-GHz-band wireless LANs.

Item	Previous RR	Revised RR	(Reference) Current national regulations in Japan
Indoor/Outdoor	Indoor only	Outdoor use is allowed.	Outdoor use is allowed.
Maximum EIRP	200 mW	• 200 mW (Indoor, Outdoor) • 1 W (Indoor, Outdoor) (The conditions below(*1) are applied with EIRP over 200 mW.)	1 W (Indoor, Outdoor)
Limitation of the number of wireless LAN devices	–	(*1) The number of outdoor devices is limited and controlled if EIRP is over 200 mW. The outdoor use ratio is up to 2%.	Registration is required for access points with EIRP over 200 mW.
EIRP mask with an antenna elevation angle	–	(*1) One of the following conditions is applied for EIRP over 200 mW: • the same condition as specified for 5250–5350 MHz in the RR • EIRP up to 1 W with 5 degrees or less, and up to 200 mW otherwise • EIRP up to 1 W with 30 degrees or less, and up to 125 mW otherwise	The same condition as specified for 5250–5350 MHz in the RR
Unwanted emission	–	(*1) The restrictions in each country for EIRP of 200 mW are applied even if EIRP is over 200 mW.	Restrictions are defined.
Others	–	In-train use with EIRP of 200 mW and in-car use with EIRP of 40 mW are allowed.	In-train use is regarded as indoor use with the maximum EIRP of 200 mW.

of wireless LANs for a large coverage area with higher throughput. The authors expect the use of outdoor wireless LANs to increase with many use cases such as sports stadiums, information or video transmission in outdoor event or concert venues, information sharing for damage or evacuation during a disaster, and cameras for crime-prevention or monitoring with high-quality images. The use cases for broadband transmission of Wi-Fi offload may also be promising to reinforce the 5G (fifth-generation) mobile services and could provide telecommunication carriers worldwide, including NTT Group companies, with more business opportunities.

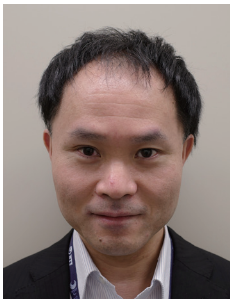
Moreover, sharing and compatibility among different wireless systems are important not only for 5-GHz-band wireless LANs; therefore, NTT Access Network Service Systems Laboratories will study efficient frequency-sharing mechanisms in the long term and engage in activities to revise national and international regulations.

References

[1] Outdoor use of wireless LANs, The Radio Use Web Site, MIC (in Japanese),
https://www.tele.soumu.go.jp/j/sys/others/wlan_outdoor/

[2] T. Ichikawa, K. Saito, J. Iwatani, and S. Otsuki, “ITU World Radiocommunication Conference (WRC-19) Report,” NTT Technical Review, Vol. 18, No. 5, pp. 49–55, 2020.
https://www.ntt-review.jp/archive/ntttechnical.php?contents=ntr202005gls.html

[3] Final Acts WRC-19, https://www.itu.int/pub/R-ACT-WRC.14-2019



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Case Studies of Telecommunication Failure Caused by Electromagnetic Noise from Inverters

Technical Assistance and Support Center, NTT EAST

Abstract

This article introduces case studies of telecommunication failure caused by electromagnetic noise generated from inverters, which are increasingly being installed near telecommunication facilities. This is the fifty-eighth article in a series on telecommunication technologies.

Keywords: switching noise, inverter, noise filter

1. Introduction

An inverter is a device for converting direct current (DC) voltage into alternating current (AC) voltage and enables energy-efficient conversion by turning (switching) semiconductor switches in circuits on and off. However, it is known that high-level electromagnetic noise (switching noise) occurs during switching operation. Accompanying the spread of energy systems, such as photovoltaic power systems and storage batteries, an increasing number of inverters are being installed near telecommunication facilities. As a result, telecommunication failures, such as audible noise in analog telephones and asymmetric digital subscriber lines (ADSLs) going down (hereafter, link down), have occurred in various parts of Japan. This article introduces cases of telecommunication failure due to electromagnetic noise generated from inverters handled by the Technical Assistance and Support Center (TASC), NTT EAST.

2. Case 1: Link down of ADSL due to electromagnetic noise generated from photovoltaic power system

2.1 Overview of telecommunication failure

A customer who manages a photovoltaic power system reported that link down of their ADSL frequently occurs (**Fig. 1**). The local maintenance personnel took countermeasures such as replacing the ADSL modem; however, link down persisted, so TASC carried out an investigation of the cause of the telecommunication failure.

2.2 Details and results of investigation

To observe electromagnetic noise in the ADSL modem, an oscilloscope (Yokogawa DLM4058) was used to measure the voltages on the telecommunication cable of the ADSL modem (measurement point (1): L1 to the earth) and on the power line cable (measurement point (2): cold line to the earth). The results showed that voltages with a repetition frequency of 180 kHz existed on the telecommunication cable (around 90 Vp-p) and on the power line cable (around 180 Vp-p) (**Fig. 2**). The magnetic-field strength around the modem was measured using a spectrum

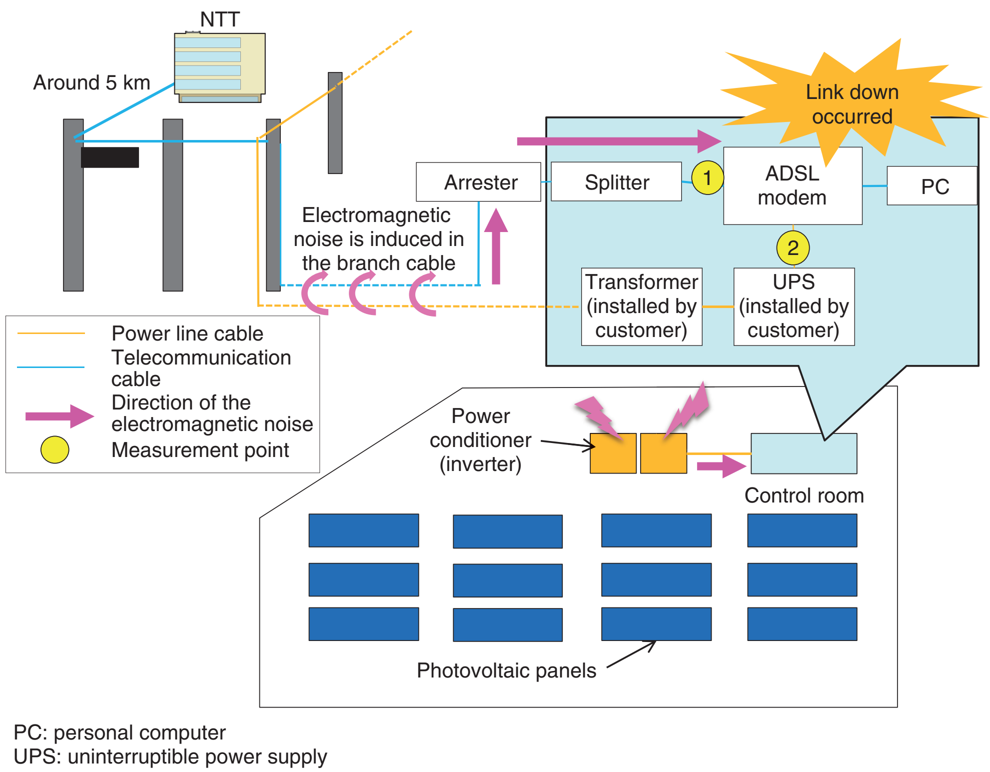

Fig. 1. Telecommunication failure state and facility configuration.

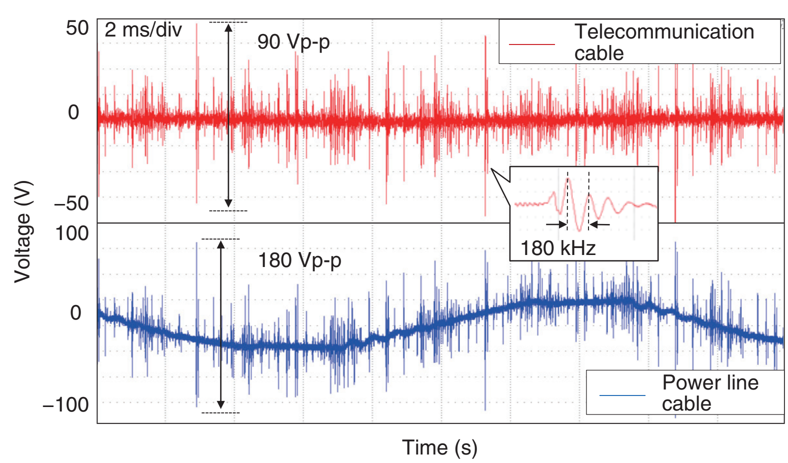

Fig. 2. Voltages on telecommunication and power line cables.

analyzer (KEYSIGHT N9020A) and loop antenna (ETS-LINDGREN6512). The results showed that the largest electromagnetic noise (92 dBμA/m) occurred around the power conditioner (with a built-in inverter) of the photovoltaic power system over the entire ADSL telecommunication band with a peak at 180 kHz (**Fig. 3**).

2.3 Cause and countermeasure

The results of the investigation indicated that this telecommunication failure was caused by electromagnetic noise generated by the power conditioner of

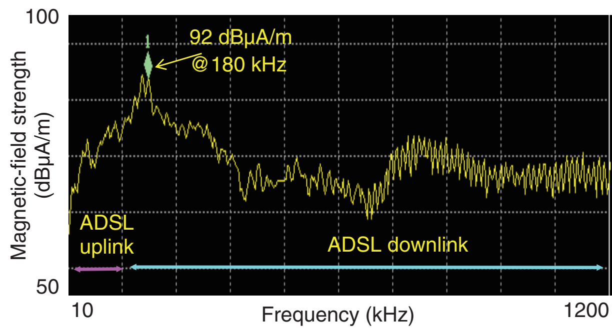

Fig. 3. Magnetic-field strength around inverter.

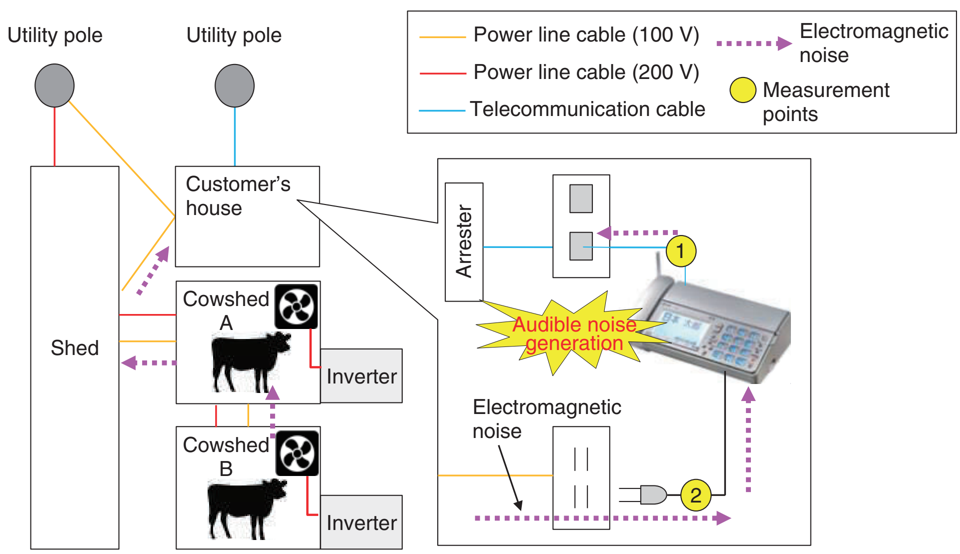

Fig. 4. Telecommunication failure state and facility configuration.

the photovoltaic power system being induced in the telecommunication cable (branch cable), which was laid out in parallel with the power line cable, and it affected the ADSL signal. As a countermeasure to this electromagnetic noise, a noise filter (V-MJS*1) was installed on the telecommunication cable (circuit-line side) of the ADSL modem. As a result of that countermeasure, the voltage generated on the telecommunication cable was reduced to 10 Vp-p and link down of the ADSL did not occur.

3. Case 2: Audible noise is heard during telephone calls due to electromagnetic noise generated by inverter for ventilation fans

3.1 Overview of telecommunication failure

A customer using a telephone fitted with a facsimile (hereafter simply referred to as the phone) reported that audible noise (a "bee..." sound) was always heard during telephone calls (**Fig. 4**). The local maintenance personnel replaced the wire with shielded one, but those measures did not resolve the telecommunication failure. Accordingly, TASC carried out an

*1 V-MJS, DMJ-100k, DMJ 6-2L: Currently, it is difficult to obtain these noise filters because they are no longer on sale, etc.; however, it is possible to respond to faults by using intelligent noise filters and accessory filters developed by TASC.

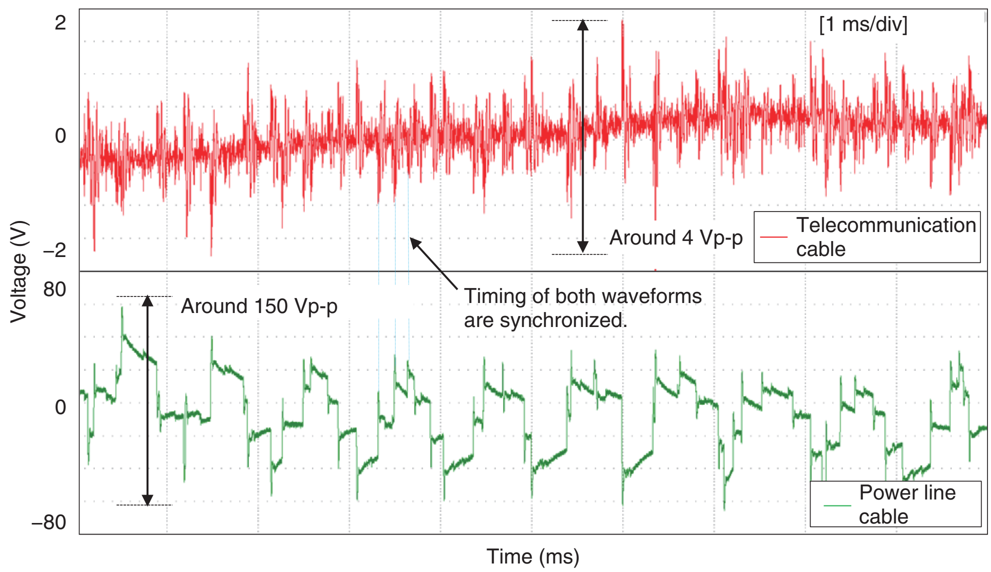

Fig. 5. Voltages on telecommunication and power line cables.

investigation of the cause of the failure.

3.2 Details and results of investigation

To observe electromagnetic noise entering the phone, an oscilloscope (Yokogawa DLM4058) was used to measure the voltages on the telecommunication cable (measurement point (1): L1 to the earth) and on the power line cable (measurement point (2): cold line to the earth) of the phone. The results showed that the voltages on the telecommunication and power line cables were around 4 and 150 Vp-p, respectively (**Fig. 5**). When the measured values were subjected to fast Fourier transform (FFT) processing, electromagnetic noise centered on 120 kHz was observed.

Additionally, the electromagnetic noise source was investigated by applying a noise propagation direction identification device (developed by TASC). The result of that investigation revealed that the inverter for the ventilation fan in cowshed B was the source of the electromagnetic noise. Accordingly, when the power of the inverter was turned off, the electromagnetic noise on the telecommunication and power line cables was reduced, and the audible noise on the phone line was eliminated.

3.3 Cause and countermeasure

According to the results, it is revealed that this telecommunication failure was caused by the electromagnetic noise, which is generated from the inverter, invaded to the phone through its power line cable. As a countermeasure against this electromagnetic noise, the phone was replaced with one without a power line cable and a noise filter (DMJ-100k*1) was installed on the telecommunication cable of the phone.

4. Case 3: CRC error on ISDN line due to electromagnetic noise generated by UPS device

4.1 Overview of telecommunication failure

A customer using an integrated services digital network (ISDN) line at a datacenter reported that a cyclic redundancy check (CRC) error occurred (**Fig. 6**). The local maintenance personnel resolved the error by installing a noise filter (DMJ 6-2L*1) on the ISDN line, but the cause of the telecommunication failure was not determined, so an investigation was requested.

4.2 Details and results of investigation

To observe electromagnetic noise entering the customer server, an oscilloscope (Yokogawa DL9040) and current probe (EMCO 91550-2) were used to measure the currents on the ISDN line (measurement point (1)), on the power line cable under the PDF*2 (measurement point (2)), and on the ground wire of the uninterruptible power supply (UPS) (measurement point (3)). As a result of FFT processing on

*2 PDF: power distribution frame

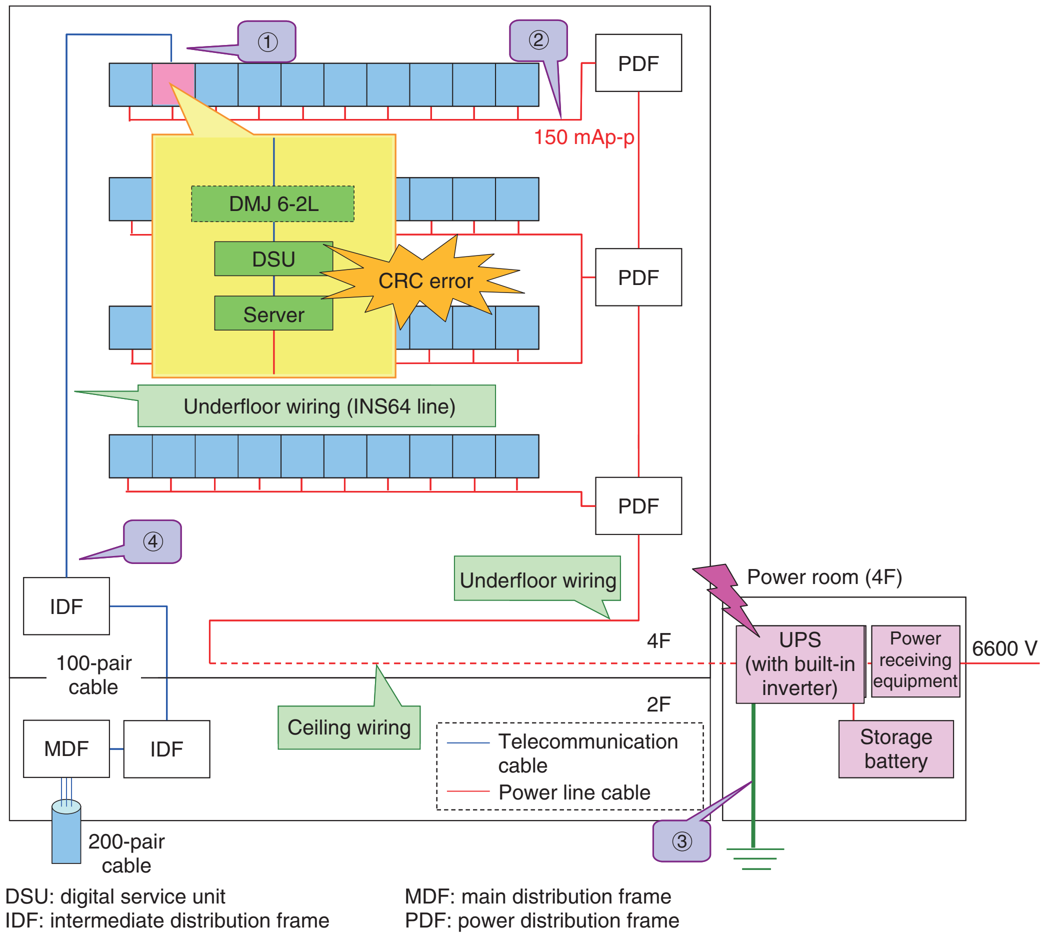

Fig. 6. Configuration of facility.

measured data, electromagnetic noise centered at 180 kHz was observed at all the measurement points; currents of –76 dBA (0.16 mA) and –39 dBA (11 mA) were observed at measurement points (1) and (2), respectively, and a largest current of –12 dBA (250 mA) was observed at measurement point (3) (**Fig. 7**).

A spectrum analyzer (Rohde & Schwarz PR100) and loop antenna (ETS-LINDGREN 6512) were used to measure the magnetic-field strength at 180 kHz inside the datacenter. The measurement results confirmed electromagnetic noise of up to 79 dBμA/m on the PDF side (**Fig. 8**). It was also observed that as for the power line cable side and ISDN-line side of the server, electromagnetic noise on the power line cable side was low and did not change even when the ISDN line was disconnected from the IDF[*3] (measurement point (4)).

4.3 Cause and countermeasure

According to the results, it is revealed that this telecommunication failure was caused by the electromagnetic noise, which is generated from the UPS, invaded to the DSU[*4] through the power line cable, PDF, and IDF. As a countermeasure against this electromagnetic noise, a noise filter (DMJ 6-2L[*1]) was installed in the same manner as done by the local maintenance personnel.

5. Concluding remarks

Cases of telecommunication failure due to electromagnetic noise generated from inverters handled by TASC were introduced in this article. Although the electromagnetic noise troubles are completely solved

*3 IDF: intermediate distribution frame
*4 DSU: digital service unit

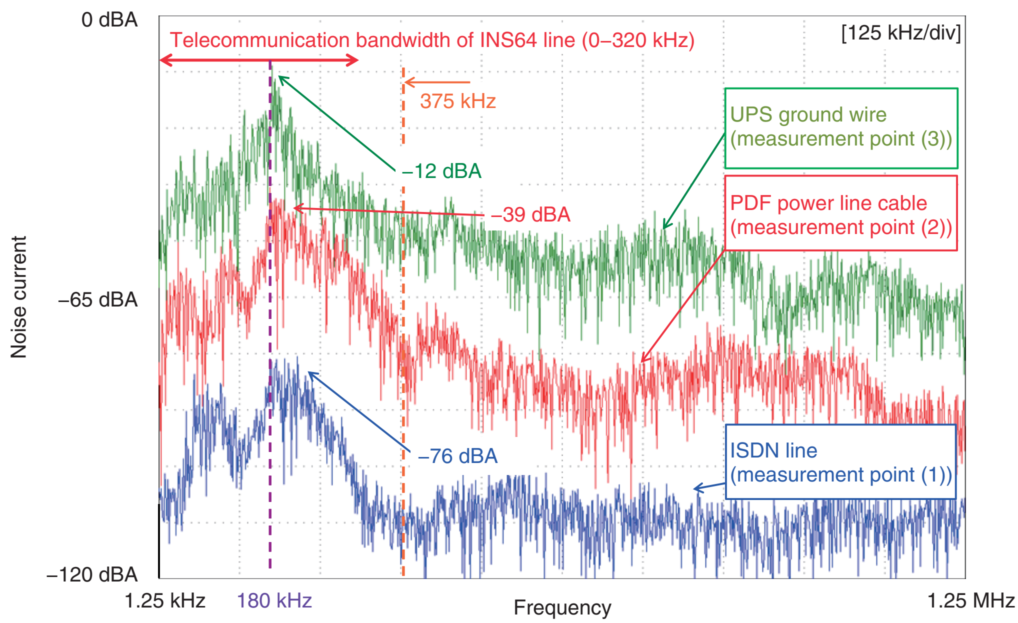

Fig. 7. Current spectrum at each measurement point.

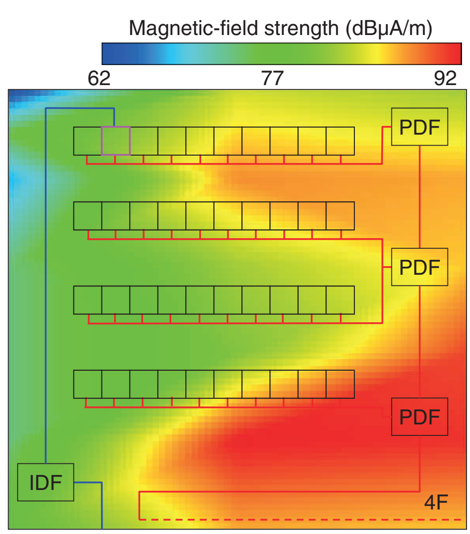

Fig. 8. Distribution of magnetic-field strength at 180 kHz.

by rejecting electromagnetic noise sources, it is possible to recover from a telecommunication failure by using a noise filter, as shown in the example cases. TASC developed a tool called an intelligent noise filter that can solve these electromagnetic noise faults without requiring specialist skill [1]. At the EMC Engineering Group in TASC, to reduce telecommunication failures caused by electromagnetic noise, radio, induction, lightning, etc., and to improve the reliability of telecommunication services, we will continue to actively engage in technical cooperation and development and disseminate our technologies through activities such as technology seminars.

Reference

[1] "Development of Intelligent Noise Filter for Skill-less Electromagnetic Noise Countermeasures," NTT Technical Journal, Vol. 30, No. 4, pp. 61–63, Apr. 2018 (in Japanese).

External Awards

CHEMINAS Young Innovator Award
Winner: Tetsuhiko Teshima, NTT Basic Research Laboratories
Date: March 13, 2020
Organization: Society for Chemistry and Micro-Nano Systems (CHEMINAS)

For the fabrication of devices for dynamic manipulation of cells using microfabrication technology.

The achievements he has made since he was a student on the discovery of the unique physical phenomenon of self-assembly based on microfabrication technology and the application of devices fabricated using this phenomenon to cell and tissue engineering were highly evaluated.

Best Paper Award
Winner: Yoji Yamato, NTT Network Service Systems Laboratories
Date: March 26, 2020
Organization: The 8th IIAE International Conference on Industrial Application Engineering 2020 (ICIAE 2020)

For "Proposal of Automatic Offloading for Function Blocks of Applications."
Published as: Y. Yamato, "Proposal of Automatic Offloading for Function Blocks of Applications," ICIAE 2020, pp. 4–11, Shimane, Japan, Mar. 2020.

IPSJ Outstanding Paper Award
Winner: Mana Sasagawa, Arinobu Niijima, Ryosuke Aoki, Tomoki Watanabe, NTT Service Evolution Laboratories; Tomohiro Yamada, NTT Electronics Corporation
Date: March 27, 2020
Organization: Information Processing Society of Japan (IPSJ)

For "A Food Texture Display with Hardness and Shape by Jamming."
Published as: M. Sasagawa, A. Niijima, R. Aoki, T. Watanabe, and T. Yamada, "A Food Texture Display with Hardness and Shape by Jamming," IPSJ Journal, Vol. 60, No. 2, pp. 376–384, Feb. 2019.

Award for Science and Technology (Development Category), the Commendation for Science and Technology by the Minister of Education, Culture, Sports, Science and Technology
Winner: Ken Nakamura, NTT Media Intelligence Laboratories; Takayuki Onishi, NTT R&D Planning Department; and Koyo Nitta, NTT Device Innovation Center
Date: April 7, 2020
Organization: Ministry of Education, Culture, Sports, Science and Technology, Japan

For the development of high-quality H.265 video coding LSI and equipment.

The Young Scientists' Prize, the Commendation for Science and Technology by the Minister of Education, Culture, Sports, Science and Technology
Winner: Keiko Takase, NTT Basic Research Laboratories
Date: April 7, 2020
Organization: Ministry of Education, Culture, Sports, Science and Technology, Japan

For her research on control of spin states and quantum transport in semiconductor quantum nanostructures.

Papers Published in Technical Journals and Conference Proceedings

Standardization Status of Immersive Live Experience in ITU-T SG16

H. Imanaka and J. Nagao

IEEE Communications Standards Magazine, Vol. 3, No. 3, pp. 15–16, September 2019.

ITU-T Study Group 16 (SG16) launched a new Question called Q8/16 in 2016 to study the standardization of Immersive Live Experience (ILE) as a new immersive service that enables audiences in remote sites to feel highly realistic sensations at the same time even if the venues are far from the event site.

Smooth Motion Parallax and High-resolution Display Based on Visually Equivalent Light Field 3D

M. Date, S. Shimizu, D. Mikami, and Y. Kusachi

Proc. of SPIE, Vol. 11402, Three-Dimensional Imaging, Visualization, and Display 2020, 1140205, California, USA, April/May 2020 (online only).

The light field concept can correctly and completely describe the distribution of rays in 3D space within the theory of geometrical optics. However, the quantity of data is huge and not easy to capture or process. Though light field 3D displays are almost ideal in principle, they are not actually practical given the huge number of pixels required. To compress the quantity of data, we proposed the visually equivalent light field (VELF), which uses the characteristics of human vision. Though several cameras are needed, VELF can be captured by a camera array. Reconstructing the ray distribution involves linear blending, but this process is so simple that we can achieve this calculation optically in the VELF3D display. It produces high image quality as its high pixel-usage efficiency overcomes the tradeoff between resolution and directional density of rays. In this paper, we summarize the relationship between the characteristics of human vision and VELF and give further details on the VELF3D display, which consists of a horizontal RGB stripe LCD panel and a parallax barrier, whose spacing width is almost the same as pixel pitch. Though it is similar to the conventional parallax barrier type autostereoscopic 3D display, it can reproduce correct rays for human vision. A high feeling of existence is induced by the display's smooth and exact motion parallax; its resolution is high enough to display characters. Head tracking allows the viewing zone to be greatly expanded while maintaining smooth motion parallax. Since image capture and display are very simple, VELF is suitable for real-time live action applications with high image quality.