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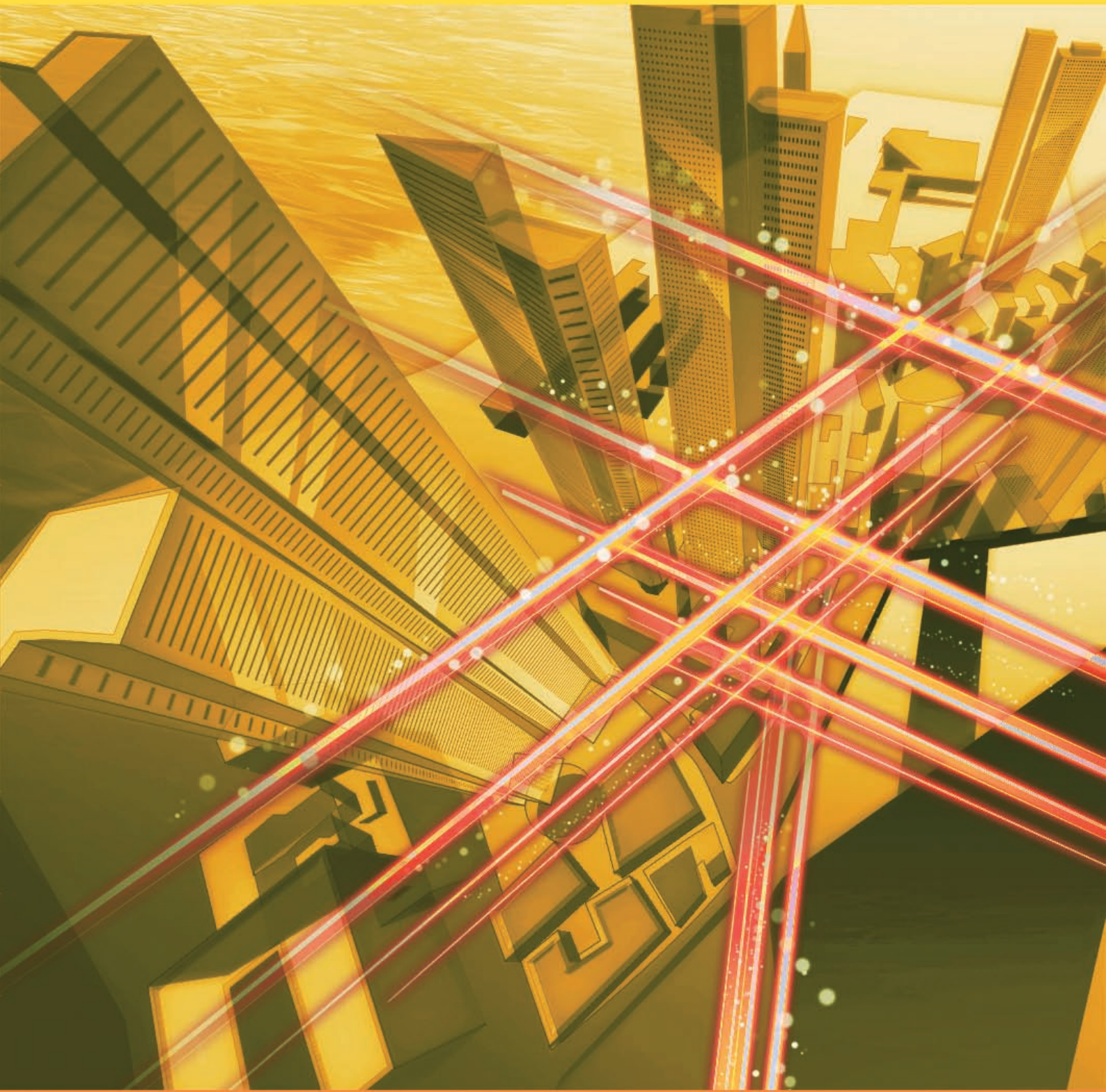

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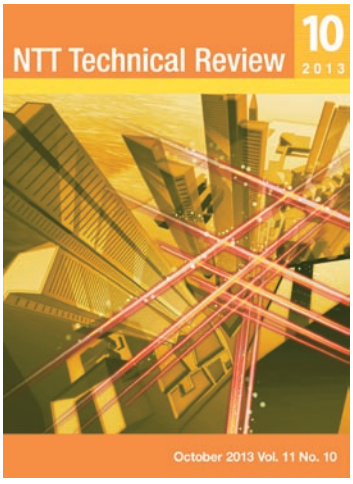

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The Cloud as Trigger for a Global Strategy Leveraging the Strengths of a Telecom Carrier

Akira Arima,
President & CEO, NTT Communications

Overview

NTT Communications is taking up the challenge of creating new business under its Vision 2015 growth strategy. What kind of approach is needed to achieve true globalization in an ICT market that demands quick results? We asked President & CEO Akira Arima to tell us about current trends in the ICT market and the strategy of leveraging the strengths of a telecom carrier in the field of cloud services.

Keywords: telecom carrier, cloud services, strategy

Providing global and total ICT outsourcing services as only a telecom carrier can

—Mr. Arima, in the three years since you took up your present position, how has NTT Communications been progressing?

These last three years have been a period of transition for our business. As for sales, operating revenue for the 2012 fiscal year of the NTT Communications (NTT Com) Group could not help but fall due to a structural decrease in revenue in voice communications and a revenue drop accompanying fierce price competition in the data-network business. Unfortunately, revenue increases in cloud services and other growth fields could not cover this decrease in revenue. Although we have not been able to apply a brake to this overall decrease in revenue, we nevertheless achieved a record operating profit since the founding of the company, following the record profit in fiscal year 2011. The issue we face now is boosting our topline growth. My goal is to increase our revenues without a moment's delay.

I feel that the efforts I have made since taking up this position in greatly restructuring the company's internal organization and making business processes more efficient are putting the company on the right path to profits.

Although the things that I want to do have not in essence changed since the time that I assumed this office, the pending issue is how to create new business as a means of increasing revenues, which is the foundation for growing profits under Vision 2015. Looking forward, I will promote global and total outsourcing services befitting a telecom carrier as an opportunity for our customers to convert their information and communications technology (ICT) to the cloud under our Global Cloud Vision.

—Please tell us how you plan to position and execute the Global Cloud Vision business strategy.

I believe that achieving corporate growth solely on the basis of the Japanese market is very difficult. Adding the word "global" to our strategy reflects my desire to make the provision of cloud services on a worldwide basis a core strength of our company.

As for the cloud, I can say that there are many

diverse ways of implementing and providing cloud services, and there are many companies competing in this field. Developing services that can differentiate NTT Com from other companies is essential. For us, the cloud, in the end, is a trigger. My aim in leveraging our strengths as a telecom carrier is not simply to provide cloud services but also to provide global and total ICT services that include our networks and datacenters connected to the cloud as well as general-purpose applications, security, operations management, and other attractive services.

Demonstrating all our strengths in providing total ICT services

—It would appear that safety and security are strong requirements in operating a cloud. What are your thoughts on this?

As companies continue to adopt ICT at an accelerated pace, it becomes more important than ever to maintain a safe and secure network environment.

For example, while a datacenter operator would ensure the reliability of the datacenter itself by securing a stable supply of power, our strength as a telecom operator would be to comprehensively provide total ICT services in a safe and secure manner. Some people probably have the idea regarding this strength that instead of a comprehensive, total provision of all services, it would be better for the customer himself to assemble a set of services from among those considered to be the best in the market in each field, such as the infrastructure, datacenter, or network field.

An ICT system, however, would generally become unusable if any one of its constituent components—such as the cloud, datacenter, or network—fails. Our strength lies in our ability to provide services under an ICT system that is totally under our control. For this reason, we pay close attention to maintaining close ties between the various sections within NTT Com so that we can fully demonstrate to our customers our strength in being a one-stop provider of services. Furthermore, as a dedicated network operator, we can embed the cloud within the network, which means that we can provide a cloud connection as a free service. While other operators charge for such a connection, we can provide it for free.

At present, we provide the same services in various regions around the world. We feature 146 global datacenters including those scheduled to be launched next fiscal year, and we have clouds set up in 10 bases spanning 8 countries. Moreover, to differentiate our clouds in the marketplace, we are rolling out functional enhancements such as automatic cloud migration (on-premise connection service), automatic virtual private network (VPN) connections, and integrated customer portal sites based on software-defined networking (SDN). We are also working on expanding our Wide Angle managed security service, on rolling out a new security platform (security information and event management (SIEM) engine) in 9 countries, and on setting up a security monitoring system at more than 450 locations in 14 countries.

These initiatives have been highly evaluated by third-party institutions. In just this past year, for example, NTT Com received the Best Cloud-based Service and Best Asian Telecom Carrier award at the Telecom Asia Awards 2013 (held April 2013) and the Grand Prize in the Security Services section at the MM Research Institute Awards 2013 (held in June 2013).

The inroads made into foreign markets by Japanese manufacturing firms and other enterprises have been truly remarkable, and we have not a few customers who obtain more than half of their profits from overseas operations. These customers are faced with a variety of issues resulting from M&A (merger and acquisition) activities with overseas companies such as the need to merge ICT systems and achieve greater operational efficiency. We are frequently receiving inquiries on whether we can provide the same quality of service overseas as in Japan and whether we can support global activities. If we cannot support our

customers in these ways, we will not be able to survive.

In addition, when thinking about our own transformation into a global enterprise, we will, of course, be providing services throughout the world from overseas bases, but I think that there is also a need to reform the company from inside Tokyo headquarters. One issue, for example, is the ratio of foreign employees. Ideally, there is a need for foreign representation at the executive level, but our efforts will begin with developing a multinational group of employees.

Face reality objectively and choose decisiveness over hesitation

—NTT Com's desire to globalize is understandable given the times and current trends, but moving with trends also involves some unknowns, which means that risk too must be taken into account. How do you assess risk?

Work at the executive level is, in one sense, an ongoing assessment of risk. As to whether one should hold back or more forward, I think it is better to advance than to stay still once the risks have been thought out. With cloud services, for example, we were confident that there was a real need for these services after reading market trends, so we felt that it was then just a matter of matching our expertise and business model with those needs.

Multinational companies in various countries around the world are now focusing on the Asia market. They're investing in Asia as a growth strategy, but when deciding where to establish a hub, their attention is unfortunately drawn not to Tokyo but to Hong Kong or Singapore. We nearly sold out the capacity of the datacenter we launched in Hong Kong in May to customers consisting of foreign corporations.

It is natural to keep in mind such data or feedback that can serve as grounds for decision making, but to promote even further growth, it is essential that on-site visits be made to collect comprehensive information as a basis for making intuitive decisions. For this reason, I see to it that we make fact-finding missions to our colleagues' sites scattered throughout the world to hold discussions and find out what our customers really need.

There is always the risk that some sort of problems will arise when expanding business, so it cannot be said that everything is going fine—there is no other choice but to deal with those problems accordingly. I believe that facing reality objectively is very important. Since we are always competing with other carriers for business, we must be able to respond to customer needs in a timely manner. The time limit for doing so is set by the market, and if we cannot propose solutions by that time, we will have achieved nothing.

—What is the state of collaboration with NTT R&D (Research and Development), which supports the business of NTT Com?

We are now in the process of receiving support from NTT laboratories as we convert the cloud infrastructure to a virtual network. While it might be easy to say that a "customer's existing system should be migrated to the cloud," doing so would normally involve lots of hard work. In contrast, our approach is to construct a virtual network between our datacenter and the customer's system and use it to move the customer's system directly to our cloud. This approach has received high marks from various quarters in the industry as the world's first auto-migration system.

Additionally, in the area of security services, we have developed a SIEM engine combining the know-how of NTT Com and NTT Com Security and the advanced technologies of NTT laboratories and have deployed it as a new security operations infrastructure. By adding blacklists that incorporate NTT Com proprietary know-how to this SIEM engine, we have

made it possible to reliably detect and deal with security risks such as by visualizing unknown threats that have previously been difficult to detect.

On the basis of these activities, we can say that without NTT laboratories we would not have these attractive cloud services to offer. I would hope that this use of research results in the business of NTT Com being a source of motivation for NTT researchers. I would like to strengthen our collaborative efforts with NTT R&D to provide products and services that draw responses such as "NTT technology is amazing" from customers around the world.

Differentiating NTT Com from its competitors by automating routine tasks and eliminating operating mistakes

—Mr. Arima, could you leave us with a message for all NTT Com employees?

In this era in which results are needed promptly, the provision of services is meaningless if they are not provided when needed. In this regard, the services that we can provide at that time will not always satisfy all customers. Even if 100% of our customers cannot be satisfied, it is important that we provide services promptly in a way that comes as close as possible to 100%.

This holds true for cloud services and network services. There are many cases in which competing companies are providing services using similar technologies, so how can we differentiate our services? The key is to provide an operation system and find ways of making operations more efficient. To this end, we are pursuing automation aggressively and are working, in particular, to automate routine tasks to cut down on as much human intervention as possible and eliminate operating mistakes.

I think that we are gradually achieving results and that customers are coming to use our reasonably priced services with confidence. We cannot allow ourselves to think that there is a market with no competitors. It is imperative that we quickly identify the problems enveloping our customers and that we deal with them promptly and appropriately.

Interviewee profile

■ Career highlights

Akira Arima joined Nippon Telegraph and Telephone Public Corporation (now NTT) in 1973 after graduating from Hitotsubashi University, Faculty of Commerce and Management. He served as Senior Vice President and Executive Manager of the Corporate Strategy Planning Department of NTT EAST, Senior Vice President of NTT, and Senior Executive Vice President of the Net Business Division, NTT Communications Corporation, before taking up his present position in June 2010.

NTT Group Global Business Strategy and NTT I^3

Eiji Kuwana

Abstract

NTT's Medium-Term Management Policy *Towards the Next Stage* calls for the early development and marketing of world-class cloud and security technologies in North America, the most competitive market in the world. To achieve this objective, NTT Innovation Institute, Inc. (NTT I^3) was established on April 1, 2013 as a research and development center in North America. This article introduces the NTT Group's global business strategy and the role of NTT I^3 in executing this strategy.

Keywords: global, security, cloud

1. Introduction

NTT's Medium-Term Management Policy *Towards the Next Stage*, announced in November 2012, introduced the goal of becoming *the value partner that customers continue to select*. The policy also describes two pillars of this new effort that are central to achieving this goal: global cloud services as the cornerstone of NTT's business operations, and highly competitive network services.

Global business is the driver of NTT Group growth. The stated goals are to double global earnings over the next five years, and in 2016, to earn $20 billion, with more than 50% of corporate earnings coming from global business.

To grow its global business, the NTT Group plans to enhance its consulting and solution-proposal abilities in order to implement effective solutions to its customers' business problems through information and communications technology (ICT). Thus, in addition to providing existing ICT services, there is a need for boosting paradigm-shifting services with an emphasis on cloud services, mobility services, and advanced analysis of diverse business data for prediction purposes (business analytics). There is also a need for operating ICT services and business processes in an end-to-end manner and for creating strong relationships with customers as a path to new service provision. The need is likewise felt to provide flexible and high-quality services that can combine the customer's existing information systems with NTT's cloud service menu and even with services of other companies (**Fig. 1**).

The NTT Group has formulated a system that drives a full lineup of business areas combining networks, datacenters, managed ICT, applications, solutions, services, and research and development (R&D) (**Fig. 2**). As reflected in the phrase *Next Value Partner for Transformation by Total Solution* (*NTT*), the NTT Group seeks to gain the trust of its customers by offering differentiated services and technologies that can support the transformation of their business models.

NTT may be a trusted brand in Japan, but from a global perspective, it is ranked number 2 among Japanese companies and number 16 among all companies in all industries in the world as announced by Brand Finance in its brand rankings [1]. While this brand recognition is certainly not unfavorable, there is still much room for improvement. To gain trust on a global scale, it is essential that NTT invest aggressively in new fields such as cloud computing and security and expand its global business.

2. Purpose of establishing NTT I^3

NTT I^3 was established on April 1, 2013 (**Fig. 3**) as part of the NTT Group's push toward globalization as

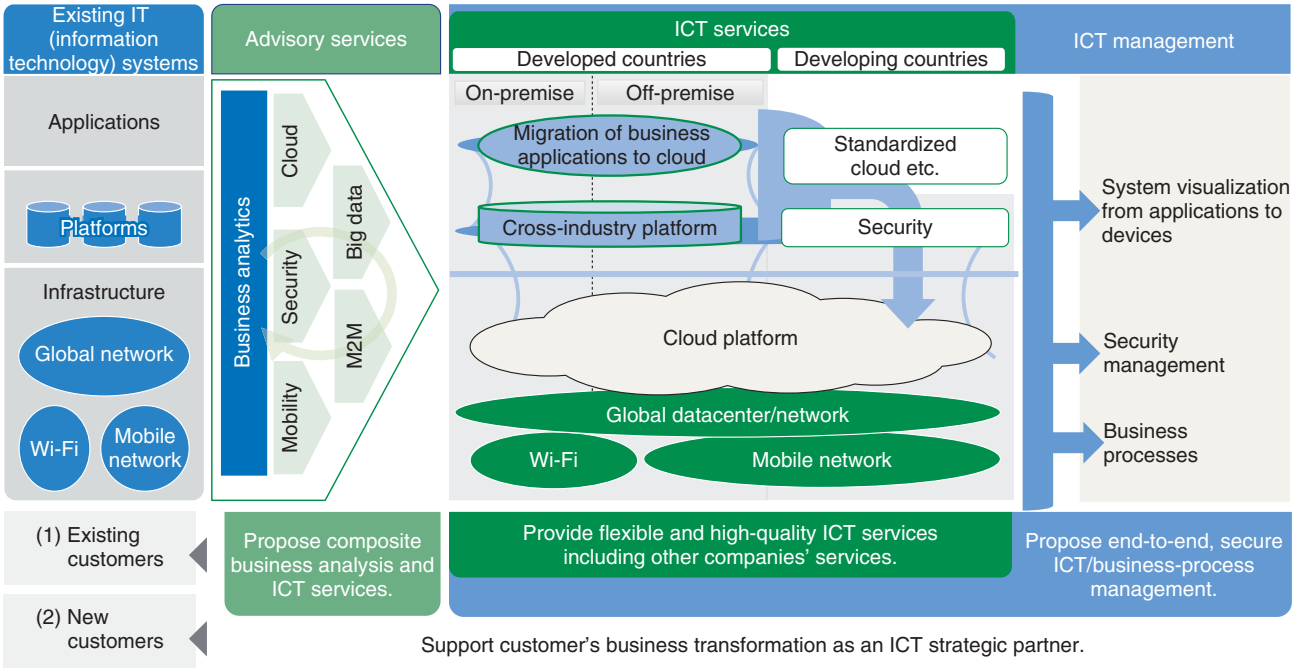

Fig. 1. Global business development in the NTT Group.

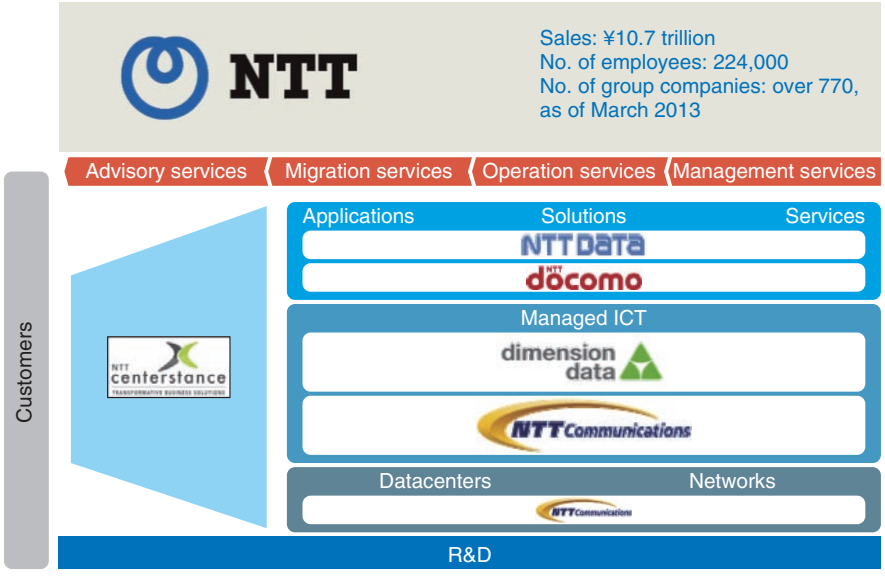

Fig. 2. NTT Group overview.

described above.

NTT I^3 seeks to become a global hub of NTT R&D and to provide new service creation to support the growth of the NTT Group's global business. To achieve this goal, it will focus on four activities, as summarized below.

Fig. 3. Map image depicting establishment of NTT I^3 as one of NTT's global holdings.

(1) Establish a market foothold: North America is considered to be an advanced region in terms of security, cloud computing, and other ICT technologies. By establishing a foothold in this market and developing competitive skills in North America, NTT I^3 can expand to other regions where markets can be opened up and can enhance its competitive skills in a wider variety of regions.

(2) Leverage the Silicon Valley ecosystem: Silicon Valley is a center of leading technology companies and a repository of information on cutting-edge technology. It is consequently an ideal location for developing strong partnerships with forward-looking companies and for quickly collecting information on advanced technologies. NTT I^3 will pursue service development making best use of the advantages of this region.

(3) Develop intellectual property (IP) for corporate global business: Being in close proximity to the North America market, NTT I^3 aims to convert technologies matching the businesses of NTT Group companies in North America into IP as quickly as possible and to bring that IP to this market. The overall plan is to modularize this IP and market it globally.

(4) Be a source of differentiation for the NTT Group: A key strength of the NTT Group is R&D, and the establishment of a center in North America is a major step forward for NTT in expanding its R&D. NTT I^3 aims to raise the level of product differentiation in the NTT Group by promoting applied R&D that can only be carried out in North America based on market needs while incorporating the results of basic research and development at the NTT laboratories of NTT Holding Company. Furthermore, while some service development has traditionally been undertaken under the separate visions of the various NTT Group companies, the promotion of applied R&D by NTT I^3 in the North American market is expected to contribute to group collaboration and to produce a synergetic effect among the NTT Group companies.

3. NTT I^3 approach to R&D

To meet the needs and desires of more than 10,000 enterprise clients around the world, NTT I^3 seeks to develop IP in cloud, security, mobility, and operations technologies with the aim of developing innovative services and providing superior operations (**Fig. 4**).

In particular, NTT I^3 focuses on innovations that contribute to the business agility of our clients. Business agility is built on five capabilities: (1) Exploring innovative technology-enabled business models, (2) responding rapidly to emerging competitive threats, (3) improving the speed at which these business models can be brought to the marketplace, (4) dealing with regulatory, security, and privacy threats in an increasingly connected global marketplace, and (5) doing all of these at a price that provides value to their customers and stakeholders. Today's organizations cannot compete successfully in the dynamic global marketplace without these capabilities.

NTT I^3 recognizes our clients' critical need for business agility and therefore drives innovation in three layers. Innovations at the top layer should

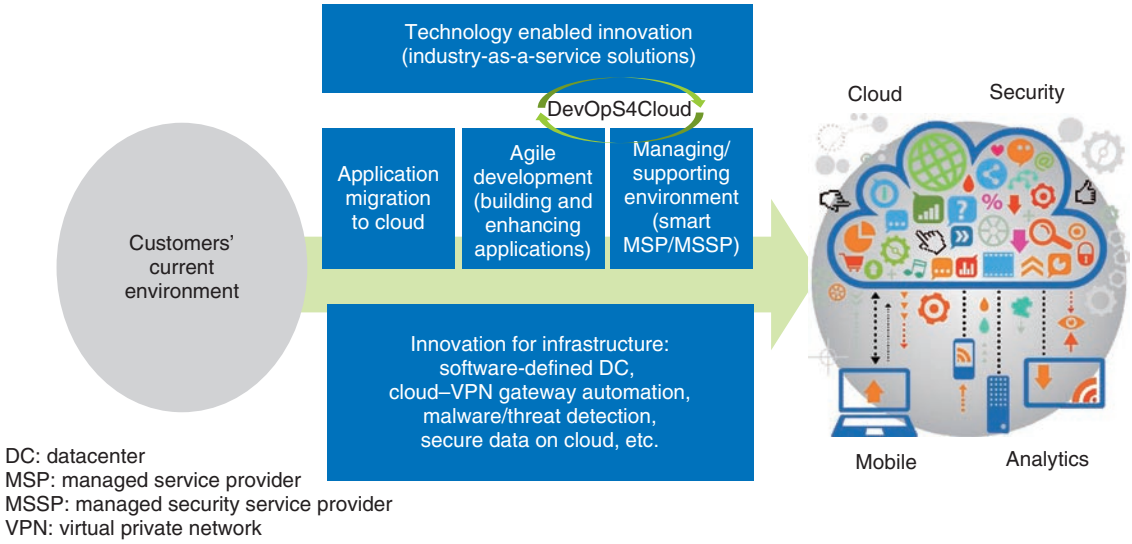

Fig. 4. NTT I^3 approach to R&D.

redesign our clients' business models and/or business processes. Innovations at the middle layer should accelerate our clients' activities of developing and operating new applications while providing up-to-date security protection. Innovations at the bottom layer should advance our infrastructure to provide services at software-speed while achieving high performance and security.

For the present, NTT I^3 will focus on service and product development in the areas of security and cloud computing. The following describes specific development efforts in these two key areas.

3.1 Cloud

A strong point of the NTT Group's cloud is that a wide range of services can be provided. For example, the NTT Group can provide total customer support throughout the life cycle of cloud-migration planning, migration execution, and post-migration operations. These services cover all layers, i.e., the application, cloud platform, and network layers. Another strong point is that the NTT Group has an R&D department for cloud development. The NTT Group strategy seeks to leverage these strengths, and in line with that strategy, NTT I^3 will work to develop IP that can extract the synergy among the wide range of services that the NTT Group provides (**Fig. 5**).

At present, NTT I^3's work in cloud computing can be divided into three main themes. The first theme is cloud migration support technology (migration technology). This technology is being developed to reduce barriers at the time of migration and to improve stability in performance. The second theme is big-data analysis technology for managing the performance of applications. With this technology, NTT I^3 aims to help customers maintain high application performance by identifying the dependencies among multiple performance metrics of a complex cloud environment. The third theme is network and storage technologies for cloud computing. In particular, NTT I^3 is working intently on software-defined networking (SDN) technology, which is essential to a service provider like NTT for creating differentiated services. For more details, please see the example of SND presented in "Networking at NTT I^3 and Outlook of SDN" [2] in these Feature Articles.

By approaching R&D in the above way, NTT I^3 will first aim for growth in the NTT Group companies doing business in North America while also planning to roll out the IP developed and recognized in this market to developing countries and Japan itself sometime in the future.

3.2 Security

Security measures and security analysis and management are undergoing changes due to a number of factors including changes in the types of threats and vulnerabilities, changes in the legal system and social demands, and the influence of stakeholders. The NTT Group aims to establish a permanent position for itself as a top-class security integrator in the world by providing comprehensive managed security services

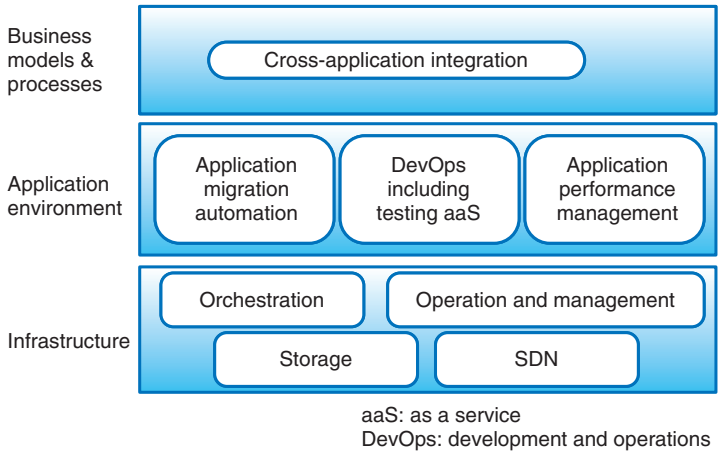

Fig. 5. NTT I^3 development efforts in cloud computing.

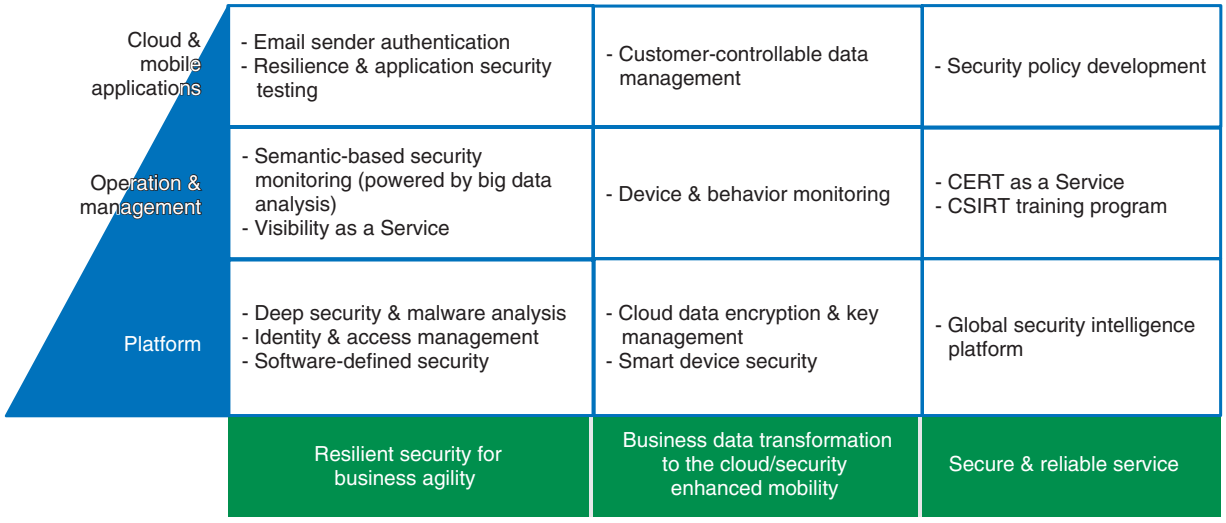

Fig. 6. NTT I^3 development efforts in security.

encompassing consulting, operations, and platforms.

To support this endeavor, NTT I^3 plans to construct a global security platform that will serve to enhance the security businesses of NTT Group companies. This plan includes the development of a Deep Security Analysis Platform for analyzing threats and an NTT Global Security Intelligence Platform for disseminating information on threats and vulnerabilities (**Fig. 6**). Incidentally, there is already a history at NTT I^3 of analyzing security intelligence in collaboration with NTT's Computer Security Incident Response and Readiness Coordination Team (NTT-CERT) and Computer Security Incident Response Team (CSIRT) organizations throughout the world. NTT I^3 aims to leverage its experience in these activities to research and develop advanced security technologies. A more detailed description of this endeavor can be found in the Feature Article entitled "Enhancing Security Analysis at NTT I^3" [3] in this issue.

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Eiji Kuwana
Chief Operating Officer, NTT Innovation Institute, Inc.

He joined the Nippon Telegraph and Telephone Public Corporation (now NTT) in 1984 and has since held positions of increasing responsibility in research, engineering, and management. Most recently, he led NTT's R&D efforts on cloud technology, and information and network security technology as the Vice President and General Manager of the former NTT Information Sharing Platform Laboratories and NTT Secure Platform Laboratories. He was in charge of formulating strategic plans for various innovative R&D projects such as building flexible cloud environments by enabling live migration between different datacenters through software-defined networking.

Enhancing Security Analysis at NTT I3

Shin Adachi
CISSP, CISM, CISA, PMP
Lead Security Analyst,
NTT Innovation Institute, Inc.

Abstract

NTT Innovation Institute, Inc. (NTT I3) has been analyzing security intelligence in collaboration with the NTT Computer Security Incident Response and Readiness Coordination Team, also known as NTT-CERT, and other CSIRTs, or Computer Security Incident Response Teams, and it aims to apply this know-how to the research and development of advanced security technologies. We asked Shin Adachi, the Lead Security Analyst at the center of security-related work at NTT I3, about the current status of information security and the benefits of establishing NTT I3 as a center for research and development in North America.

Keywords: security, CSIRT, security research

Introduction

A Computer Security Incident Response Team (CSIRT) works to prevent (if possible), detect, respond to, and mitigate security incidents, including cyber attacks on companies and organizations. In large corporations or in companies operating a critical infrastructure, it may be a dedicated organization consisting of a full-time staff or team whose members hold concurrent posts in the company. The NTT Computer Security Incident Response and Readiness Coordination Team, also known as NTT-CERT, was launched in 2004 within NTT R&D (research and development) of NTT Holding Company as the CSIRT representing the NTT Group. It supports the NTT Group in security-related matters, including the provision of up-to-date information, and acts as an NTT Group contact point for interacting with outside security organizations and collecting information.

NTT I3 has been supporting the monitoring functions of NTT-CERT since 2012 originally in the form of its predecessor, NTT Multimedia Communications Laboratories (NTT MCL). Specifically, it has been in charge of surveying security conditions especially outside Japan and of maintaining and boosting interaction with outside organizations (**Fig. 1**). Given that security and cloud computing are major areas of R&D at NTT I3, this work can be expected to take on an increasingly important role in the years to come.

Shin Adachi, the Lead Security Analyst at the center of this work, is well known for his activities in major security-industry organizations including the Forum of Incident Response and Security Teams (FIRST)—the global forum of CSIRT organizations—and is recognized internationally as a security expert. Last year, he was elected co-chair of the FIRST Education Committee, one of the oldest committees in FIRST, succeeding his predecessors from the CERT Coordination Center (CERT/CC) at Carnegie Mellon University, which is known as the first

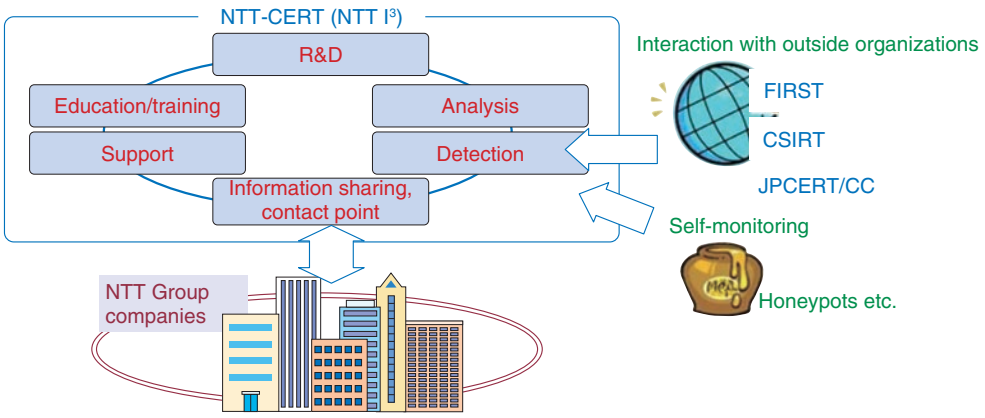


Fig. 1. Overview of NTT-CERT (NTT I^3) activities.

CSIRT. Mr. Adachi was elected as co-chair together with Franz Lantenhammer, head of Computer Emergency Response Team Bundeswehr (CERTBw) of the German Federal Armed Forces. He is the first Committee Chair elected from a company based in Asia.

The CSIRTs belonging to individual companies or organizations form human networks to create mutually trustworthy relationships, which are often reflected in daily activities such as obtaining reliable, up-to-date information from that network and working together to deal effectively with security incidents. Mr. Adachi has a large network of personal relationships and extensive experience in the security industry, and his NTT I^3 colleagues often refer to him as "our treasure" for this reason.

—Mr. Adachi, can you tell us about the present state of cyber attacks?

To begin with, let me say a few things about these incidents that we call "cyber attacks" considering that we don't usually know from whom or where, or how an attack will be mounted.

The first thing that probably comes to mind when hearing the words "cyber security" is attacks on personal computers (PCs). However, it was not so long ago that an attack was made on the Subway restaurant chain in the United States in which a vulnerability in their POS (point-of-sale) terminals was exploited. This attack caused considerable damage and was later found to have originated in Romania.

If we look at recent trends, survey reports and security-related literature tell us that there is a considerable time lag between the first occurrence of a malware attack and its detection, specifically, from 240 days to more than 365 days. Conditions such as these make it difficult to obtain an accurate number of malware incidents. The literature indicates that at least 200 days are now needed to detect that something has occurred. It can therefore be said that, at any point in time, we just don't know what is going on where.

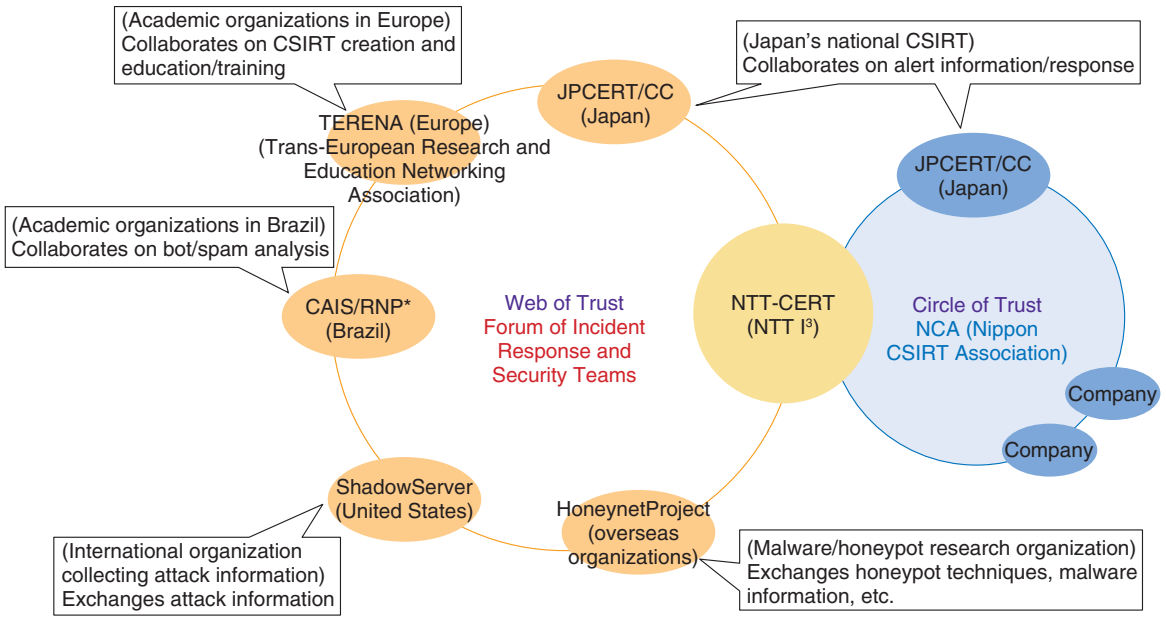
Japan is the home of many globally known corporations that have a high probability of being targeted by malware attacks, so it should be acknowledged that attacks are occurring here and there on a daily basis.

Reports from Microsoft and elsewhere state that the risk of PC malware in Japan is not that high compared to other countries, but I believe that it is only a matter of time before Japan too is affected by some global-wide incident.

Obviously, malware targets things of high value. There are numerous cases of financial crimes and fraudulent uses of information in North America, and case studies from South America reveal that the methods used in committing financial crimes can be quite skillful and varied. Each country, region, and business field features particular methods of deception.

It appears that attack techniques that originate in South America and elsewhere arrive in Japan about one or two years later. The good news here is that understanding and analyzing incidents that are occurring in other regions in the world should enable us to anticipate and prevent to some extent security incidents in Japan. Case studies can help us make advanced preparations and take appropriate actions.

—Given this state of affairs, what specific activities are you involved in?



*The full name is Centro de Atendimento a Incidentes de Segurança / Rede Nacional de Ensino e Pesquisa (in Portuguese)

Fig. 2. Collaboration between NTT-CERT (NTT I^3) and key CSIRTS inside/outside Japan.

I am involved in incident monitoring work in conjunction with NTT-CERT. The term "monitoring work" may convey the idea of real-time incident monitoring, but it also involves the important work of releasing new information on which companies have experienced vulnerabilities and when, and of updating previously released, beneficial security information.

I also act as a liaison to other organizations involved with information security.

In fact, in addition to issues involving attacks and vulnerabilities, my work spans the full breadth of the IT industry. I must consider, for example, judicial and legal matters, service providers, incident responders, universities, other CSIRTs, vendor information, and endorsements.

My job is to uncover important information from a complex web of data from which I need to determine what type of information lies hidden and where, and what kind of impact that information might have. So it's not just a matter of keeping myself glued to a screen 24 hours a day to collect information.

I also exchange information with organizations in other industries and with security activists in the same industry via teleconferencing as the need arises. In short, security work covers a wide range of activities—the day is over before I know it!

—You have participated in conferences and meetings throughout the world. What are your prime objectives here?

First of all, NTT became a member of the Forum of Incident Response and Security Teams, or FIRST, the global consortium of CSIRTs, in 2005, which was relatively early as a CSIRT in Japan (**Fig. 2**).

Being a member of FIRST helps NTT-CERT facilitate trustworthy interaction with other members and strengthen all sorts of relationships, human or otherwise. It also ties in with incident response. For example, there was a case in which we were able to track an actual incident by receiving exceptional cooperation from a CSIRT in another country. The feeling is that we can get our hands on important facts from reliable information sources in FIRST and reflect those facts in our response. There are also cases in which incident reports from FIRST sources are submitted prior to any problems occurring on our side. All in all, becoming a FIRST member promotes bidirectional problem solving.

I recently attended a number of conferences held in Brazil, Argentina, Malta, and other countries either for FIRST members or general participants (**Photo 1**).

I've also attended non-FIRST conferences on an

Photo 1. Participants at a FIRST meeting held in Thailand June 16–21 (Lead Security Analyst Shin Adachi is second from the left).

invitation basis, for example, those sponsored by the National Cyber Security Center of The Netherlands (NCSC.NL). These conferences and meetings help me to build up my knowledge and expand my network of contacts.

Of course, collecting information is an important task here, but raising one's profile and obtaining the trust of others is also an important activity. I also accept invitations to lecture to increase my exposure to the outside world. Speaking out in this way enables me to disseminate the strengths of NTT I^3 and NTT-CERT. Through these activities, I hope to increase the number of colleagues I have in this field and to decide on what direction I should take.

Just recently, for example, NTT I^3 applied for and received approval for membership in the Cloud Security Alliance (CSA), thereby joining ranks with well-known companies such as AT&T and Verizon.

I believe that the CSA is the only global industry body taking on both cloud computing and security. Its activities include drafting white papers, so I believe that offering our help in such work is a good way for others to learn about the highly talented staff, activities, and core competencies of NTT I^3. I also think that we can engage in effective PR through advertising and other activities targeting specialized fields.

Establishing a name will take several stages, but at first, our aim is just to increase recognition of the NTT I^3 name and to signal to the industry that our top priorities are cloud computing and security.

To spread the word about NTT I^3's capabilities, I think the best approach is to combine such efforts with other activities.

—There are security risks in all regions of the world, with researchers there to pursue them. Therefore, what are the benefits of working out of Silicon Valley?

One advantage of establishing an R&D center in North America is that the time difference with Japan can be put to good use. Specifically, in the case of California, our colleagues in Japan can send us messages and inquiries before they leave for the day, and since we are working while they are resting, we can reply to their messages by the early evening in our time. This means that they will receive our responses, results, or progress reports first thing in the morning the following day in Japan.

At the same time, working in just any location in the United States is not necessarily beneficial. For example, New York and Washington D.C., though being the respective centers of American finance and government and being located on the East Coast three hours ahead of California, are disadvantageous in the sense that software vendors tend to be located in California.

Let me explain using a specific example, which occurred some time ago. A new type of malware began to infect computer systems on a certain weekend, and as dawn broke around the world, the malware infections spread from New Zealand and Australia to Japan and Europe, and eventually infected computers on the East Coast of the United States. As a result, one financial institution after another fell victim to this malware and suffered damage. However, because major antivirus software vendors are concentrated on the West Coast, no effective countermeasure to stem the effects of that damage could be taken until the start of the business day on Monday in California. Such a situation would probably not occur today, but there are still various reasons why time differences can sometimes be a major problem. It can also be said that there are both good aspects and bad aspects to having a concentration of vendors in the California area, but understanding both sides also has its benefits.

At present, I make an effort to get up before 4:00 AM Pacific Time in California every morning to collect information on security matters affecting financial and government institutions, but looking forward, I would like to enhance and fortify the way we cover East Coast problems.

At the risk of repeating myself, I'll say that the present situation is such that I don't know what is going on security-wise at all points around the world.

But I do know that a new day begins with New Zealand and Australia—that will never change!

—What types of activities does NTT I³ intend to focus on going forward?

As a new direction from a business point of view, NTT I³ aims to support the datacenters and security services of three NTT companies doing business in North America, namely, Dimension Data, NTT America, and NTT DATA, Inc. Our mission is twofold: to protect the business operations of these companies and to determine which technologies are needed to protect their customers.

Furthermore, to expand NTT's cloud business, we must keep two questions in mind: how do we protect the security of the cloud business, and conversely, how do we leverage the power of the cloud to protect security?

The business of the NTT Group differs greatly between Japan and North America in the services provided to customers, the temperament and characteristics of customers, the business environment, and the regulatory environment. This difference has a big impact on security, the form of attacks referred to as the "attack vector," the way of dealing with vulnerabilities, and the incident response. I would like to apply the experience and achievements that we have built up so far as a CSIRT to develop intellectual property (IP) that can effectively support managed security services.

To this end, I am beginning to exchange information on a face-to-face basis while also investigating the specifics of how best to proceed from here on. I am currently at the stage of establishing a firm foundation, and the key to this process is conducting interviews and meetings with the relevant players.

I also think that there is a wealth of talented, hard-working people in NTT R&D who are a true asset to the company. In addition to being responsible and loyal professionals, their knowledge extends beyond their specialized technologies to a broad range of peripheral technologies, too. I believe it's the duty of NTT I³ to inform the outside world about the high level of R&D activities underway in the NTT laboratories.

If we remain silent about this, nothing will get off the ground. Other Japanese firms may be involved in similar activities, but I believe that NTT is at the forefront of security technologies. I would like the vast capabilities of NTT to become well known.

Interviewee profile

■ Career highlights

Shin Adachi brings experience and expertise on information security gained over many years to NTT I³, as the Lead Security Analyst. He currently represents and serves NTT-CERT in the Americas. In addition, he has spoken at, played significant roles at, and/or contributed to, well recognized organizations such as FIRST, NIST Cloud Computing Program, Liberty Alliance, Kantara Initiative, APEC TEL eSecurity, Asia PKI Consortium, and ITU-T. Currently, he is serving FIRST as CoChair of its Education Committee and as a senior member of its Program Committee.

Networking at NTT I3 and Outlook of SDN

Robert Raszuk
Distinguished Research Engineer,
NTT Innovation Institute, Inc.

Abstract

NTT I3 (NTT Innovation Institute, Inc.) has actively been carrying out the tasks of developing cloud-related network technologies. Software-defined networking (SDN) in particular is considered to be a key technology for creating differentiation services for service providers such as NTT. Robert Raszuk, Distinguished Research Engineer at NTT I3, has a lot of experience in achieving company visions of implementing networking and SDN. We asked him about the current status and prospects of SDN.

Keywords: global, cloud, SDN

Introduction

Distinguished Research Engineer Robert Raszuk, who hails from Poland, has a wealth of experience needed to develop network solutions and achieve the Institute's vision of software-defined networking (SDN). In 1993, he went to the U.S. to study computer science, which led to his starting a business in Poland. He completed his master's degree in electrical engineering in 1995, as the growth of the Internet was booming, and began his career as a network engineer. He has a wide range of experience in areas involving network management to the development of technologies involving internal customers.

How will Mr. Raszuk's experience at vendor companies be utilized at NTT, a service provider? He had the choice of working at a number of world-famous companies. However, he decided to join NTT, saying, "I admire Japanese culture, and believe that Japanese companies are No. 1." We asked Distinguished Research Engineer Raszuk about the state and outlook of SDN.

—What is a network and what is SDN?

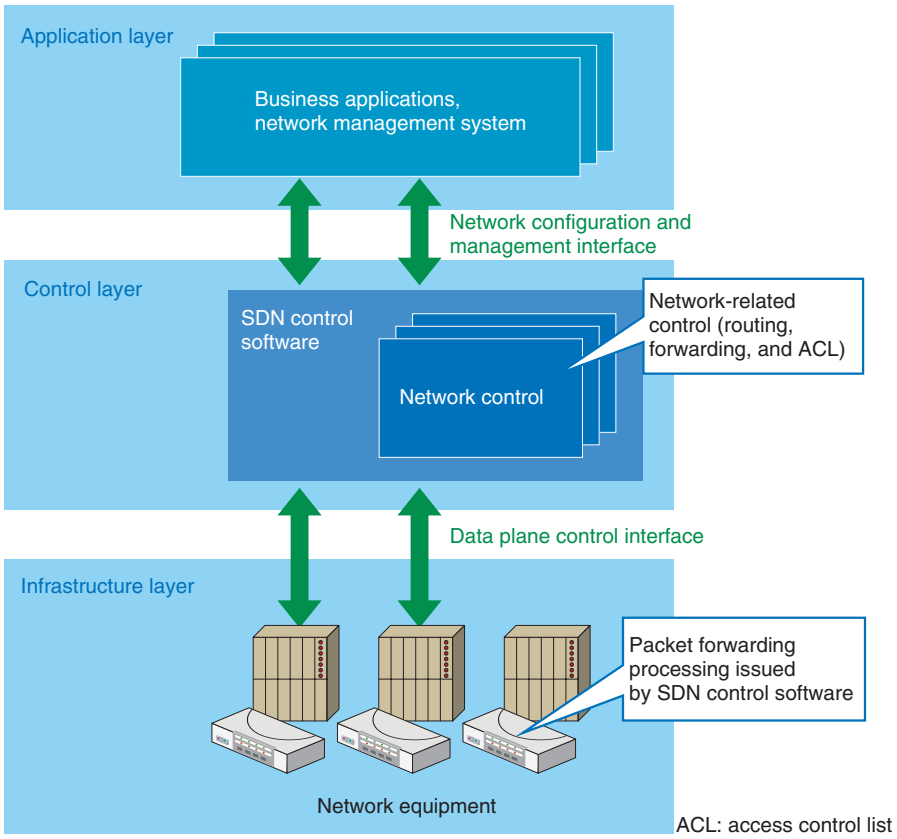
There are a variety of definitions of a network. My interpretation is, "A network is composed of data transport and services." Please think of it this way.

Right now, the concept of SDN differs from person to person (**Fig. 1**). SDN is a technology for quickly offering new, competitive services. I think that instead of standing for "software," the S in SDN really should stand for "service."

In general, there is no fixed way of thinking about SDN, even among people in the industry. I can only explain my concept by giving specific examples of what I want to offer.

Some of my colleagues and I think that the value of SDN lies in the focus on services. But there are also developers who think that it is also important to build and reinvent the transport part of the network.

A variety of groups such as I2RS (Interface to the Routing System) and IRTF (Internet Research Task Force) working groups (WGs), are working on standardizing SDN. There are also foundations such as EWSDN (European Workshop on SDN) that develop services and the ETSI (European Telecommunications Standards Institute) Network Functions Virtualization WG, which is focusing on software-based



Source: Y. Nakajima, "Standardization Progress in Software Defined Networking/OpenFlow," NTT Technical Review, Vol. 11, No. 2, Feb. 2013.

Fig. 1. Overview of SDN architecture.

network functions and services.

So, there are many standardization efforts going on. ONF (Open Networking Foundation) is working only on the standardization of the OF (OpenFlow) portion, which is the protocol for controlling the data plane from the remote server.

Also, similar activities are being advanced by IETF (Internet Engineering Task Force). They are standardizing definitions of methods of building APIs (application programming interfaces) into network equipment.

Because of these activities, it is difficult to completely follow what is happening in the SDN world. There are activities being undertaken from various perspectives, so understanding their real value as services will take a little more time.

There are many people in this industry who just focus on services. However, if we don't strengthen data transport, we can't provide safe and secure networks.

An example of a service is a virtual private network (VPN). With a VPN, Internet websites and portals can also be provided. VPNs are therefore highly profitable services in the industry.

Using enterprise systems as an example, we see that many things are involved in the back office. For example, solving different problems for document management and server management and figuring out how to manage them using a cloud-based infrastructure are issues of great concern right now. In addition, cloud security is very important.

Instead of companies originally having their own networks, more and more customers are outsourcing their back office or using ready-made networks.

Almost all of these services are developed internally. The task of development is nothing special in particular, since general programming languages are used. I think the challenge lies at the level of

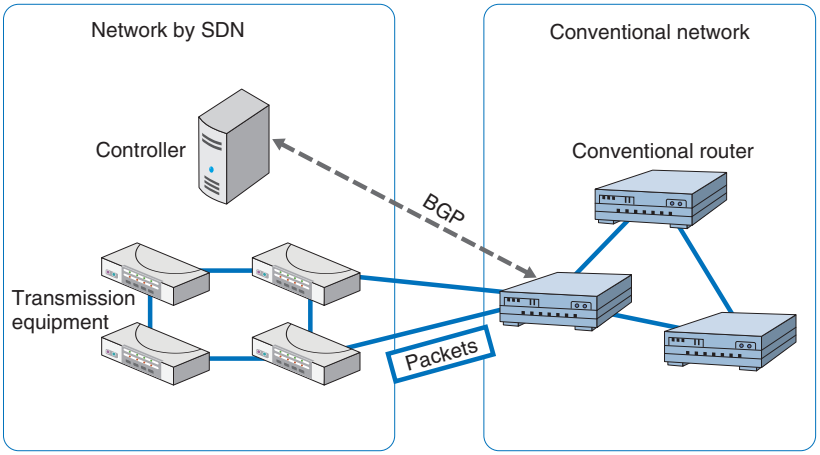


Fig. 2. BGP linkage.

innovation. What determines success is how to turn something from a concept into something real and commercial.

The No. 1 purpose of network operators and service operators is to increase revenue. In this industry, when one vendor develops a unique service, other vendors will quickly be able to provide similar features. Consequently, taking a year or two to conceive a new service and to study and realize it will not bring success to a business.

What is needed is the ability to conjecture what customers will need and what they will demand, and quickly provide solutions. Customers want to pay as little as possible for services that best match what they need. Also, customers do not like to be locked into just one service provider.

For mission critical applications, they generally rely on several service providers. Even for services, they do not wish to use a company's proprietary technology, but prefer to be able to migrate easily from one service provider to another. They also wish to integrate service providers' infrastructure and their existing applications, especially the applications they created in-house.

In recognizing these conditions, I think the way to proceed is to first understand what the customer is requesting, develop the service, and then design it for the existing transport method.

For example, instead of using Internet services from major vendors like Google for existing customers, I would rather offer services within NTT whose quality is guaranteed by service level agreements (SLAs).

Customers are more interested in the services themselves than in how they are offered. I think we should effectively leverage existing technologies. I don't think it's desirable to offer competing technologies especially for the transport part of networks.

By the way, a variety of work being developed by IETF can be applied to SDN. Border Gateway Protocol (BGP) is becoming an actual service transport protocol (**Fig. 2**).

—Mr. Raszuk, please share with us the specific research projects you are involved in.

I'm focusing on how to bring my knowledge of routing protocols into NTT I^3 products. My first project at NTT was the invention of a service called BGP Free Edge in 2011. This service removed the BGP control plane from all the network edges and centralized the state plane while maintaining the data plane. For example, we applied research to make use of technologies such as OpenFlow as applications.

BGP Free Edge is a technology that makes it possible to expand the footprint without additional costs for service providers. For example, adding a new POP (point of presence) can be implemented at an extremely low cost without purchasing expensive routers or switches. This project is complete. We are currently at the stage of carrying out trials with NTT Communications.

Another project I'm involved in is AP (access point) gateway automation. This project involves speeding up connections to customers' datacenters by using a type of hotspot. I'm also actively participating

in IETF's router-related activities.

I think new services can be produced as a result of the in-house development of the control portion of network controllers related to NTT I^3's own two BGP protocol implementations. I'm tackling this right now. We have made it to the trial stage, but we are not quite there yet for the development release. However, I expect that the fruit of our labor from this project will give a boost to its productization. This project will be the first contribution of NTT I^3 to NTT's telecommunication companies.

—Why does NTT I^3 need to be involved in SDN?

Right now, it looks like we are in an SDN bubble. Small companies, not big companies, are beginning to participate. Opportunities to develop new X86-based services are being created. There is a trend of not only big network equipment vendors but also many hardware manufacturers selling ODM (original device manufacturer) boxes.

However, service providers, not vendors, are most dominant in the area of the overall network becoming software-defined. Also, even as service providers have become involved in software recently, there aren't many companies that can develop their own services as NTT I^3 can. As a result of NTT I^3's involvement in SDN, the NTT Group is more competitive and can provide customers with innovative products and services.

—How is NTT I^3 positioned in the IT industry with the research you are involved in?

I believe NTT I^3 is trusted as a company that delivers quality services and delivers them securely.

Recently, I have been doing R&D on internal service development for NTT Communications. Because I have been focusing on improving infrastructures that are associated with operators, my contribution to the technology being developed that enhances the overall lives of people in society has only been indirect, and I have not disclosed anything about this work to the public due to its proprietary nature. However, I know from experience that this is the first research of its kind in the industry.

In the future, we can make life richer by building robust systems, and contribute, for example, to the medical field. I want to work on such projects that will make life better and deliver them to the world.

So I want to leverage NTT I^3's strength, which is its ability to develop services that meet customers' needs, in order to build up its competitiveness. Major vendors tend to provide solutions for worldwide use. I think we can strike a different path by using open source software and open stack orchestration to create services with value and offer them in a timely manner.

—Mr. Raszuk, you are living in Poland while working for NTT I^3, which is in Silicon Valley. To me, this reflects a unique lifestyle. Is it natural?

There are various ways to work on a project. A concept is formed by having different ideas. After you come up with the general idea, you create the basic design called the system architecture, and then move on to creating the component architecture. And then you move onto the actual tasks of development. You start from the beginning with ideas of individuals, and gradually move on to forming an organization. You consider what personnel with what kinds of skills are needed depending on the project, and build a team. There are times when we use people who live in Silicon Valley, and there are times when people from other countries participate.

I lived in Silicon Valley for a period of time before, but then moved back to Poland for family reasons. Since 2002 I have been working in Poland by telecommuting. Where a person lives is not an issue for engineers at companies like Cisco or Juniper. There are people who communicate with one another through e-mail and videoconferences even though they work on the same floor. By the way, when I was living in Silicon Valley, my entire team was near Boston, and we communicated by telephone/video conference without any problems.

I'm able to do this because I maintain good relationships with team members. When we must hold important meetings for a project in person, engineers from around the world, including me, gather in Silicon Valley. I spend two to three weeks every quarter in San Mateo (Silicon Valley), or we organize meetings in Japan.

The key to achieving success on a project doesn't hinge on where a developer lives, but lies in gathering outstanding human resources. The only challenge might be in finding a suitable time for people in different locations to participate in a teleconference.

It's very exciting to be able to create and develop new services with my colleagues at NTT I^3 in Silicon Valley. Going forward, I want to improve these services by solving the challenges we face together with NTT Group companies around the world, include the

Group companies in North America. I'm looking forward to collaborating with Dimension Data, which is a system integrator. We can make a big impact on the industry overall as a result of having common goals.

Even now, I'm building quite a close relationship with the NTT laboratories. I'm thinking of further building up and expanding this relationship by involving the research departments in different NTT Group companies. To seriously carry the concept of SDN further, we must focus more on the area of development than on research when it comes to "R&D".

Interviewee profile

■ Career highlights

Robert Raszuk began working for NTT in 2011. His work currently focuses on defining new network architectures for innovative network services. He has over 20 years of experience working with large scale computer networks, including Nations Bank (now Bank of America), Cisco Systems, and Juniper Networks. At NTT Innovation Institute, Inc., he holds the position of Distinguished Research Engineer.

Load Modulation Applied to Magnetic Resonance Wireless Power Transfer Technology and Its Applications

Mamoru Akimoto and Masataka Iizuka

Abstract

The newly developed magnetic resonance wireless power transfer technology is being intensively researched since it is easier to use than conventional technology and has potential applications in various fields. In this article, we first provide an overview of similar techniques; then we introduce a method of using this power transfer technology that adopts load modulation in order to increase its range of applicability. We also describe an example of how this method can be used to reduce the effort needed for manhole maintenance, and we present evaluation results regarding the optimal placement of the transmitter and receiver coils in the example application.

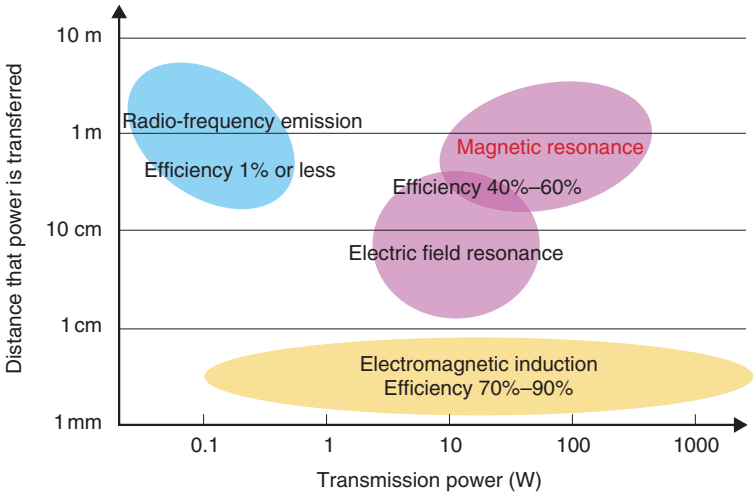
Keywords: wireless power transfer, magnetic resonance, load modulation

1. Introduction—magnetic resonance wireless power transfer

In 2007, a new wireless power transfer technology was developed at the Massachusetts Institute of Technology (MIT) [1]. This technology is referred to as magnetic resonance*1 and differs from conventional wireless power transfer technologies such as radio frequency radiation and electromagnetic induction, as shown in **Fig. 1** [2]. One example of radio frequency radiation technology is a solar power satellite (SPS)*2, where energy is changed from an electrical current to an electric wave and transmitted between antennas. This method is applied when transmission distances are comparatively long. By contrast, electromagnetic induction is used in, for example, chargers for electric toothbrushes and electric shavers. Another name for this technology is the non-contact method. As the name suggests, electrical power is transmitted when one of a pair of coils is brought into close proximity with the other coil. Current is passed through the transmitter coil, and magnetic flux is transmitted to the receiver coil where a current is induced. In 2010, Qi, an international inductive power standard (Ver. 1.0) for up to 5 W, was established, and devices based on this standard have since been commercialized [3]. In comparison to these conventional technologies, magnetic resonance has intermediate characteristics, as shown in Fig. 1. Furthermore, even if the direction or position of the opposite coil is not aligned perfectly, the degradation in the transmission efficiency is slight, and in this sense it is easy to use. Research and development on this technology is being actively pursued over a wide range of fields such as automotive, consumer electronics, and medical fields, and new applications are expected to be introduced.

*1 This technology is referred to by many names, including magnetic resonance and magnetic coupling. For consistency, we use the term *magnetic resonance* in this article.

*2 Solar power satellite (SPS): Research is being conducted on generating electrical power from sunlight in space and transferring the electrical power to terrestrial power stations using microwaves regardless of the time of day or the weather conditions.



*Since the efficiency rating includes the power source, the efficiency rating for the entire transmission system is given.

Fig. 1. Comparison of wireless power transfer methods.
(http://bwf-yrp.net/menu-03-06-01.html)

The principle of magnetic resonance power transfer is often explained by using the example of two distant tuning forks, where when one is struck the other resonates and begins to generate sound. A more precise explanation is that the quality factors (Q factors) of the transmitter and receiver coils are increased, and by matching the resonant frequencies of both coils, the electromagnetic coupling between the coils is strengthened, and electrical power is transferred. This transmission principle is basically the same as that for the electromagnetic induction mentioned earlier. The transmission efficiency of both methods is given by the product of the coil Q factor and the coupling coefficient. The electromagnetic induction approach increases the coupling coefficient by bringing the coils into close proximity, and the magnetic resonance approach increases the coil resonance characteristics, i.e., the Q factor.

2. Adopting load modulation

The NTT Access Network Service Systems Laboratories is engaging in preparations for plans to further improve the utilization of various anticipated applications for magnetic resonance power transfer technology. One such application involves adopting load modulation [4]. Load modulation is a technology used in conducting communications. An example is passive radio frequency identification (RFID) tags, which are already widely used. A reader-writer transmits a carrier wave, and in response, the internal impedance in the RFID tag changes depending on the response data and generates a reflected wave, which is then received by the reader-writer. A schematic illustration of a magnetic resonance power transfer setup that adopts load modulation is shown in **Fig. 2**. In the figure, the receiver is connected to a sensor, and electrical power that is transmitted from the transmitter coil drives the receiver circuit and sensor. Conversely, on the receiver side, the load impedance inside the receiver changes depending on the sensor information, and the resonant state between the transmitter and receiver coils changes. This change manifests a change in the reflection characteristics of the transmitter coil input port, and through detection and demodulation, information is extracted as a signal. With this construction, the use of power sources such as commercial power supplies and batteries is unnecessary on the receiver side (maintenance-free). It is then possible for the receiver side to draw power off the power supplied to the sensor and obtain sensor information.

3. Coupling properties of arbitrarily set coils and application example of manhole maintenance

As mentioned earlier, various applications of the magnetic resonance wireless power transfer technology are expected since it is easier to use than conventional power transfer technology. The transmitter and receiver coils do not need to be positioned facing

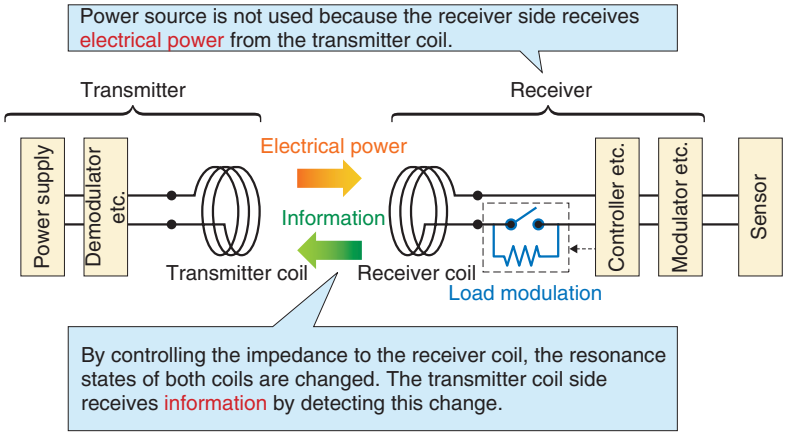


Fig. 2. Overview of magnetic resonance wireless power transfer method with load modulation.

each other and therefore, the transmission efficiency properties of an arbitrarily arranged coil configuration need to be ascertained. On the basis of coupling mode theory, we show the transmission efficiency of magnetic resonance wireless power transfer using performance index U in the following equation [1].

$$U = \frac{\sqrt{Q_1 Q_2}}{L_1 L_2} M \qquad (1)$$

Here, Q_1 and Q_2 are the respective Q factors for coils C_1 and C_2, L_1 and L_2 are the respective self-inductance values for coils C_1 and C_2, and M is the mutual inductance between coils C_1 and C_2. From Eq. (1), if the Q factors of the coils and self-inductance are assumed to be fixed, the transmission efficiency representing the performance index U depends on mutual inductance M. The following equation expresses mutual inductance M when it is an ideal conductor based on Neumann's formula (μ_0: magnetic permeability in free space)

$$M = \frac{\mu_0}{4\pi} \oint_{C_1} \oint_{C_2} \frac{\cos\theta}{r} ds_1 ds_2 \qquad (2)$$

On the basis of Eq. (2), using the loop coil pair in **Fig. 3**, we calculated the mutual inductance, which is plotted in **Figs. 4** and **5**. It is evident in Fig. 4 that the mutual conductance is high for the intermediate range of 45°–70° as the angular position of coil C_2, Θ, when the angle of inclination of coil C_2, α, is 90°. Furthermore, we can see in Fig. 5 that the maximum value of the mutual inductance, M_{max}, does not change significantly (1 => 0.75) even if the angular

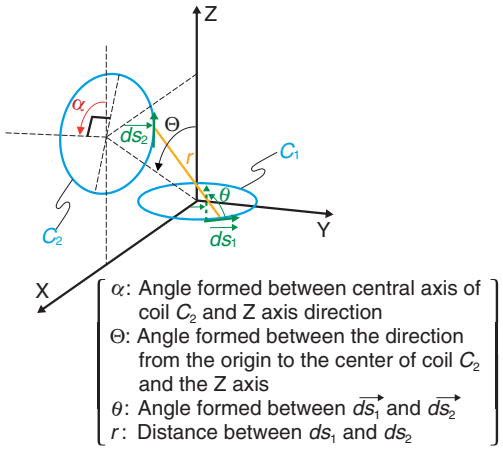


Fig. 3. Loop-coil pair.

position of coil C_2, Θ, is changed; that α_{max} when M = M_{max} depends on Θ; and that α_{max} changes over the range of 0–180°. Keeping in mind the above characteristics, we describe the maintenance of manholes as an application example of wireless power transfer adopting load modulation [5].

There are approximately 680,000 communications related manholes throughout the country. Among these, 80% have been in service for more than 30 years [6] and are deteriorating. Furthermore, inspecting the interiors of manholes requires much effort. Permission must be obtained in advance to access the road, and arrangements such as for traffic control and manhole ventilation must be made prior to inspection. Accordingly, studies have been done on optimizing the maintenance work using wireless technology

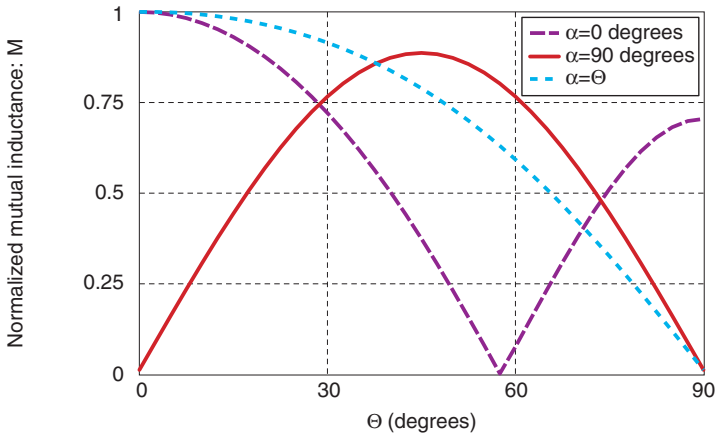


Fig. 4. Dependence of normalized mutual inductance on Θ.

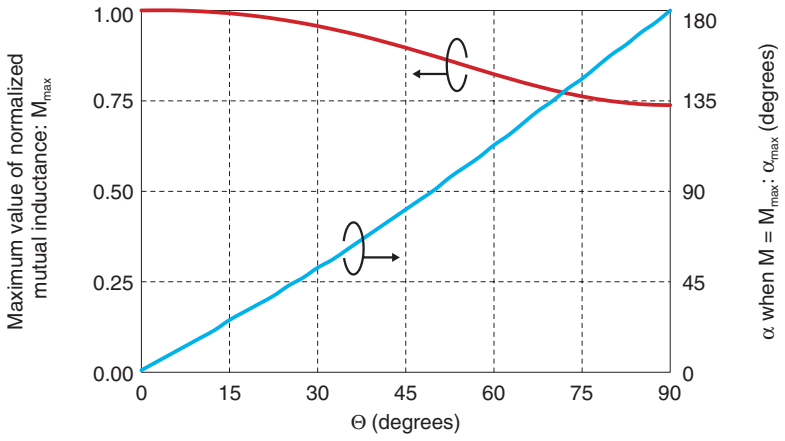


Fig. 5. Dependence of M_{max} and $α_{max}$ on Θ.

[7], [8]. In this application example, a receiver coil and sensors used in structure diagnosis such as a strain gauge and accelerometer are installed inside the manhole. Load modulation is used to communicate the sensor information, and magnetic resonance power transfer technology is used to supply electricity to the sensors. This makes it possible to tackle the goal of reducing the amount of maintenance work in manholes and also that of strengthening the cost competitiveness and improving the reliability of the transmission equipment.

Here, we investigate a specific configuration method for the receiver coil based on the mutual inductance characteristics in Eq. (2) for this type of application. The construction of a general manhole is classified into the cover, the chamber, and the neck that connects the chamber and surface (**Fig. 6**). In some cases, the chamber is constructed of concrete that contains a rebar grid; because the rebar can affect the magnetic resonance wireless power transfer, the receiver coil is placed in the neck. In contrast, the cover is made from cast iron, which has a large effect on this system. Therefore, the transmitter coil is positioned level to the ground on the periphery of the cover to avoid the upper part of the cover and to simplify the maintenance work.

We calculated the mutual inductance based on the above conditions; the results are shown in **Fig. 7**. These results show that when the receiver coil is positioned in the neck at 90˚ (vertical), the range of the angle of the transmitter coil placement (angle at which the transmitter coil is installed) to achieve high mutual inductance is extremely wide. Next, we show the results when the required mutual inductance of the system is tentatively 0.5, and the range of angles of the transmitter coil location that exceeds this requirement is calculated from the depth of the receiver coil as a parameter (**Fig. 8**). From these

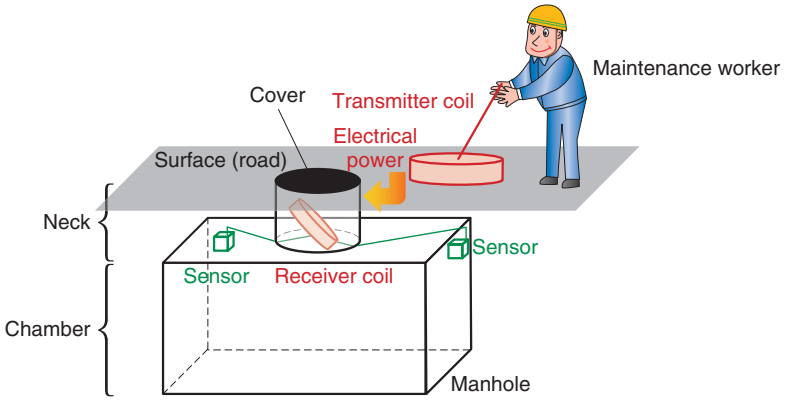


Fig. 6. Manhole maintenance setup.

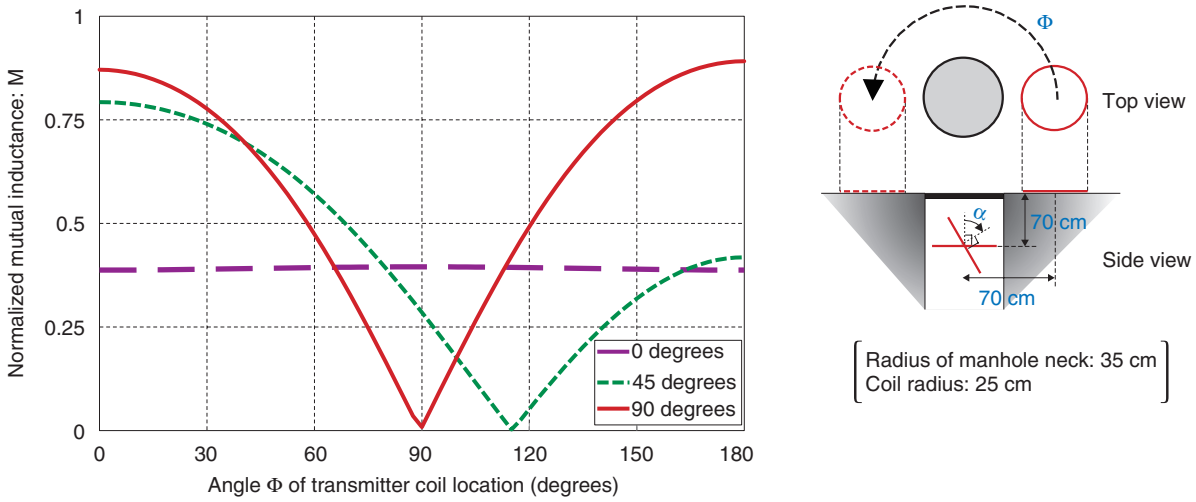


Fig. 7. Dependence of normalized mutual inductance on angle of the transmitter coil location.

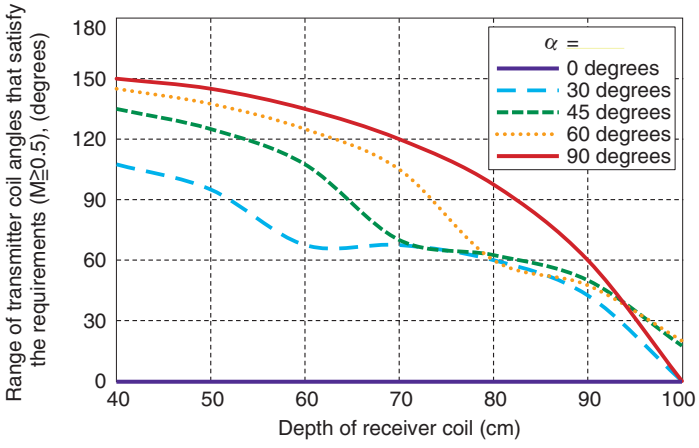


Fig. 8. Range of transmitter coil angles that satisfy the requirements.

results as well, for a practical receiver coil depth (a few tens of centimeters), when the receiver coil is installed in the neck at 90˚, we find that the range of angles of the transmitter coil placement that satisfied the standard value ($M \geqq 0.5$) is extremely wide.

4. Future development

In this article, we summarized wireless power transfer technology and introduced the magnetic resonance method that has been extensively researched and developed in recent years. We also described the magnetic resonance method adopting load modulation, a method for improving applicability, and an application example. In terms of practical application, various problems exist such as achieving high efficiency of the coils themselves, achieving high efficiency of the entire system including the load system, and determining how to adjust and alleviate the reduction in efficiency due to variations in impedance caused by the influence from the surrounding environment. The Wireless Power Transfer Working Group of the Broadband Wireless Forum is actively discussing standardization with a focus on wireless power transfer including magnetic resonance, cooperation with other countries, and legislation and regulation related to radio laws and human safety. Over the past few years, extensive discussions and investigations have taken place from various viewpoints, and we anticipate that the day will be upon us soon when products and services employ this technology.

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Reducing Electric Power Consumption for Air Conditioning by Improving Temperature Distribution in Telecom Equipment Rooms

Masato Maruyama, Akiko Takahashi, Hiroya Yajima, Akira Takeuchi, Nobuhiko Yamashita, Morihiko Matsumoto, and Kimihiro Tajima

Abstract

This article presents the results of an electric-power-reduction experiment that was conducted in collaboration with the NTT WEST Kochi branch. One effective way to reduce the amount of electric power required for air conditioning in a telecom equipment room (TER) is to eliminate hot spots. In the experiment, the causes of two hot spots generated in the existing TER were analyzed, and various heat-control methods were implemented to eliminate them. Then the effects these methods had on reducing the temperature and on reducing the required air conditioning power were evaluated.

Keywords: telecom equipment room, air conditioning, electric power reduction

1. Introduction

The suspension of nuclear power plant operations after the catastrophic disaster in northeastern Japan in March 2011 caused an electric power shortage during the subsequent summer and winter in Japan. It has also led to an increase in the price of electric power. The NTT Group consumes 8 billion kWh of electricity per year (corresponding to 1% of gross electric power consumption in Japan) in order to provide its telecommunication services. Consequently, any reduction in the power supply is an extremely important issue from the viewpoint of corporate social responsibility and business continuity. The NTT group has therefore been implementing various measures to remedy this situation.

One of these measures involves reducing the amount of power required for air conditioning in telecommunication equipment rooms (TERs). TERs are found in NTT buildings throughout Japan and contain various kinds of information and communications technology (ICT) equipment such as routers and servers, as well as the power supply units and air conditioning units required by them. Most TERs utilize a raised-floor system so that cold air from the air conditioning units can circulate throughout the floor space in order to cool the ICT equipment. The hot exhaust from the ICT equipment is then returned to the air conditioning units located near the ceiling. However, in many TERs, a variety of factors may result in the formation of hot spots, where the temperature is higher than in other parts of the room. In this situation, the air conditioning outputs have to be set higher in order to prevent failure of the ICT equipment. However, this also causes an increase in electric power consumption. If such hot spots can be eliminated, the power consumption could be reduced by lowering the air conditioning output.

NTT Energy and Environment Systems Laboratories has been researching various methods to cope

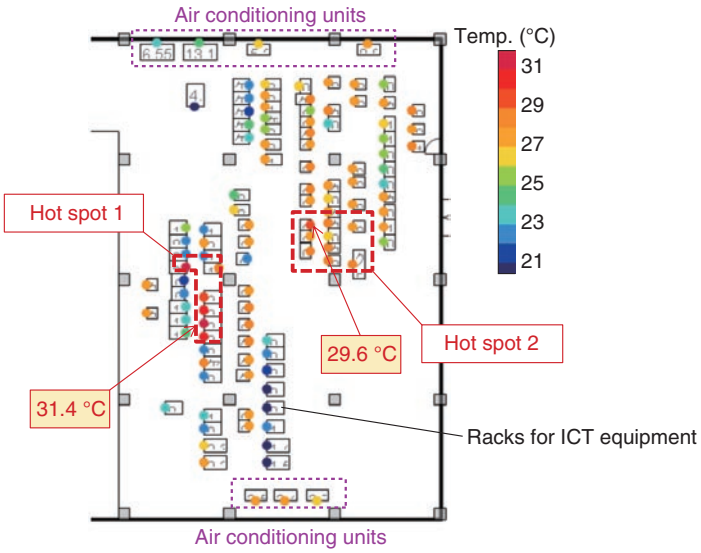


Fig. 1. Temperature distribution map of TER.

with these sorts of heat problems in TERs [1]–[3]. This article presents the results of a power-reduction experiment that was conducted in collaboration with the NTT WEST Kochi branch. In this experiment, various methods to control heat were implemented and compared. As a result, air conditioning power-reduction effects were achieved in conjunction with reductions in hot spots.

2. Visualization of TER in NTT Kochi-Naka building

The TER in the NTT Kochi-Naka building where the experiment was conducted covers an area of 430 m^2 and contains 100 racks for ICT equipment and seven air conditioning units. It also houses the power and temperature visualization system that NTT Energy and Environment Systems Laboratories developed and installed. This system monitors the value of electric power that each piece of ICT equipment consumes and the temperature around it, and displays the data as a two-dimensional distribution map or time-domain graph. The sensors that record the data are installed in each rack and air conditioning unit.

The temperature distribution map for the entire room is shown in **Fig. 1**. The color of each balloon in the figure signifies the temperature at that point. As shown in the figure, there were originally two hot spots in the room. One (hot spot 1) was found near the center of the room on the left-hand side, where the maximum temperature recorded was 31.4°C. The other (hot spot 2) was located near the center on the right-hand side, and the maximum temperature recorded there was 29.6°C.

We investigated the causes of the elevated temperatures at these two hot spots, introduced some modifications in an attempt to overcome the overheating problem, and evaluated the effectiveness of these solutions. We carried out this work with the cooperation of the NTT WEST Kochi branch, NTT WEST-SHIKOKU, NTT NEOMEIT Shikoku branch, and NTT FACILITIES KANSAI.

3. Solutions for hot spots in TERs

3.1 Solution 1: Airflow control panels

Our investigations revealed that hot spot 1 had two causes. One was the rear-to-front layout in which the exhaust port of one ICT unit faces the intake port of another. As a result, the high-temperature exhaust from the ICT equipment (emitter equipment) flows directly into the intake port of adjacent units (affected equipment), thereby raising the intake temperature (**Fig. 2(a)**). To avoid this situation, ICT equipment has in recent years been arranged to form a cold aisle (hot aisle) across which intake ports (exhaust ports) face each other when new TERs are constructed. However, in TERs that were constructed before this arrangement was introduced and that are still in

operation today, the rear-to-front layout is still common.

To improve this state of affairs, we added airflow control panels to the exhaust port of the emitter equipment, so that the exhaust was now directed upwards (**Fig. 2(b)**). As a result, the direct effect of the high-temperature exhaust on the affected equipment was eliminated without needing to alter their actual layout. The shape of the panel was designed with the help of airflow computer simulations so that other equipment nearby would not be affected.

(a) Before (rear-to-front layout) (b) After

Fig. 2 Airflow control panel for rear-to-front layout.

3.2 Solution 2: Blank panels

The other cause of elevated temperatures at hot spot 1 was the hot air exhaust emitted from the top face of the equipment. When ICT equipment has an exhaust port on its top face, bottom face, right side or left side, the exhaust from that port enters the cold aisle as well as the hot aisle and raises the temperature (**Fig. 3**).

To correct this, we installed blank panels so that the hot exhaust only flowed into the hot aisle (**Fig. 4**).

3.3 Solution 3: Adjustment of air quantity taken in by forced-air cooling racks

While investigating hot spot 2, we found that the

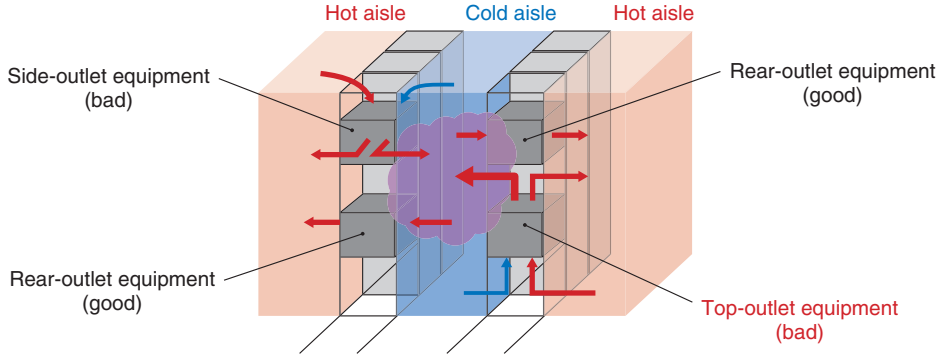
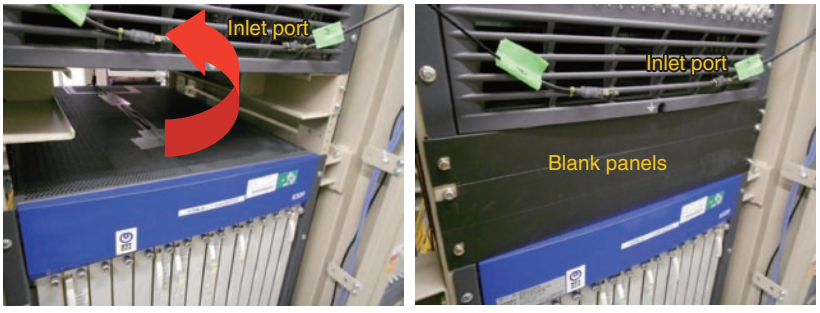


Fig. 3. Example of hot air inflow into the cold aisle.

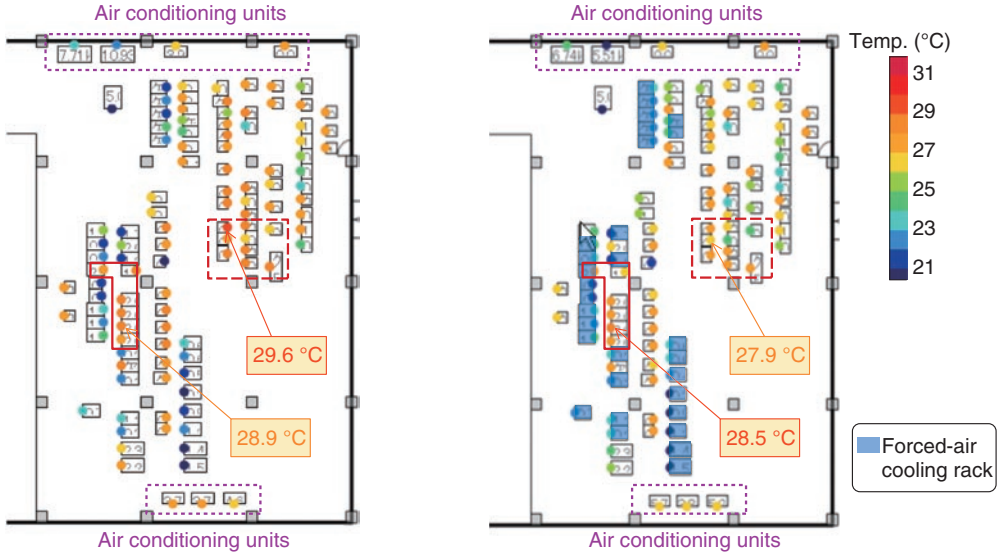


(a) Before (b) After

Fig. 4. Blank panels installed to block hot air inflow into the cold aisle.

(a) Exterior (b) Rack fans

Fig. 5. Forced-air cooling rack.



(a) After implementing solutions 1 and 2 (b) After implementing solutions 1, 2, and 3

Fig. 6. Temperature reductions after implementing solutions.

circulation of cold air under the raised floor was inadequate in that area. One of the reasons for this was suspected to be excessive cooling of the forced-air cooling racks, 30 of which were installed in that particular room. A forced-air cooling rack is a type of closed rack that takes in cold air from under the raised floor using fans, and then uses this cold air to cool the ICT equipment (**Fig. 5**). It is often used for equipment that produces a lot of heat because it can supply large amounts of cold air for cooling purposes. Generally, the quantity of air that the rack takes in is set in the design phase and is not changed after that. As a result, the quantity of air that the rack takes in may be considerably larger than the amount of cooling the equipment in the rack actually requires. Massive overconsumption by a number of racks may, therefore, cause a lack of cold air under the raised floor.

We adjusted the quantity of air taken in by the racks so that the inside temperature was maintained at the optimum level. This was achieved by measuring the temperature of the exhaust from the upper surface of each rack and then minimizing the number of fans running so that the temperature of the exhaust did not exceed the steady-state value determined in advance.

4. Some solutions to optimize temperature and prevent hot spots

The temperature distribution throughout the room after introducing the airflow control panels and the blank panels is shown in **Fig. 6(a)**. A comparison of the results with the image in Fig. 1, which shows the

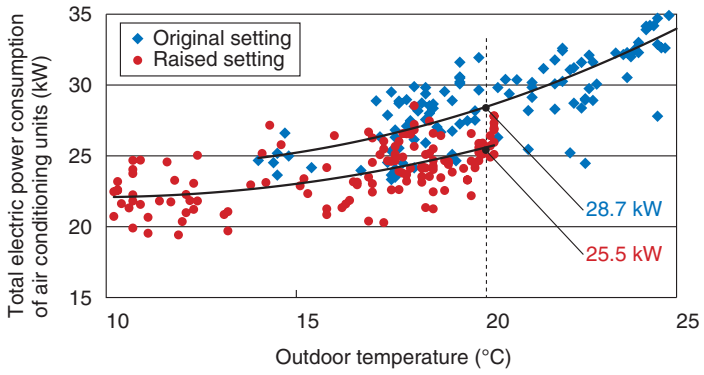


Fig. 7. Air conditioning electric power consumption versus outdoor temperature.

temperature distribution before alteration, shows that the temperature at hot spot 1 was significantly reduced. The maximum temperature fell from 31.4°C to 28.9°C. By contrast, the temperature at hot spot 2 did not change significantly. This is because the solutions implemented only have a localized effect.

The temperature distribution after adjusting the quantity of air taken in by the forced-air cooling racks, in addition to the two solutions implemented earlier, is shown in **Fig. 6(b)**. Comparing Fig. 6(a) with Fig. 6(b) shows that the temperature of most of the racks (except the forced-air cooling racks) was reduced as a result. The maximum temperature of hot spot 2 fell from 29.6°C to 27.9°C, and that of hot spot 1 dropped to 28.5°C.

5. Electric power savings achieved by reducing air conditioning

Adopting the three solutions described above reduced the maximum temperature of the room to 28.5°C. This meant that it was now possible to reduce the amount of air conditioning needed, so we altered the settings of all the air conditioning units and observed the change in electric power consumption. The temperature setting for the return air entering the air conditioning units was raised by 1.5°C in order to raise the maximum temperature of the room to 30°C (the usual temperature maintained in TERs).

The relationship between the total amount of electricity used by all the air conditioning units in the room and the outdoor temperature is shown in **Fig. 7**. The blue and red points show the power consumption levels measured when the room temperature was at its original setting and at the raised setting, respectively. Air conditioning power consumption decreased by 3.2 kW (11%) after raising the temperature setting by 1.5°C (at an outdoor temperature of 20°C). This means that the cost of air conditioning could be reduced by 300,000–400,000 yen every year.

6. Conclusion

As a result of this joint experiment carried out in conjunction with the NTT WEST Kochi branch, the status of hot spots in the TER inside the Kochi-Naka building was improved significantly, and the air conditioning requirements were reduced. Changing the temperature settings by 1.5°C achieved an 11% reduction in air conditioning power consumption when the outdoor temperature was 20°C. We are continuing to research and improve these power-saving techniques so that they can be adopted more widely, in cooperation with each company within the NTT Group.

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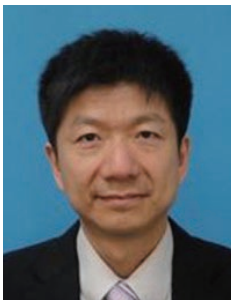

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IEEE 802.11 Wireless LAN Standardization Trends

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Abstract

This article gives an overview of the Institute of Electrical and Electronics Engineers (IEEE) 802.11 Working Group (WG), which creates standards for wireless local area networks (LANs). We include information on its relationships with external organizations, its standardization processes, and a list of existing amendments to IEEE 802.11. Some of the latest trends in standardization are also introduced, including IEEE 802.11ac, which is an amendment of the IEEE 802.11 standard to increase system throughput, and we explain the status of the High Efficiency WLAN Study Group (HEW SG), which has begun standardization work to enhance transmission efficiency in high-density deployment of access points and stations.

Keywords: IEEE 802.11, wireless LAN, multi-user MIMO

1. Overview of 802.11 WG

The Institute of Electrical and Electronics Engineers (IEEE) 802 Committee (from here on, "802 Commitee") is the organization that develops and maintains standards for the physical and data-link layers of transmission media for wired and wireless networks. The 802.11 Working Group (WG) was established within this organization in 1990 to create standards for implementing wireless Ethernet. The 802.11 WG carries out development by cooperating widely with standardization and industry organizations within and outside of the 802 subcommittees (**Fig. 1**). In particular, the Wi-Fi Alliance, which certifies interoperability among IEEE 802.11 wireless local area network (LAN) devices, has played a large role in the explosive spread of wireless LAN products [1]. As shown in **Fig. 2**, since the initial 802.11 standard was published, it has been extended with many amendments that address the increasing speed and functionality, which include faster transmission speeds (802.11a/b/g/n/ac/ad), priority control based on type of traffic (802.11e/aa/ae), security improvements (802.11i/w), extended wireless LAN functionality (802.11F/h/k/r/s/u/v/z), and support for frequencies used in different countries (802.11d/j/y).

2. 802.11 WG standardization process

The standardization process adhered to in the 802.11 WG is as follows. First, the needs for a new standard for future wireless LAN systems are discussed in the Wireless LAN Next-Generation Standing Committee (WNG SC). Here, the need for a new standard is proposed, and if this is approved by the New Standard Committee (NesCom) in the IEEE Standards Association (IEEE-SA), which is a higher-level organization of the 802.11 WG, a study group (SG) is established. In the SG, a prospectus is created that outlines the goals of the new standard to be created, including the scope, marketability and feasibility of the study. After the prospectus is approved, a task group (TG) is established, and concrete discussion toward creating the specification begins.

The TG decides, to some extent at its own discretion, how the work will proceed. The following is one example. First, documents summarizing the functional requirements to achieve the goals of the activity and the evaluation methodology for each technical proposal are created. Then, technical proposals that satisfy these conditions are invited. If there are multiple competing proposals, the technology to be used is narrowed-down through voting or other means. After a single technical specification has been

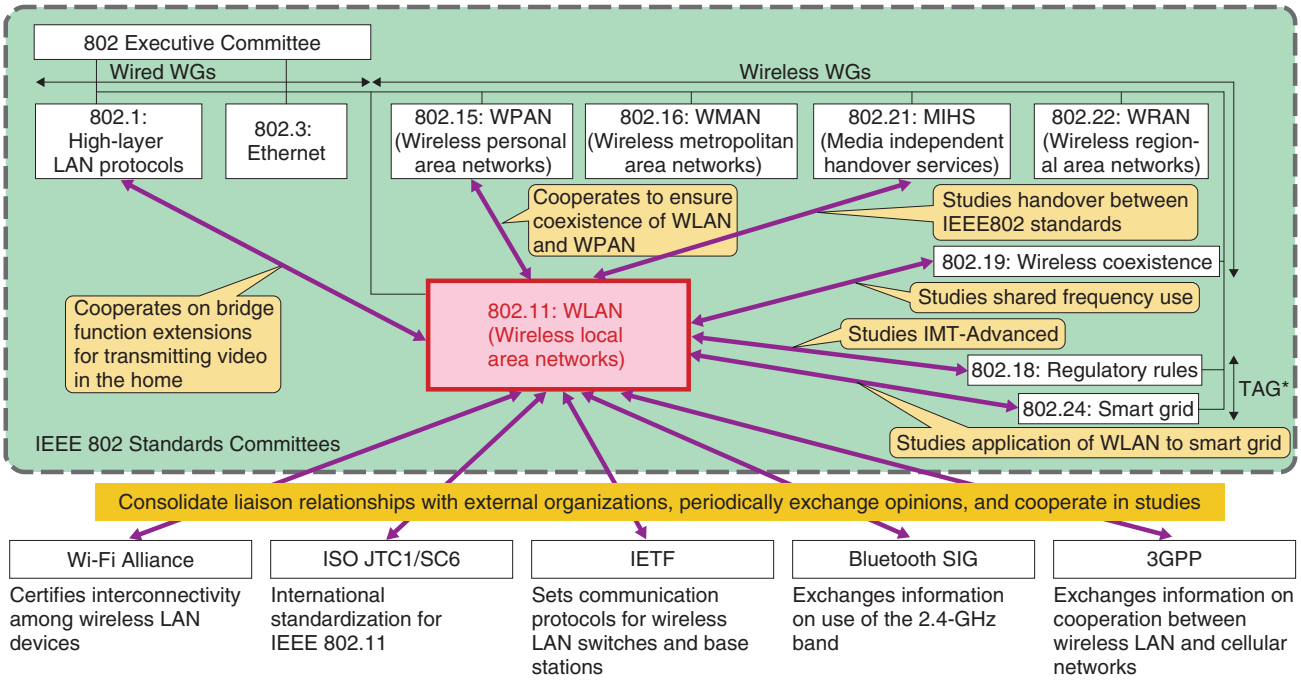


Fig. 1. Positioning of 802.11 WG within the IEEE 802 Standards Committees.

selected, a draft summarizing the basic technical specifications is created. The 802.11 WG and the IEEE-SA hold an electronic ballot to vote on the draft. In each ballot, voting members vote to either support the specification of the draft or not, and they optionally attach comments for revision. The TG resolves these comments by revising the draft as necessary; then the next electronic ballot is carried out. This process is repeated until the comments are resolved through the ballot and voting process and the approval rate meets certain prescribed conditions. Finally, when the proposal receives approval by the 802 Committee, it is published as a standard specification.

3. Status of work in 802.11 WG

The active TGs and SG in the 802.11 WG, as of July 2013, are listed in **Table 1**. This article focuses on the activities of the following two groups in creating amendments of the 802.11 standard for increasing throughput. The current state of their work is also discussed.

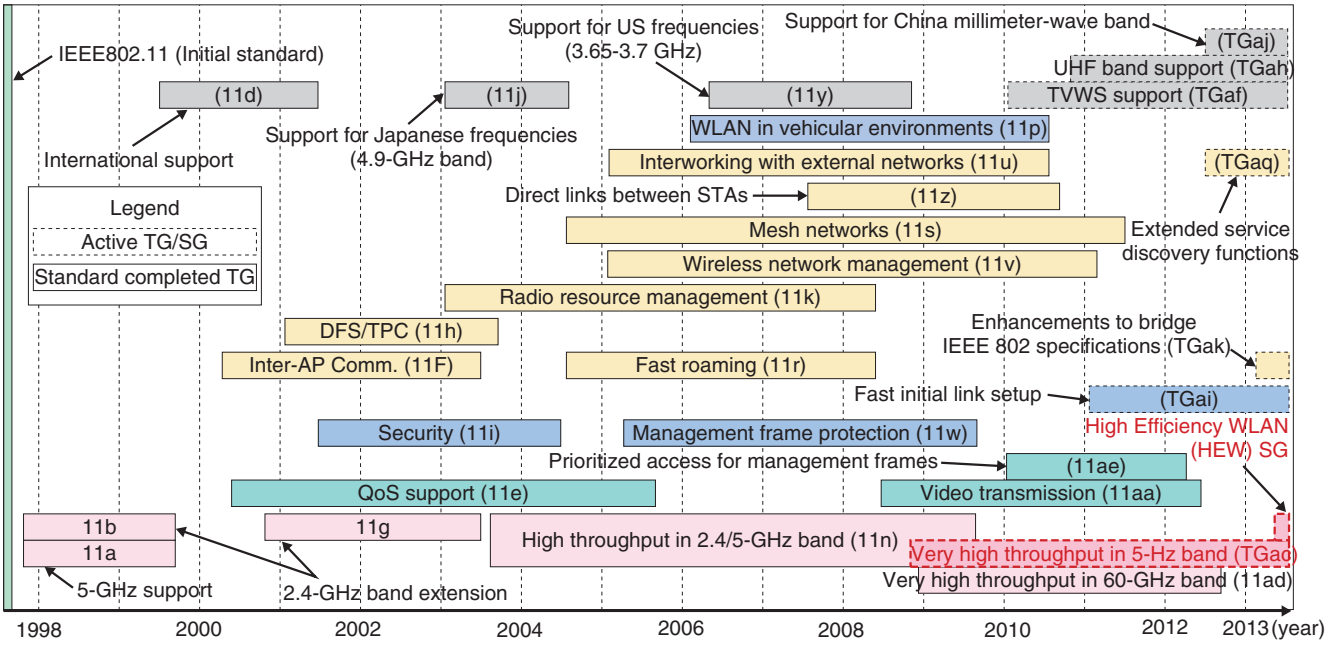
1. TGac, which is working on creation of the standard that achieves system throughput of 1 Gbit/s and greater.
2. The High Efficiency WLAN SG (HEW SG), which is preparing to form a TG to work on realizing high system capacity in the dense deployment of wireless LAN access points (APs) and stations (STAs).

3.1 Status of TGac

TGac began its activities in November 2008; these activities concerned the next generation of wireless LAN to follow 802.11n, which has been widely adopted. It assumes use of the 5-GHz band. TGac has set the following two target values for speed increases:

(1) Throughput of 500 Mbit/s on a single wireless link
(2) Total throughput of 1 Gbit/s on multiple wireless links

For target (2), a multi-user MIMO (multiple input, multiple output) (MU-MIMO) technology that extends the MIMO technology specified in 802.11n,



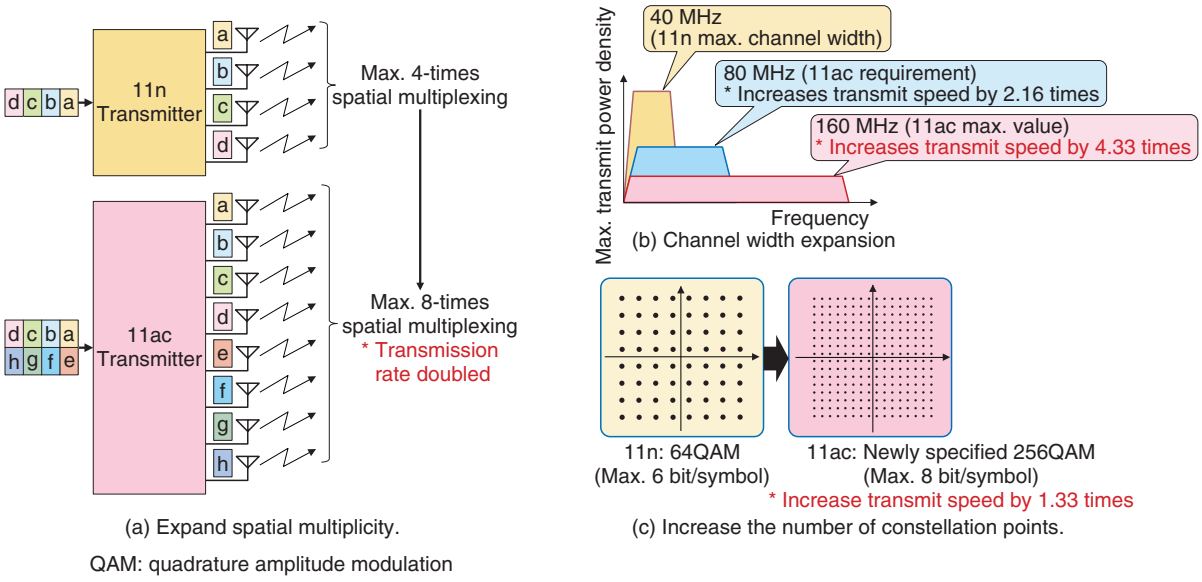
DFS/TPC: Dynamic Frequency Selection/Transmit Power Control
Inter AP Comm: Inter-Access Point Communication
QoS: quality of service
TVWS: television white space
UHF: ultra high frequency

Fig. 2. History of IEEE 802.11 standard and its amendments.

Table 1. Active TGs/SG in 802.11 WG. (As of Sept. 2013)

TG/SG	Focus of study	Status	Completion date (planned)
TGac	Very high throughput below 6 GHz (System throughput of Gbit/s and above)	Draft D7.0	Feb. 2014
TGaf	Wireless LAN in TV white space	Draft D5.0	Jun. 2014
TGah	Wireless LAN supporting wide areas and many terminals under 1-GHz frequency band	Draft D0.1	Mar. 2016
TGai	Fast initial link setup	Draft D1.0	Feb. 2015
TGaj	Millimeter-wave-band wireless LAN in China	Technology under study	Oct. 2016
TGak	Enhancements for transit links within bridged networks	Technology under study	(undecided)
TGaq	Pre-association service discovery	Technology under study	May 2015
HEW SG	Highly efficient wireless LAN SG	Usage models and scope under discussion	TG to be established in Jul. 2014

is adopted to achieve simultaneous transmission to multiple STAs over the same frequency band. Experimental results from NTT's testbed in real environments [2] are being used to confirm the feasibility of this technology. The technologies to be adopted have been refined over approximately two years since TGac began its activities, and the work of conducting ballots and revising the draft is still continuing. As of September 2013, the work to resolve comments on the sixth edition draft (D6.0) had been finished, and efforts are proceeding on target to complete standardization by February 2014.



QAM: quadrature amplitude modulation

Fig. 3. Technology addressed in 802.11ac focusing on increased speed.

Table 2. Comparison of 802.11ac requirements and maximum values.

Speed increase function/ characteristic	11n Regulated max.	11ac	
		Min. value	Max. value
Spatial multiplicity	4	1	8
Transmit bandwidth	40 MHz	80 MHz	160 MHz
Modulation	64QAM	64QAM	256QAM
Maximum frame size	65,535 Bytes	8191 Bytes	1,048,575 Bytes
Physical layer transmit speed	600 Mbit/s	292.5 Mbit/s	6933.3 Mbit/s
Maximum throughput (Transmission efficiency)	485 Mbit/s (81.0%)	157 Mbit/s (53.4%)	5.85 Gbit/s (84.4%)

Throughput using only the required conditions and functions is limited to approximately 1/3 of the 11n maximum.

There is a large difference between the required and optional functions.
- PHY transmit speed: 23.7 times
- Throughput: 37.3 times

3.2 802.11ac Specification for throughput enhancement

For target (1) (increasing the speed of individual wireless links), the techniques already defined in 802.11n such as spatial multiplexing, and techniques related to channel bandwidth and the number of constellation points have been extended further (**Fig. 3**). Wideband transmission using the 80-MHz or 160-MHz channel specified in 11ac was not previously allowed under Japanese Radio Regulatory Rules, but recent changes in the regulatory rules in March 2013 make it possible to use these bandwidths. There are also large differences between the mandatory conditions, which must be supported, and the maximum provisions in 802.11ac (**Table 2**). This is intended to reflect the diversifying needs of wireless LAN terminals and to impart high scalability.

To achieve target (2) (increasing system throughput

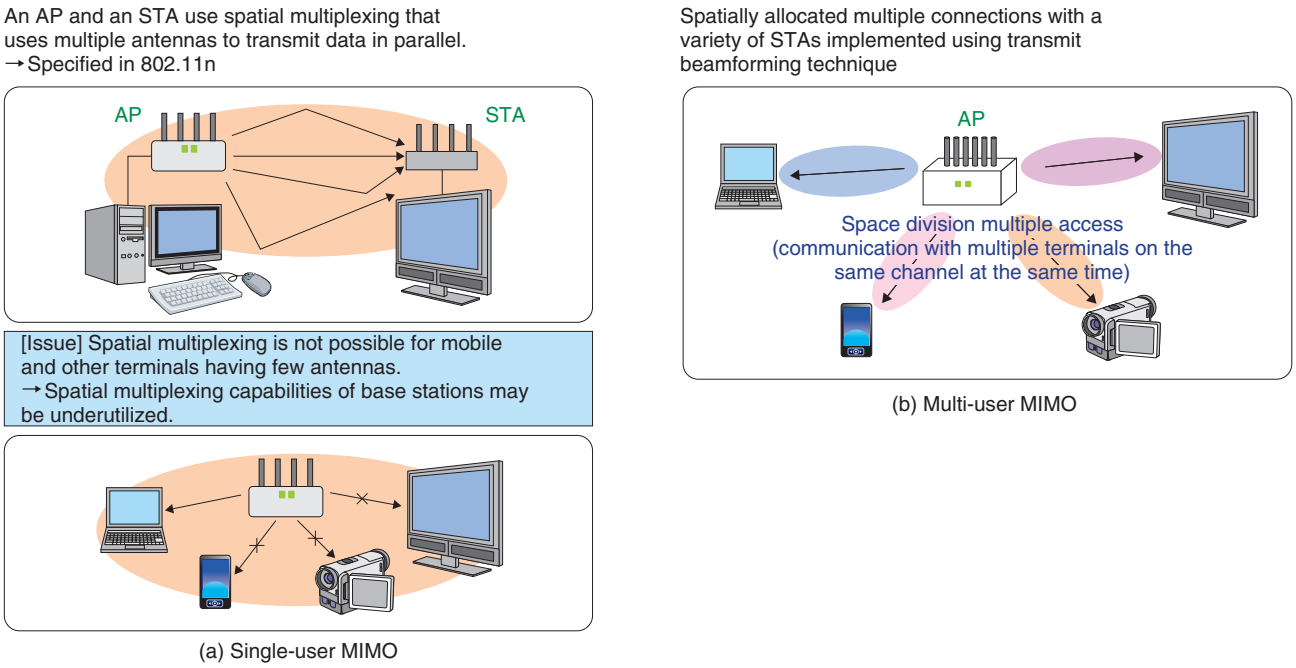


Fig. 4. Depiction of SU- and MU-MIMO.

by transmitting over multiple wireless links simultaneously), MU-MIMO technology is specified for the downlink (DL) transmissions. An AP transmits to up to four STAs simultaneously using beamforming techniques to cancel inter-user interference in order to implement simultaneous transmission to multiple STAs.

Single-user MIMO (SU-MIMO) technology, which transmits between individual STAs using spatial multiplexing, is already specified in 802.11n. Additionally, 802.11ac defines DL MU-MIMO technology, which enables increases in transmission efficiency without requiring multiple receiver antennas or complex signal processing at each destination (**Fig. 4**). The 802.11ac standard specifies wireless frame formats, methods for allocating user groups, methods for channel state information feedback observed at each STA in order to achieve transmit beamforming, and other aspects needed to implement DL MU-MIMO transmission. With DL MU-MIMO technology, even if STAs do not support SU-MIMO technology, the AP's spatial multiplexing transmission using transmit beamforming makes it possible to transmit multiple frames to different STAs simultaneously over the same frequency band, which enhances the total system throughput.

In addition to a variety of transmission modes including combinations of spatial multiplexing, transmission bandwidth, and SU/MU-MIMO transmission, 802.11ac defines the frame format encapsulated in the same header format as 802.11a/n. This format enables compatibility among 802.11a/n/ac transmissions on the 5-GHz band.

3.3 Status of HEW SG

Recently, wireless LAN has been widely deployed. These networks are now being implemented in mobile terminals such as notebook PCs, smartphones, and tablet computers. Transmission speeds have also increased to up to several hundred Mbit/s with the advent of 802.11ac. However, the frequencies available for wireless LAN are severely limited. These frequencies are also used by many wireless LAN systems in crowded environments such as train stations and airports, which results in problems such as significantly reduced transmission speeds and longer times required to connect to the network.

The WNG SC has been deliberating on these conditions in its discussions of next-generation wireless LAN systems to follow 802.11ac since the end of 2011, including the need to increase transmission efficiency in environments with a high concentration of terminals. At the March 2013 meeting, a motion to establish a new SG was approved, which had been

proposed jointly by 19 companies including NTT. The motion to establish the HEW SG confirmed the need to begin working on various issues. The proposal was as follows.

"Do you support starting a new study group called *high efficiency WLAN* to enhance 802.11 PHY and MAC in 2.4 and 5 GHz with a focus on:

- Improving spectrum efficiency and area throughput
- Improving real world performance in indoor and outdoor deployments
    - in the presence of interfering sources, dense heterogeneous networks
    - in moderate to heavy user loaded APs?"

The HEW SG began its activities at the May 2013 meeting [3]. At that meeting, the following officers of the SG were elected:

- Chair: Osama Aboul-Magd (Huawei Technologies)
- Secretary: Yasuhiko Inoue (NTT)

During the May and July meetings, more than 50 contributions were submitted regarding usage models (specific examples of congested environments) and technical issues with current wireless LAN standards, and the SG had a lively discussion on them. At the July meeting, the SG created the draft version of the consolidated document of usage models. This document was sent to the Wi-Fi Alliance, and discussions on prioritization from the perspective of future wireless LAN ecosystems will be held. Next, the contributions from each company will be summarized and the areas requiring study by the SG will be narrowed down. This will be used to clarify the technical issues that need to be resolved, clearing the way for creating a prospectus for establishing a TG.

4. Summary

This article introduced the 802.11 WG and described the state of work on the 802.11ac standard, which will expand throughput. It also discussed the HEW SG, which is working to standardize high-speed technology for future high-efficiency wireless LANs. Activity in the HEW SG has just begun, but there is already much anticipation for the introduction of 802.11ac, the next generation that will further increase efficiency.

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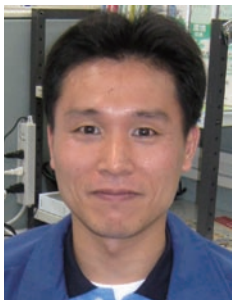

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Case Studies of Recent IP Problems in Homes

Abstract

In this article, we explain some case studies of recent IP (Internet protocol) problems that have occurred in homes. This is the nineteenth in a bimonthly series on the theme of practical field information on telecommunication technologies. This month's contribution is from the Network Interface Engineering Group, Technical Assistance and Support Center, Maintenance and Service Operations Department, Network Business Headquarters, NTT EAST.

Keywords: IP problem, IPv6, case study

1. Introduction

A wide variety of terminals have come to be connected to the Internet protocol (IP) network in unison with the rapid expansion of Internet services in society. At NTT EAST, the Technical Assistance and Support Center has seen the number of problem incidents in the IP system increase annually as FLET'S and other IP communication services grow, and it has been working to identify and explain the causes of these IP communication problems using packet-capture analysis. This month's article describes recent developments in Internet technologies and introduces case studies of IP problems that have been solved by packet-capture analysis.

2. IPv4

This section describes recent developments in Internet Protocol version 4 (IPv4) and an associated problem.

2.1 IPv4 global addresses

On February 3, 2011, the Internet Assigned Numbers Authority (IANA), the organization that manages the allocation of IPv4 global addresses used mainly for establishing Internet connections, announced that these addresses had been exhausted. Then, about two months later on April 15, the Japan Network Information Center (JPNIC), the organization in charge of allocating and registering IP addresses in Japan, also announced the exhaustion of IPv4 addresses. At present, this applies only to IPv4 global addresses allocated to Internet service providers (ISPs) and corporations; the efficient use of existing addresses means that Internet usage is continuing as usual. However, as new allocation of IPv4 global addresses is no longer possible, it may not be possible to launch new services using the Internet via IPv4 connections.

2.2 Case study: slow Internet access

The following describes a problem related to the allocation and exhaustion of IPv4 global addresses. Specifically, a customer using the FLET'S service reported that Internet access was sometimes slow.

2.2.1 Customer's equipment configuration and conditions at time of problem occurrence

The equipment and systems used to establish this customer's Internet connection are shown in **Fig. 1**. In this setup, a Point-to-Point Protocol over Ethernet (PPPoE) session is established at the broadband router, while the customer equipment is connected on the local area network (LAN) side. After connecting to the Internet from a home personal computer (PC), the customer sometimes found that the connection was slow. A check of the broadband router log around the times the problem occurred revealed that PPPoE sessions had been released ten or more times in one day, as shown in **Fig. 2**.

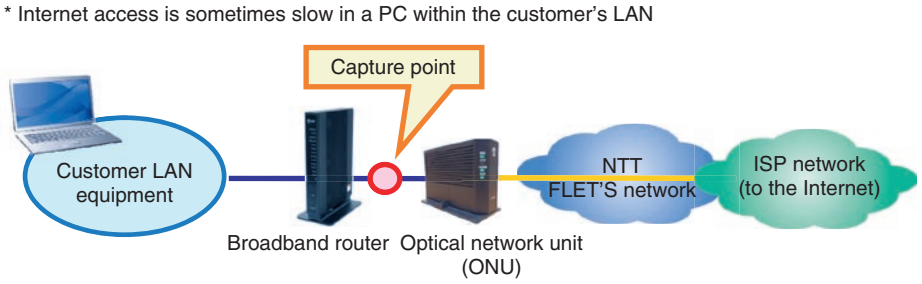


Fig. 1. Customer's Internet connection configuration.

```
02/03 22:34:37,PPP-IPCP established
02/03 22:34:37,PPP authentication successful
02/03 22:34:37,PPP-LCP established
02/03 22:34:36,PPPoE session initiation successfu
02/03 22:34:36,PPPoE AC discovery successful
* 02/03 22:34:31,PPPoE session released
02/03 21:55:39,PPP-IPCP established
02/03 21:55:39,PPP authentication successful
02/03 21:55:39,PPP-LCP established
02/03 21:55:39,PPPoE session initiation successfu
02/03 21:55:39,PPPoE AC discovery successful
02/03 21:55:34,PPPoE session released
02/03 20:51:16,PPP-IPCP established
02/03 20:51:16,PPP authentication successful
02/03 20:51:16,PPP-LCP established
02/03 20:51:16,PPPoE session initiation successfu
02/03 20:51:16,PPPoE AC discovery successful
02/03 20:51:11,PPPoE session released
```

Fig. 2. Excerpt of PPPoE session release log in broadband router.

2.2.2 Inspection method and analysis results

We performed packet capture on the wide area network (WAN) side of the broadband router at the times the problem was occurring and then analyzed in detail all of the captured data corresponding to the time of that PPPoE session release indicated in the broadband router log. By doing this, we were able to determine why the problem was occurring.

(1) Log analysis at PPPoE session release time

We analyzed captured data before and after a PPPoE session release time as recorded on the broadband router log (Fig. 2). As shown in **Fig. 3**, the broadband router first receives and acknowledges a PPP Termination Request from the network side and then receives and acknowledges a PPPoE Active Discovery Terminate (PADT) signal, also from the network side. These actions result in the release of the PPPoE session.

(2) Captured data before/after PPPoE session release

Captured data before and after a PPPoE session release (marked by * in the broadband router log of Fig. 2) are outlined on the log and shown in **Fig. 4**. The data indicate that the 10-minute period prior to the PPP Termination Request from the network was an idle state between the broadband router and ISP (in this case, an idle Internet connection). The same was true for PPPoE session releases in other time slots; all were preceded by a 10-minute idle state. As shown in the figure, about 6 seconds was needed to reestablish a PPPoE session after its release, so it can be assumed that the system response would seem slow to the user if an Internet connection were to be attempted during such a session-reestablishment period.

2.2.3 Discussion based on analysis results

The analysis results (1) and (2) above indicated that communications control on the ISP side would release a PPPoE connection (perform disconnection processing) if an idle state existed for at least 10 minutes. The ISP most likely does this for allocated addresses that are not being actively used, with the intention being to achieve more effective use of IPv4 global addresses.

2.2.4 Cause of problem

The results of analysis suggested that this problem was caused by communications-control measures on the ISP side and not by any problems in the FLET'S network. We therefore contacted the ISP manager in question and confirmed that processing to release a PPPoE connection would indeed be initiated on the ISP side to recover IPv4 global addresses if an idle state continued for at least 10 minutes.

Looking forward, we can envision a large-scale rollout of the IPv6 next-generation Internet protocol

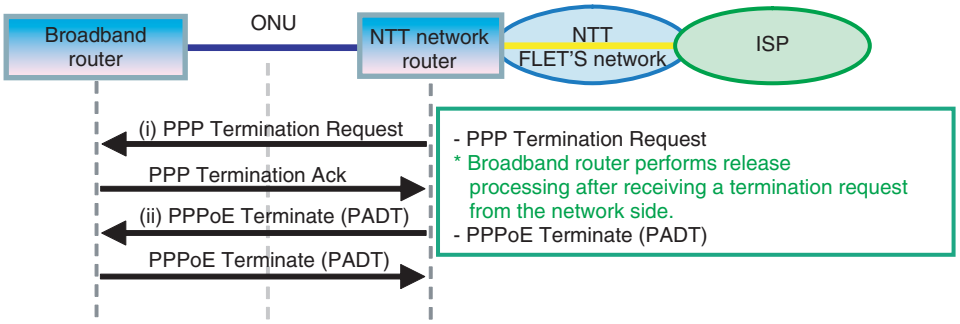


Fig. 3. Session release sequence.

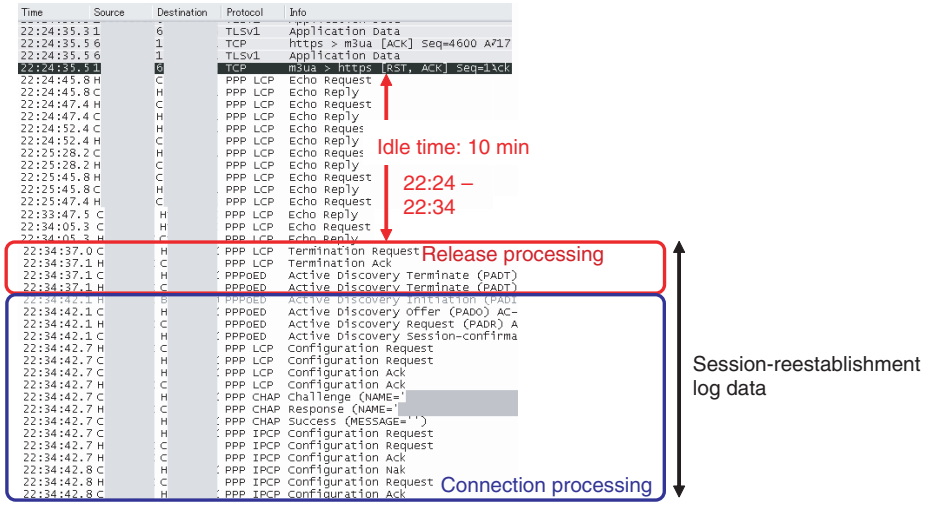


Fig. 4. Captured data before and after session release.

in response to this problem, and we can also consider the introduction of a mechanism to achieve more efficient use of IPv4 global addresses.

3. IPv6

This section describes recent developments in Internet Protocol version 6 (IPv6) and an IPv6 Internet connection problem.

3.1 IPv6 features

IPv6 was developed as the next-generation IP to succeed IPv4, which has been the protocol used to support Internet connections to date. As the scale of the Internet grew over the years, a number of shortcomings in IPv4 came to light, the most obvious of which is the exhaustion of IPv4 global addresses. Another problem is network address translation (NAT) traversal.

The aim of NAT traversal is to use IPv4 global addresses efficiently (economically) on the WAN side. With this method, a broadband router can increase the number of connected terminals by using private addresses on the LAN side and converting addresses by NAT (more accurately, network address and port translation (NAPT) since the process includes port translation). This method, however, prevents a terminal on the LAN side from being directly specified from the outside, thereby hampering bidirectional communications. Specifically, it can result in complicated settings and problematic communications in such applications as 050-type IP telephony and online multiplayer games.

In contrast to the above, IPv6 extends the address

Table 1. IPv4 and IPv6 features.

Version	IPv4	IPv6
Address length (number of addresses)	32 bits (about 4.3 billion)	128 bits (about 3.4×10^{38})
Address notation method	Decimal notation	Hexadecimal notation
Address allocation method	Specifications do not provide for automatic allocation of addresses, so other mechanisms must be used.	Specifications provide for automatic allocation of addresses.

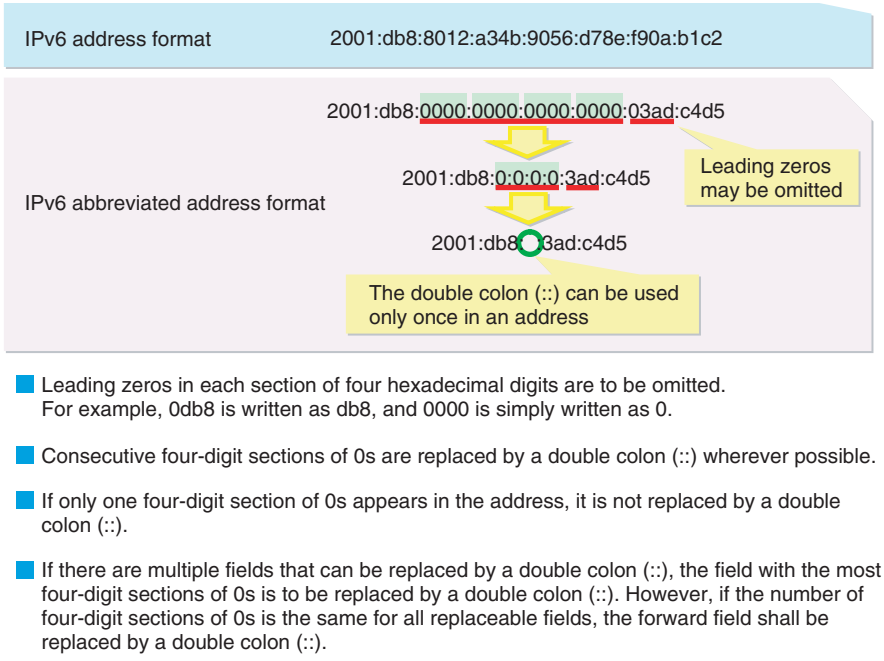


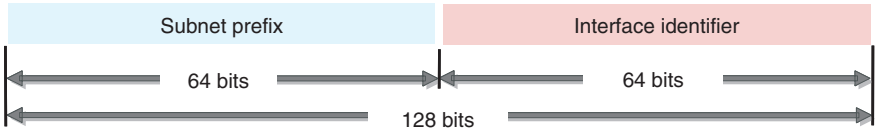
Fig. 5. IPv6 address notation.

space to 128 bits, thereby resolving the problem of an insufficient number of global IP addresses. The features of IPv4 and IPv6 are listed in **Table 1**. IPv4 uses 32-bit addresses, which means that it can handle 2^{32} or about 4.3 billion IP addresses. However, with 128-bit addresses, IPv6 can handle 2^{128} or about 3.4×10^{38} IP addresses, a significantly larger number. If all of these IP addresses were to be allocated to the entire human race (which we set to 7 billion people for calculation purposes), the number of addresses per person would turn out to be 480×10^{26}. It can therefore be said that the number of IPv6 addresses that can be implemented is essentially infinite. The IPv6 specifications also feature enhanced security functions and the addition of Internet Protocol Security (IPsec) as a standard function enabling the creation of a secure communications environment.

3.2 IPv6 address notation

The IPv6 address notation method is shown in **Fig. 5**. Since the address space has been extended to 128 bits in IPv6, a hexadecimal (0–f) notation method has been adopted that divides the 128 bits (16 bits × 8) into 8 groups of 16 bits connected by colons.

Furthermore, as shown in **Fig. 6**, the IPv6 unicast address used for Internet connections treats the first 64 bits of the 128-bit address as a subnet prefix and the last 64 bits as an interface identifier making for a clearly defined address format. In IPv4 addresses, the bit sequences for the network address and host address could change, which means that address processing at network interfaces has been mainly



- The interface identifier of a unicast address beginning with other than binary 000 is configured in Modified EUI-64 format with a length of 64 bits.
- The boundary between the network-identifying and node-identifying sections is variable in IPv4 but fixed in IPv6.

Fig. 6. IPv6 unicast address structure.

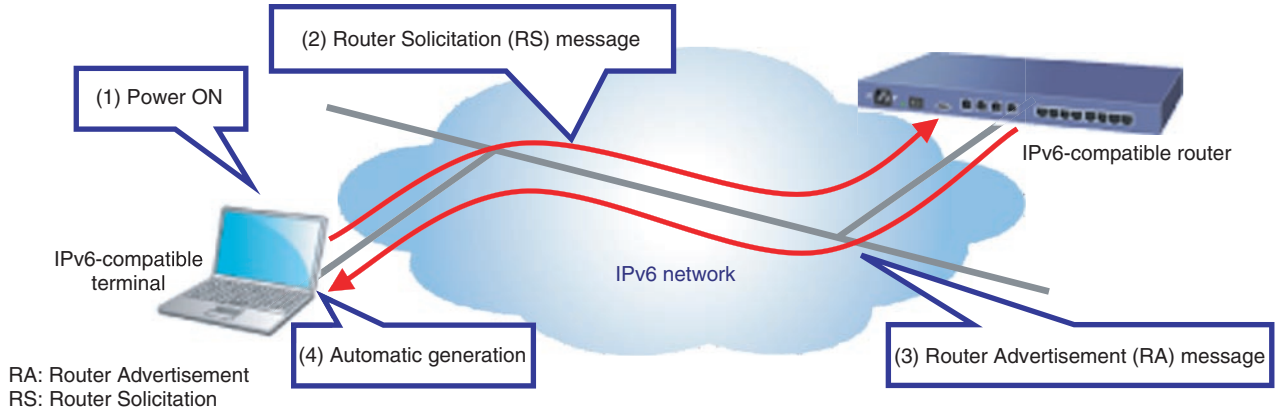


Fig. 7. IPv6 automatic address generation method.

handled by software. In short, while achieving high-speed processing was problematic with IPv4 addresses, this uniform method of using bit sequences in IPv6 addresses means that high-speed processing can be achieved by hardware.

3.3 IPv6 address allocation method

Unlike IPv4, the address allocation method specified by IPv6 automatically allocates IP addresses for establishing IPv6 connections. This IPv6 automatic address generation scheme, called IPv6 plug and play, is shown in **Fig. 7**. The convenience of IPv6 plug and play is analogous to the ease of using a home appliance by simply plugging it into a power outlet on a wall. When a LAN cable is connected to an IPv6-compatible terminal (and authentication is performed in the case of a wireless LAN) (1), the terminal transmits a Router Solicitation (RS) message (2), and an IPv6 router in the network returns a Router Advertisement (RA) message (3). The IPv6-compatible terminal then extracts from this RA message the information needed to automatically generate an IPv6 unicast address (4). The above process can be mainly accomplished by hardware, which means that an IPv6 unicast address can be configured in even less time that it takes to boot up the OS (operating system) on a PC running Windows.

3.4 Toward full-scale deployment of IPv6

The *World IPv6 Launch* was held on June 6, 2012 as a global event to introduce the new protocol. The intention behind this event was to convey the idea that IPv6 would be supported on an ongoing basis well beyond the launch date. This includes support for IPv6 standards by IP-network-compatible terminals to be marketed in the future as well as IPv6 support for website connections. The holding of this event signified a transition to a full-scale IPv6 deployment stage.

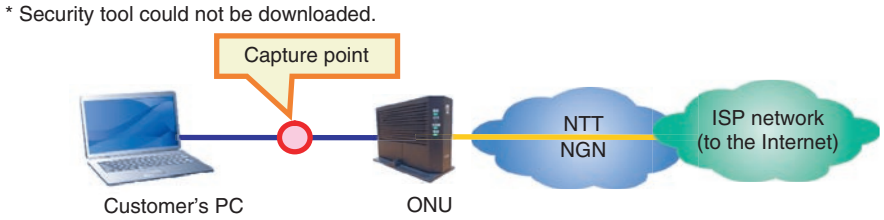


Fig. 8. Customer's Internet connection configuration.

3.5 Case study: Security Tools cannot be downloaded on FLET'S HIKARI NEXT

We present here a case study of a problem related to IPv6 connections. Specifically, a customer subscribing to the *FLET'S HIKARI NEXT High-speed Type* broadband access service was unable to download Security Tools (the name of this service at NTT WEST, but called FLET'S VIRUS CLEAR v6 at NTT EAST) from FLET'S simple setup tools. Additionally, while IPv4 Internet communications presented no problems, connections to IPv6 sites such as an IPv6 service information site could not be achieved.

3.5.1 Customer's equipment configuration and conditions at time of problem occurrence

The customer's Internet connection configuration is shown in **Fig. 8**. Here, one PC running Windows 7 was connected to the ONU, and Internet connections to the PC were established using installed startup tools (i.e., PPPoE connection functions in the OS). In this environment, IPv4 Internet communications were able to be performed without incident, but Security Tools could not be downloaded from the FLET'S simple setup tools.

3.5.2 Inspection method and analysis results

We performed packet capture between the ONU and PC at the time the problem occurred. We also performed packet capture when connecting a test PC that was shown to be capable of downloading Security Tools, and we compared and analyzed the captured data between these two PCs.

(1) Problem trigger

The sequence flow at the time of a Security Tools download-destination connection failure is shown in **Fig. 9**. To begin with, the series of operations from turning on the PC to determining the IPv6 unicast address for connecting to the FLET'S HIKARI NEXT service (NGN: Next-Generation Network), was executed normally. This was followed by name resolution (DNS: Domain Name Service) of the URL (uniform resource locator) for the Security Tools download destination, which was likewise performed without any problems.

Next, the PC transmitted a hypertext transfer protocol (HTTP) synchronize (SYN) request to initiate the HTTP connection process. Immediately after this, the NTT network router transmitted a Neighbor Solicitation (NS) message (media access control (MAC) address request in IPv6 communications) to the PC's NGN unicast address. However, no Neighbor Advertisement (NA) message (MAC address reply in IPv6 communications) was subsequently transmitted from the PC side, so the NTT network router entered a state in which it could not move to the next sequence. Finally, after the PC repeated the transmission of the HTTP SYN request three to four times, the connection terminated. At this time, the message "Cannot Display" appeared on the PC browser's screen. The above analysis led us to conclude that there was some reason why NA messages were not being transmitted from the PC side.

(2) PC operation at time of problem occurrence

In searching for the reason why no NA messages were being transmitted from the PC, we found that NA transmission for that NGN unicast address was being blocked by the PC's Windows firewall.

3.5.3 Discussion based on analysis results

We also found that default settings for the Windows firewall do not block NA transmissions. However, depending on the security software preinstalled in PCs, settings that restrict IPv6 communications can also be made, and we surmise that those default settings were changed at the time of product shipment.

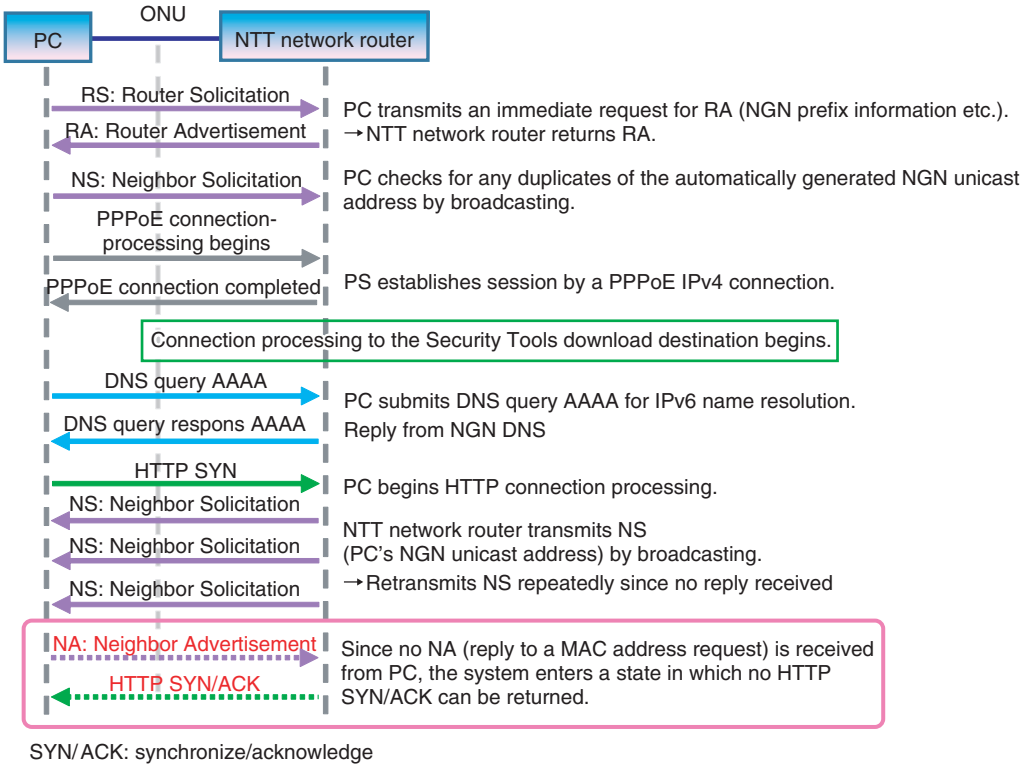


Fig. 9. Sequence at time of Security Tools download-destination connection failure.

3.5.4 Cause of problem

The search for the reason why no NA messages were being issued by the customer's PC revealed that NA transmissions for that NGN unicast address were being blocked due to that PC's Windows firewall settings. This is why the PC entered into a state in which it could not connect with an IPv6 site. Consequently, changing the Windows firewall settings or temporarily disabling the firewall made it possible to connect to the Security Tools download site and download those tools. This case study underscores the importance of checking PC settings in the event that specific types of communications cannot be performed.

4. Conclusion

In this article, we gave an overview of the IPv4 and IPv6 protocols and introduced two case studies of recent IP problems experienced by customers in their homes. New services and products using IP connections are constantly being launched, and the IP network within customers' homes is becoming increasingly diversified and complex. The Technical Assistance and Support Center is committed to uncovering the causes of IP-related problems and to finding early solutions.