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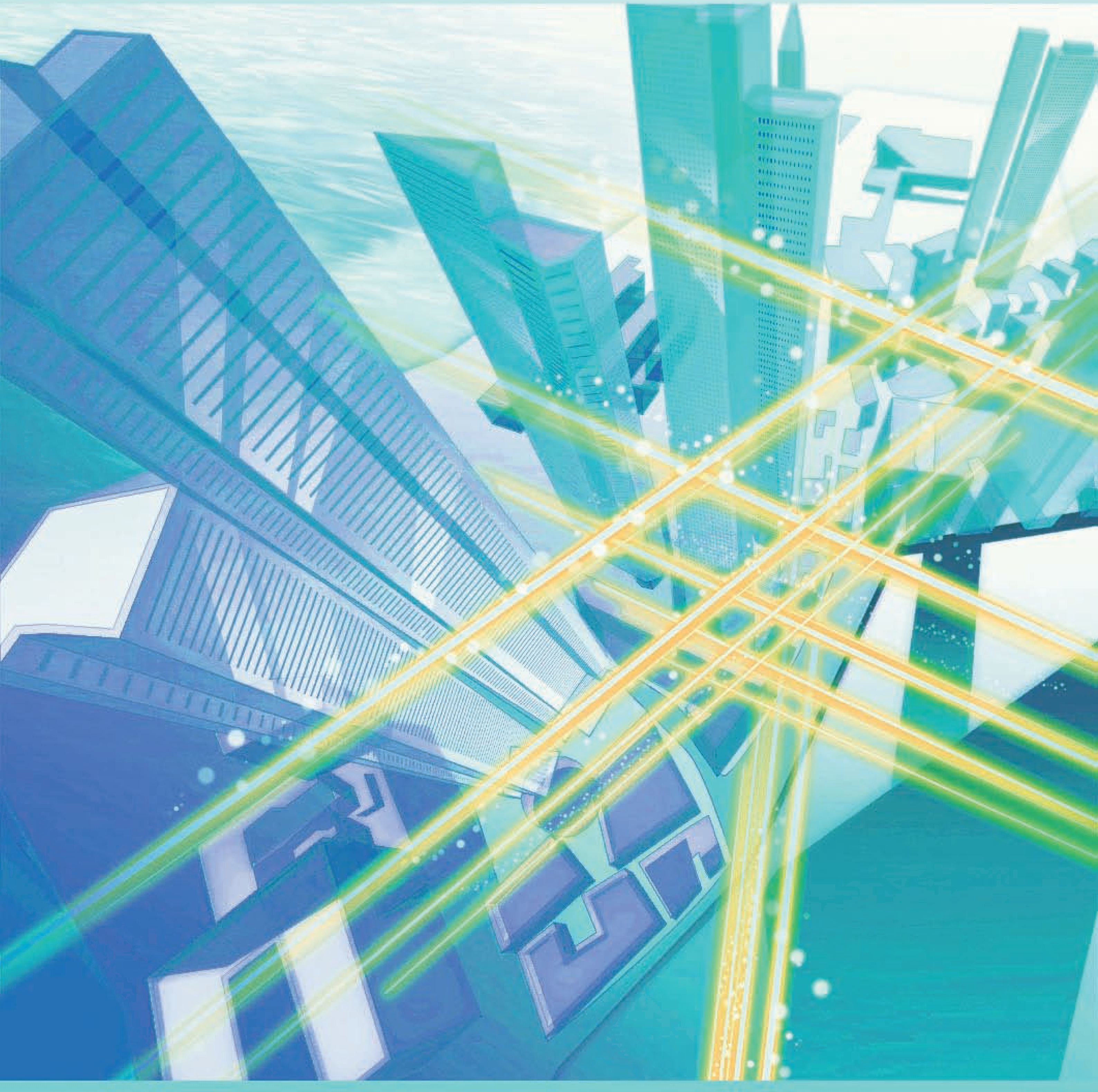

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How Innovation Drives Japan's Development and Growth—ICTs for New Industry Creation and Global Competitiveness

Coordinator:

– ***Waichi Sekiguchi, Editorial Writer, Nikkei Inc.*** [1]

Panelists:

– ***Norio Murakami, President, Norio Murakami Office Co., Ltd. (former President, Google Japan Inc.)*** [2]
– ***Asako Hoshino, Corporate Vice President, Nissan Motor Co., Ltd.*** [3]
– ***Noritaka Uji, Representative Director and Senior Executive Vice President, CTO, and CIO, NTT***

Abstract

During the NTT R&D Forum 2012, a panel discussion entitled "How Innovation Drives Japan's Development and Growth" was held on February 17. Noritaka Uji, NTT Senior Executive Vice President, participated as a panelist. This article reports on the discussion between the coordinator and panelists.

1. Introduction

Sekiguchi: Last year, we experienced a terrible disaster. The Great East Japan Earthquake on March 11 gave us the opportunity to think about this country from different perspectives. In the field of industry, it made us recognize the strengths and weaknesses of Japan when the shutdown of component plants in northeastern Japan halted the operation of many assembly plants in other parts of the world. Today, we will talk about how we can boost Japan's technical strengths. First, I'll ask each panelist to make a presentation and then we'll move on to discussion.

2. Presentations

What the 2010s are for the Internet of Things is equivalent to what the 1990s were for the Internet

Murakami: I think that Japan and the USA are at two opposite poles when it comes to reaction to technical advances. Protest by the Luddites against technological progress in the UK in the 19th century, at the time of the industrial revolution, is well chronicled. The Japanese also seem to have a mentality of resisting new things, on principle—a sort of immune rejection. When a new function is introduced in Japan, it is disabled by default. This is called *opt-in* in the world of

Waichi Sekiguchi, Coordinator

Norio Murakami, Panelist

Asako Hoshino, Panelist

Noritaka Uji, Panelist

information technology. If you want to use it, you must enable it. In contrast, Americans are typically willing to try a new function and, if anything goes wrong, take remedial measures. That is to say, a new function is enabled by default. If you don't want to use it, you must disable it; i.e., you must opt out.

When we consider technical development against these societal backgrounds, certain dilemmas [*sic*] emerge (**Fig. 1**). For example, should we seek perfection in a product at the sacrifice of the opportunity to gain a foothold in the market through its early introduction? How can we strike a balance between high performance & functionality and cost? If we pursue the development of elemental technologies in earnest, we may fail to achieve superiority in the overall system or platform. Japan also suffers from what is known as the *not invented here* syndrome: a propensity to prefer technologies developed within one's own company, and from the so-called *monkey trap*, a tendency to stick with highly successful products.

Another point where Japan differs from the USA concerns the creation of national strategies. A case in point is large national projects. In around the 1980s, Japan did have such projects, namely the super LSI project and the fifth-generation computer project (LSI: large-scale integrated circuits). Both of these yielded some good results and also revealed some mistakes. But is it right to put an end to such national projects? The USA has DARPA (Defense Advanced Research Projects Agency), an organization that is strategically important to the nation. Although it is connected with national defense, DARPA also plays an enormous role in creating new technologies for the nation. While Japan does not need a similar

Dilemmas in (technical) development.

- Speed vs. perfection
  Should we seek perfection at the sacrifice of time to market?

- Cost (price) vs. performance, functionality, and quality
  How should we strike a balance between the performance, functionality, and quality that consumers demand and the price they are willing to pay?

- System vs. elemental technologies
  We must ensure superiority in the platform (create necessary mechanisms), leaving elemental technologies to subcontractors.

Fig. 1. Dilemmas in (technical) development.

New horizon of the Internet

- 1.9 billion personal computers (starting with iPads toward mobile Internet)
- 5.3 billion mobile phones (from just net access toward smartphones)
- Several billion TV sets (starting with AppleTV/GoogleTV toward smartTVs)

- Unlimited number of devices on the smart grid:
  Smart houses, smart meters, smart appliances, smart cars (plug-in hybrid vehicles and electric vehicles), smart parking, etc.

In addition to conventional support for communication between people, the Internet now supports communication between people and things and between things.

Smart grid = Internet of Things (IoT)

Fig. 2. New horizon of the Internet.

organization, its strategy for science and technology should take the absence of an equivalent organization into consideration.

We are now witnessing a change in the tide, in that the entire world is heading in a new direction. There is a new horizon appearing in the form of the mobile Internet (**Fig. 2**). Japan blazed the trail toward enabling Internet access via mobile phones, thereby paving the way for smartphones. SmartTVs are expected to make their debut this year. Personal computers are becoming even smarter. Houses and meters are also getting smarter, with smart houses and smart electric power meters being connected with smart grids, which are intelligent power grids. They are ushering in the Internet of Things (IoT), in which communication takes place between people and things, and between things, in addition to conventional communication between people. What kinds of applications will run on the IoT is yet to be seen, although it is clear that the first application will be the visualization of power consumption, followed by demand response and demand-side management to control power consumption. While some people suggest that the third application will be remote care services for elderly people who live alone, what will follow it is completely unknown. Mind you, we must be alert to the possibility that there are some clever people who have already foreseen what will come next and have begun to write code in American university dormitories. What the 2010s are for the IoT is equivalent to what the 1990s were for the Internet; namely the decade when the Internet began to grow and blossom. We should seriously consider encouraging the creation of new industries through information and communications technology (ICT) and strengthening our competitiveness.

Engineers' understanding of customers makes a difference

Hoshino: I'm often asked what I do in the Global Market Intelligence Department, where I work. My colleagues think that I'm foreseeing the future by looking into a crystal ball. Actually, I analyze information about the world at large and provide the technical team, product development team, and marketing team with intelligence regarding international, regional, and local trends: how they will develop and what actions we should take.

Let me start with two examples of charismatic chief executives. The first is Steve Jobs, one of the cofounders of Apple. He is famous for having been anti-market-research. For example, on the day he unveiled the Macintosh, a reporter asked him what type of market research he had done. Jobs replied, "Did Alexander Graham Bell do any market research before he invented the telephone?" He also said, "Customers don't know what they want until we've shown them" and "You can't just ask customers what they want and then try to give that to them. By the time you get it built, they'll want something new." These remarks may seem to be a rejection of market research but my interpretation is that he meant that he needed a crystal ball.

The second example is someone very close to me, Carlos Ghosn. He came to Nissan in 1999 and told us that the problems that had plunged Nissan into crisis at that time were: lack of profit orientation, lack of customer orientation, lack of cross-functional and cross-border work, lack of a sense of urgency, lack of a shared vision, and no medium-term plan. The most important message from him was that all processes must be customer-oriented.

I'm in charge of market intelligence. While developers of elemental technologies look five to ten years ahead, we provide them with information about what the global market for mobility will be like ten to twenty years ahead and about how technologies should be developed. People in product development are engaged in projects covering a five- to six-year timespan, so we provide them with information about what the world will be like in five or six years. Marketing people look only one or two years ahead, so we provide them with information about current hot trends. For each group, we provide appropriate insight and foresight that are appropriate.

The strength of Nissan today is that it has created a stringent process whereby top management must approve our insight and foresight and no project can move onto the next milestone unless our prognoses are verified to support decision-making. Back in 2002, there was a general mood of apathy in the air. People tended to say, "It's no use listening to customers, and it's a waste of time looking at previous data." We, in a position to project future trends, were told that market research and analysis were unnecessary. This mood was the very source of the lack of a customer-oriented approach, which is what brought Nissan to crisis point. What pleases people? What should be done to please people? How can we excite people? You need to understand the market to know the answers. You need to have engineers who think about how to excite people. To put it in a nutshell, it is only through good technology and good understanding of your customers that you can create hit products. Once engineers understand their customers, they exhibit tremendous power. I think that one person who did it alone was Steve Jobs, and one person who tries to do it within an organizational framework is Carlos Ghosn.

Convergence of industries and services through ICT

Uji: The key words that symbolize the business tides in the ICT world are paradigm shift, service convergence, and globalization. Among these, I want to focus on service convergence in my presentation. Let's get an idea of what that means by taking as an example something that we use every day: the mobile phone. It was originally designed to be a tool for conversing and transmitting messages via a network. However, today's mobile phones do a lot more. You can listen to music, watch television, read books, use it as your commuter pass, and even use it as a pedometer. On top of all that, you can use it as an interpreter between languages such as Japanese, English, Chinese, and Korean.

Starting with the INS Concept in 1985, NTT has announced a series of visions from time to time: multimedia, global information sharing, and, most recently, service creation. We are now moving into

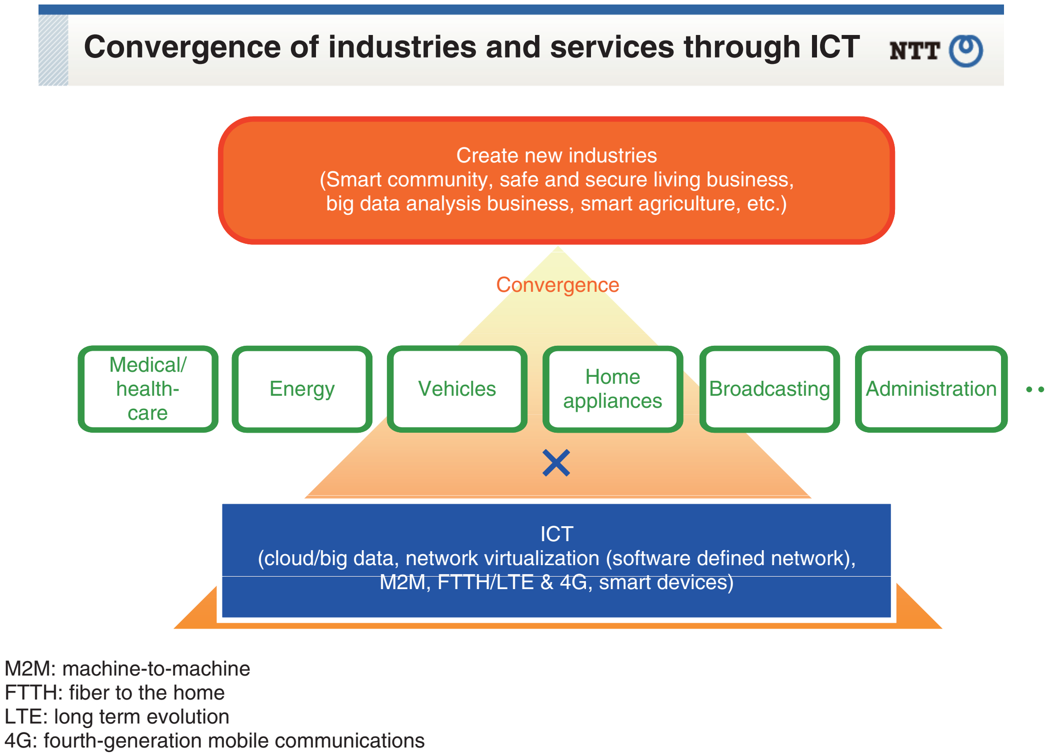


Fig. 3. Convergence of industries and services through ICT.

the age of convergence. A variety of industries and services will converge (**Fig. 3**). For example, up to now, a vending machine has merely been a device for selling and dispensing merchandise but, combined with ICT, it can manage inventory in real time and enable communication between the machine and the shopper. If a camera and a display are attached to it, the vending machine can recognize what type of person is standing in front of it and make appropriate recommendations. ICT can completely change what a vending machine is. When an automobile becomes an electric vehicle, it is no longer just a means of transport. It is also a mobile battery. When combined with ICT, a car can take on a bigger role. For example, it can become a sensor and can provide the driver with information appropriate for the particular situation. Interworking and convergence of broadcasting and communication are accelerating. Last year's business plan for NHK (Japan Broadcasting Corporation) clearly referred to the convergence of broadcasting and communication. NOTTV, a mobile multimedia broadcasting service for smartphone and tablet users, will start in April. Now let us turn our attention to energy issues. Since the earthquake in March last year, power supply shortages have emerged. Today, energy policy should involve not only energy suppliers but also energy users. By combining energy use with ICT, it is possible to visualize energy consumption and, by incorporating demand response, it is possible to optimize energy supply and demand. These innovations will lead to the development of smart communities.

The NTT Group is undertaking a wide range of research activities, including ICT, that will achieve the convergences that I have just mentioned. To bring research results to the market quickly, we are organizing teams tasked with bringing a comprehensive commercialization orientation to research and development (R&D). What we call *producers*, who are in charge of this initiative, build the service concept and business model, conduct market research, analyze the latest technologies available around the world, and set up collaborative arrangements with various industries. Where necessary, they seek collaboration with venture capital providers and foreign companies. They definitely play vital roles in creating innovation.

Our laboratories are also pursuing leading-edge research that can bring breakthroughs to the world. We have many excellent personnel involved in basic research, which includes communication science and materials science. Their papers are published in Nature, Science, and other leading scientific journals. Thomson Reuters in the USA published its list of 2011 Top 100 Global Innovators. NTT was one of the companies on the list. Japan, with 27 Japanese companies, followed the USA in the number of companies listed [4]. This is a sign that Japan has more potential to lead the world than it currently exhibits. ICT accelerates the convergence of industries and services, providing opportunities for existing companies to expand their businesses. It provides horizontal integration among different communities, industries, and organizations. The convergence of industries and services will give rise to new industries. Since R&D is the prime engine for boosting international competitiveness, the NTT Group, as a leading ICT company, will continue to pursue R&D.

Question: How should the Japanese companies compete?

Sekiguchi: The three companies that have led the home appliance industry in Japan expect to record a huge combined deficit of 1.29 trillion yen in the business year ending March 2012. In contrast, in our next-door neighbor, Korea, Samsung is steadily sharpening its competitive edge. Made-in-Japan home appliances once dominated the global market. Surprisingly, thirty years on, these companies are still competing the way they did decades ago, engaged in a futile battle of beating each other domestically and sticking with home-grown technologies, resulting in ever-lower prices, and shorter product lifecycles.

I am also concerned about the recent malfunctions in mobile communication services. They are said to be due to the network's failure to keep abreast of the sharp rise in the use of smartphones. The question is whether or not the communication industry can swiftly and technically cope with the emergence of smartphones.

Some companies have achieved success by incorporating new technologies. Apple is one example. Steve Jobs briefly left the company, but when he returned, he threw out the whole existing product lineup, focused on the iMac, and began meeting the demands of the market by providing color variants of the product. Apple successively introduced the iPod, iPhone, and iPad: new information appliances that give the user access to the Internet. Within a short time span, Apple's business performance recovered. In 2001, personal computers accounted for 80% of the company's sales. They now account for less than 20%. This transition is the secret of Apple's latest success. By contrast, Japanese companies have neglected to explore unbeaten paths.

It is forecast that, by 2015, the number of smartphones in use worldwide will top 1 billion. In Japan, smartphones are expected to account for more than 70% of all mobile phones in use by 2015. A source of concern is mobile devices from Japanese vendors. Although the domestic market is growing, the share of mobile devices held by Japanese manufacturers is falling. We are concerned that Japanese ones do not sell in overseas markets, and we refer to the isolated domestic evolution of these devices as *Galapagosization*. Our concern is exacerbated by evidence that even the domestic market is being taken over by foreign companies.

The penetration of mobile devices is generating explosive growth in information volume. The volume of data exchanged by mobile devices today is around 0.6 exabytes (10^{18} bytes) per month. This is expected to grow to 10 exabytes over the next five to six years. The generators of this huge volume of data are smartphones, tablets, and home gateways together with IoT and machine-to-machine (M2M) traffic. There is a great business opportunity to be grasped in providing solutions that can handle this huge volume of data. If you look at the geographical distribution, data volume is growing fastest in the Asia-Pacific region. Japanese companies should do all that they can to expand business in this region.

The reason Japanese companies cannot currently win in world markets despite having adequate technology, funds, and human resources is that their approach to business is flawed. For one thing, they rely too heavily on the assets that they built up during the era of analog devices, neglecting to adapt to the world of the Internet. For another, they have been lulled into complacency by past successes and have failed to discard earlier business models, with the result that they have fallen behind in technical innovation. Both technology and the business management to control it are hard pressed to make the transition from the past to the present.

3. Discussion

Change in the sense of value driven by a sense of urgency and diversity

Sekiguchi: First, I'd like to address the business management issues. Why was Nissan unable to solve its problems, and why, when Ghosn came to Nissan, was he able to do so?

Hoshino: Among the five problems he identified, the most deeply rooted was the lack of a sense of urgency. By nature, people tend to resist change. At that time, Nissan was on the verge of bankruptcy. Ghosn launched a campaign called SHIFT_. It was a top-down program to educate employees that it was worthwhile to change things. "You never do the same thing." "Anyone who has thought of an idea that is different from past practice is to be lauded." It was critical that they accept this change in the sense of value. Another top-down action was to instill a sense of urgency. "This company will go under. Yes, it will, unless we change!" I think people, at heart, didn't like the idea of achieving synergy with Renault. "Without doubt, the cars we make are better." However, it was this attitude that brought Nissan to the brink of bankruptcy. It was essential that they sincerely felt the sense of urgency and believed in the idea of trying something new.

The move to change the sense of value was aided by the introduction of diversity. Diversity was brought to Nissan when a foreigner came to take the helm. When the only people in meetings were Japanese men, they just nodded in agreement with many issues, but when foreigners and women, people with completely different perspectives, faced such issues, they asked why. These men, comfortable with a shared sense of value, suddenly found themselves having to explain what they had thought to be obvious. Through being required to explain, they had the chance to discover that they had been wrong or to strengthen their ideas.

Japan's problems: Weaknesses in developing superior systems and attaining de facto standards

Sekiguchi: I would like to try and identify the weak points of Japanese companies. What caused them to fall behind?

Murakami: I think their weakness lies in their obsession with perfection, performance, and elemental technology. It slows the introduction of products to the market, raises the cost above what the market can accept, and erodes the supremacy of the total platform, even though individual elemental technologies may be excellent. Why has this happened? Japanese companies have been caught in the monkey trap of experience that earnest pursuit of perfection, performance, and elemental technologies brought about the great recovery from the devastation of the second world war and impressive development thereafter. Such a strategy may have worked once, but these companies appear unable to identify the next strategy. To make matters worse, Japanese enterprises are not ready to accept charismatic leadership. Their decision-making process consists of prolonged meetings. This has remained the same for ten or twenty years. The time to revise this attitude is long overdue.

Uji: With respect to Japan's weakness, I'd like to stress the importance of international standardization. Remember that de facto standards are just as important as de jure standards. Japan is not good at attaining global de facto standards. Japan may have excellent elemental technologies but it cannot assemble them into superior systems. NTT is no exception. While the individual elemental technologies we have are fine, we frequently have to discuss the need for a systematic approach.

Sekiguchi: Why is Japan not good at developing superior platforms or systems?

Murakami: The first reason is that Japan has a population of 120 million people. This large market grabs the attention of Japanese companies, which close their eyes to the global market. The domestic market is sufficient to yield a reasonable return on investment. You can maintain a respectable market as long as your elemental technologies are good enough. If the domestic market had been too small for your business to flourish, you would have looked at the Asian market, at least, and would have optimized your marketing strategy on that basis.

The second reason relates to *Galapagos cell phones*—ones finely adapted to the Japanese market alone. Interestingly, when Google put Android on the market, it learned a lot from Galapagos cell phones. However, by mocking Japanese cell phones as Galapagos cell phones, we are assessing the products too early and too lightly. We tend to label products too quickly when we really need to evaluate them more carefully. Just looking at what's bad and disregarding what's good is like throwing the baby out with the bath water.

How to sell products and services abroad

Sekiguchi: I heard from an Apple staff member that they learned from Galapagos cell phones. If Japanese technologies can penetrate the global marketplace, why can't Japanese products and services?

Uji: Back in around 2000, we tried, in vain, to diffuse our i-mode service overseas. We learned that simply investing money isn't enough. It's important to follow up. With that lesson still fresh in our minds, NTT has, over the last few years, been working on reinforcing existing initiatives and launching new ones for globalization. Watch this space.

In order to introduce products and services to overseas markets, it's necessary to adjust them to suit local market conditions. Just because something was well accepted in Japan, there is no guarantee that it will also magically work overseas. For example, East Japan Railway Company's prepaid card, Suica, can be used with ticket machines made for the private railways' system PASMO and can also be used as electronic money. It's very convenient. However, while Suica's high quality and convenient service may meet the expectations of Japanese commuters, their counterparts in other countries do not necessarily demand such high quality. The story is the same for mobile phones. For example, it is said that, in India, what they want are simple, low-cost cell phones that can make only phone calls. Needs differ from country to country. Japanese products and services may have some features that do not suit the needs of local markets abroad. That said, there are cases where our products do meet local needs as they are. For example, we have digital cinema, which, with its 4K resolution, boasts higher definition than the conventional high-definition TV. When we introduced it to Hollywood, it perfectly matched their needs. Products tempered in Japan's demanding market can have high potential in focused markets around the world.

Hoshino: Nissan and other Japanese automakers focus on the global marketplace rather than the Japanese domestic one. So, we have no tradition of undertaking technical development from the perspective of the Japanese market in isolation. Today, China is the largest available market. So we are looking at China, and also India. Because the Asian region has the fastest growing economies, we watch Asia very closely. We also, to a slightly lesser degree, keep an eye on Africa and the Middle East, whose growth rates are tagging along behind that of Asia. The requirements in these regions are quite different from those in Japan.

We do not think in terms of simply taking something attractive that we have manufactured in Japan to overseas markets. We need to adapt our products to individual markets. For us, it's important to involve ourselves in a particular market (observe it, talk with local people, and understand the future prospects of the market and the sense of value of the local people). People who can successfully do this we define as globally oriented businesspersons. It's not simply a matter of having people who speak fluent English. It's timely to ask what attributes are needed to be a globally oriented Japanese businessperson.

Murakami: Speaking of Google having learned from Galapagos cell phones, let me mention one globally oriented person: John Lagerling. He came to Japan, joined NTT DOCOMO, and was entrusted with the task of diffusing the i-mode service globally. He traveled around the world in this capacity, and then moved to Google Japan. He was well acquainted with the Japanese mobile phones that evolved in isolation from the world. Drawing on his deep knowledge about the pros and cons of Japanese devices, as well as his experience of the difficulty of trying to spread a particular service globally, he now leads global deployment of Android at Google Head Office. It's wrong to think that every aspect of a certain human resource or technology is good or, conversely, that every aspect of the Galapagos cell phone is bad.

High expectation for smartTVs

Sekiguchi: What fields should Japan focus on, and how should it approach them?

Murakami: Today, the Internet is seeing a new horizon appear. The International Consumer Electronics Show held in Las Vegas in January was symbolic. It was apparent that there are two different trends with regard to making things smarter. One is the trend from personal computers to smartTVs: Samsung and LG Electronics are the frontrunners in this field. The other trend is toward smart-grid devices: again, it was Samsung and LG Electronics that unveiled smart appliances. Even though Japanese manufacturers were the first to introduce the concept of information appliances, Japan now lags behind Korea just when these appliances are taking off. However, Japan still has a chance to catch up in the area of smartTVs. The TV industry has a layered structure. Receivers make up just one layer. There are others: the platform layer, application layer, and content layer. There is still scope for Japanese companies to penetrate, depending on how skillfully they go about it.

Among these layers, the most important is applications. And what heads the list in the application layer is something that may cause you to think "What? That one?" Yes, it's Apple's iBooks Author. Although iBooks Author is said to be a tool for editing textbooks, it is also capable of handling cross-media content. Will the advent of authoring tools in the application layer of smartTVs make it possible to present cross-media content in totally unforeseen ways? TV programs today are said to be uninteresting. Could these tools make them more interesting?

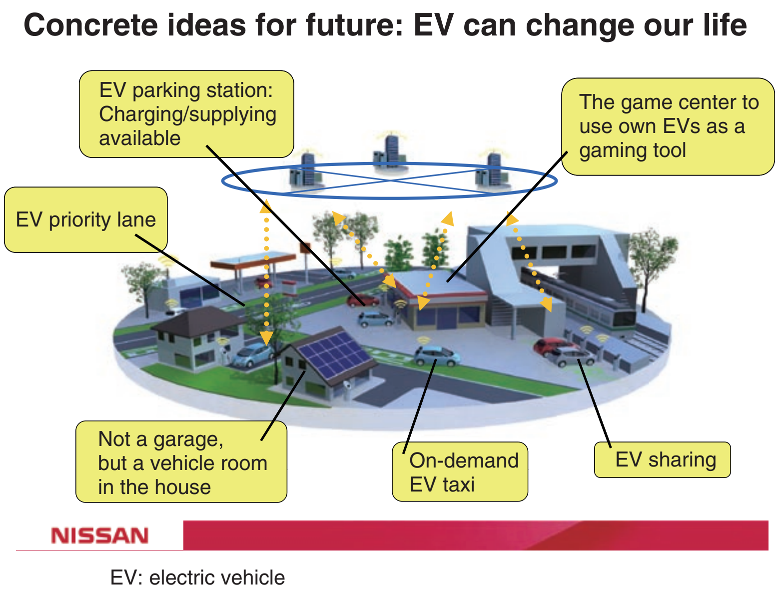


Fig. 4. Concrete ideas for future: EV can change our life.

The application layer is still an unoccupied area. The door is wide open. Furthermore, electric vehicles, which are representative smart-grid devices, can also become IoT devices. Since the age of IoT has just begun, I hope that Japanese companies will try hard to gain a foothold in this field.

Sekiguchi: The development and manufacture of products have traditionally been Japan's forte. Japan may have been overtaken by Korea in the area of mass production, but it should experiment by combining ICT with its elemental technologies while these are still superior.

Japan may be the leader in conventionally powered automobiles, but can it retain its competitive edge in the age of electric vehicles? I don't think it will be easy. Japanese automakers should combine their automobile technology with ICT while they still enjoy the leadership position, to create a brand-new field—that of smart cars—which will be the equivalent to smartTVs in the home appliance industry.

The key opportunities are in the communication field and services for the elderly

Hoshino: Yes, we automobile makers are actively exploring the possibilities of smart cars and smart cities (**Fig. 4**). We think that this is a field in which Japan can demonstrate its strengths. One key to the smart city concept is seamless communication: between cars and houses, between cars and people, between houses and people, and between cars. This is a field where we should make sure that we win. Speaking of communication, it should be noted that many people in advanced countries are still using conventional telephones while people in emerging countries are starting out with smartphones. Smartphone use is spreading at an extraordinary rate in emerging countries, resulting in the odd situation in which the value of communication in these countries is higher than in advanced countries. I'm convinced that, by fully grasping these developments, we can create a winning scenario in emerging markets.

Societies around the world are aging, and Japan is in the front line in this regard. If Japan can produce smart solutions to these issues, it could emerge as a winner five to ten years from now, when Europe and China start to experience what's already happening here.

It's important to continue to innovate

Uji: Addressing societal problems, such as medical and healthcare requirements and aging society issues, through the convergence of existing systems and ICT, and the launch of NOTTV through the convergence of broadcasting and communication, are examples of new industries that can emerge. If these initiatives prove to be successful in Japan, we should be able to successfully deploy them overseas.

NTT's technical development teams will innovate

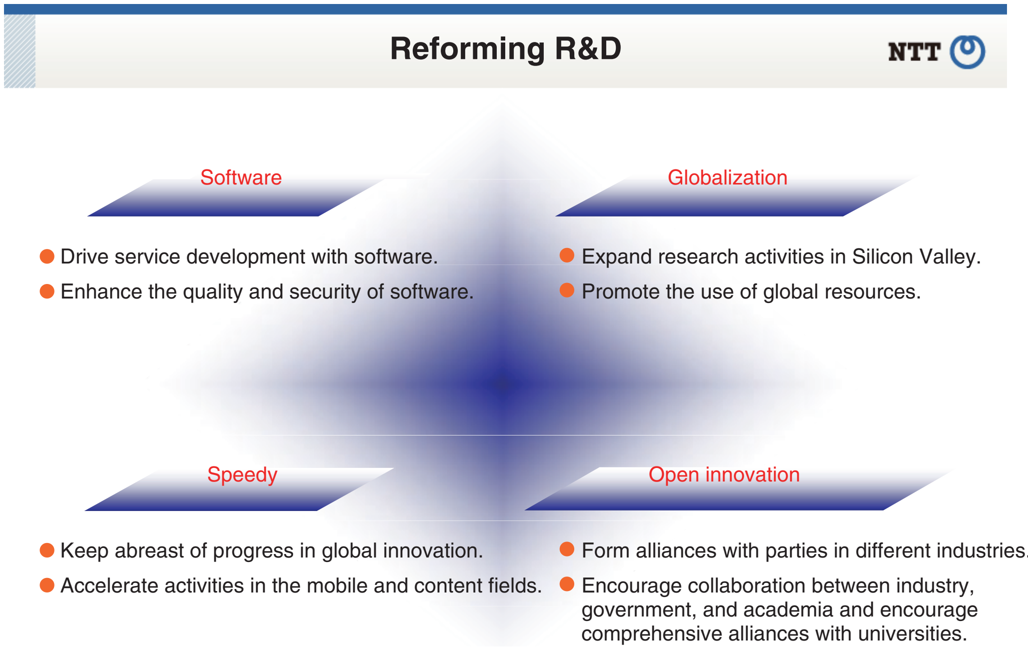


Fig. 5. Reforming R&D.

through active use of software to make new services and capabilities, globalization, increased speed, and open innovation (**Fig. 5**). Ms. Hoshino said that the Japanese automobile industry looks at the world market rather than the domestic one. For our part, NTT will look first at the domestic market, and then broaden its scope to take in overseas markets. As a way to promote science and technology in Japan, the government is advocating *life innovation* and *green innovation*. These are also new industries emerging through the convergence of various fields. Life innovation has to do with health, medical, and nursing care, while green innovation is aimed at addressing environmental and energy issues. But if you just hear these terms on their own, you might think that they completely unrelated to ICT. In fact, to drive these innovations, it is important to ensure convergence between them and ICT. Nissan Motor Company and the NTT Group are jointly conducting a feasibility test of a smart city concept. Such collaborative innovation with other enterprises and industries will become increasingly necessary.

Let me conclude with a remark made to me on the day that the news media reported that Eastman Kodak in the USA had filed for Chapter 11 bankruptcy. This person said, “How does NTT manage to keep its head above water!” If we were still purely a telephone company, we might have gone under. Instead, we have reinvented our business by venturing into the delivery of not only voice communication but also images and video and by providing Internet access and services, mobile communications, and solutions to customers’ business operations. Besides reforming business, we must also reform R&D, which is a fount of business growth and competitiveness, to suit the needs of the time.

Sekiguchi: Although Japan has its weak points, it can change if it tries hard. If Japan achieves success in the fields that it is good at or that it has embarked upon ahead of the rest of the world, such as automobile manufacturing, health and medical care, and care services for the elderly, then surely Japan is capable of successfully deploying them overseas.

Today, we have been fortunate to hear a lot of insightful views from three distinguished panelists. Thank you all very much.

References

[1] Nikkei Inc.
http://www.nikkei.co.jp/nikkeiinfo/english/index.html

[2] Norio Murakami Office Co., Ltd.
https://plus.google.com/118020952254072119863/about

[3] Nissan Motor Company.
http://www.nissan-global.com/EN/index.html

[4] https://www.ntt-review.jp/archive/ntttechnical.php?contents=ntr201202in1.html

Profiles of the coordinator and panelists

■ Waichi Sekiguchi

Editorial Writer, Nikkei Inc. [1]

Member of the Research and Development Strategy Committee, Information and Communications Council, Ministry of Internal Affairs and Communications; member of the Information Economy Sub-Committee, Industrial Structure Council, Ministry of Economy, Trade and Industry; member of the Security Measures Council, National Police Agency.

■ Norio Murakami

President, Norio Murakami Office Co., Ltd. [2]

Formerly, Vice President, Google Inc., and President (later Honorary Chairman), Google Japan Inc. He currently serves as a professor at the Center for Global Communication, International University, and as a special guest professor at the Graduate School of Keio University.

■ Asako Hoshino

Corporate Vice President, Nissan Motor Co., Ltd. [3]

Joined Nissan Motor in 2002 after having worked for Nippon Credit Bank, Co., Ltd. and Intage, Inc. She is currently Director of the Global Market Intelligence Dept.

Regular Articles

10-Gbit/s Phase-shift Keying Modulator and Demodulator MMICs for 120-GHz-band Wireless Link

Hiroyuki Takahashi†, Akihiko Hirata, Jun Takeuchi, Naoya Kukutsu, Toshihiko Kosugi, and Koichi Murata

Abstract

We are developing a 120-GHz-band 10-Gbit/s wireless link and have already demonstrated wireless transmission of a 10GbE (10 Gigabit Ethernet) data stream over a distance of 5.8 km. In its present state, the link uses amplitude shift keying (ASK) for the modulation scheme. To improve the system's performance, such as sensitivity and spectral efficiency, we need phase shift keying (PSK) modulation in the 120-GHz band. However, it is difficult to make a PSK modulator for frequencies above 100 GHz because the design is fundamentally more complicated than that for ASK. In this article, we introduce new PSK monolithic microwave integrated circuit technologies for 120-GHz-band 10-Gbit/s wireless links.

1. Introduction

The capacity of data communication systems continues to increase each year to meet the data rates of high-speed protocols and those needed for the transfer of high-definition video. Along with this tendency, demand for high-speed wireless systems is also increasing. In the broadcasting field, standards for high-definition video, such as high-definition television (HDTV, 1.5 Gbit/s), three-dimensional video (3 Gbit/s), and 4K digital cinema (6 Gbit/s), have been developed to catch up with the demand for high-presence applications. To transmit them in a live-relay broadcast, broadcasting companies need a long-distance wireless technology that can handle multigigabit-per-second data streams. In communication networks, Gigabit Ethernet (GbE, 1 Gbit/s) and 10 Gigabit Ethernet (10GbE, 10 Gbit/s) have been widely used and the standard for the 10-Gbit/s Ethernet passive optical network (10G-EPON) was approved in 2009. Multigigabit-per-second wireless systems are useful for the last mile of fiber-to-the-home (FTTH) services and for setting up temporary connections to restore a network after a disaster or other disruptive event. To meet these demands, there has been a lot of interest in broadband wireless technologies using the millimeter-wave band from 30 to 300 GHz, because this band can provide sufficient bandwidth.

In the 60-GHz band, some wireless systems that can transmit multigigabit-per-second data over a short distance have been reported [1], [2]. Some commercial point-to-point wireless links using 71–76 GHz and 81–86 GHz provide 1.25-Gbit/s data transmission over a link distance of more than 1 km. However, there are no practical wireless systems that can transmit 10-Gbit/s data a distance of 1 km.

NTT Microsystem Integration Laboratories is developing a 10-Gbit/s wireless link [3] and monolithic microwave integrated circuits (MMICs) [4]. The wireless link will be suitable for fixed wireless access for 10GbE, OC-192, and certain other protocols. It will also be able to handle uncompressed high-definition video. There have already been several successful trials over distances of several

† NTT Microsystem Integration Laboratories
Atsugi-shi, 243-0198 Japan

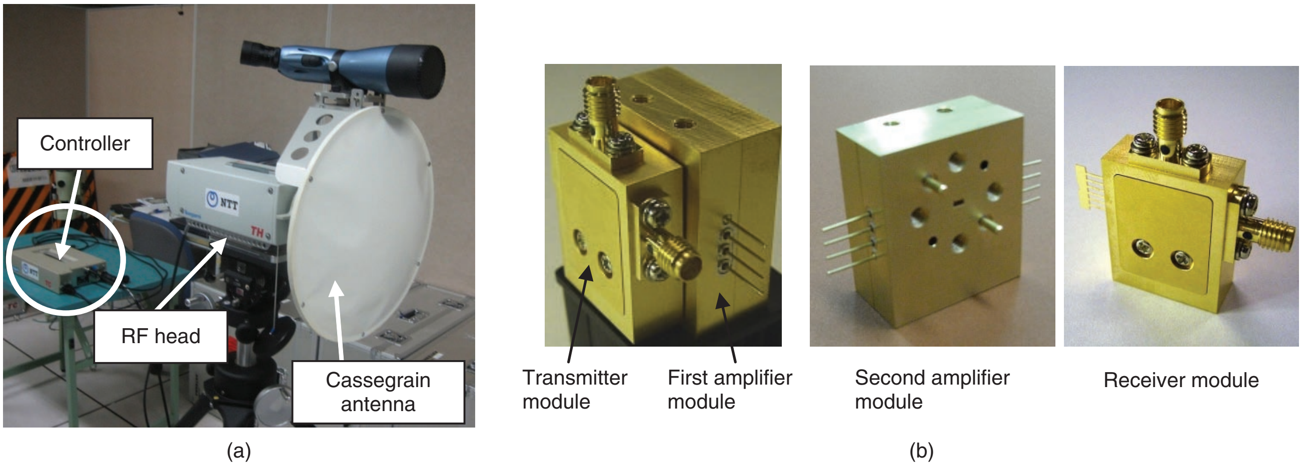


Fig. 1. External views of (a) 120-GHz-band wireless link and (b) RF modules.

kilometers; they include live relay broadcasts of HDTV [5], 10GbE transmissions in Sapporo, and 4K digital cinema streaming. At present, the link uses amplitude shift keying (ASK) and a bandwidth of 17 GHz for 10-Gbit/s data transmission with a spectral efficiency of 0.6 bit/s/Hz.

In this article, we present 120-GHz-band wireless technologies that improve the link distance and spectral efficiency. First, we introduce the 120-GHz-band wireless link with ASK modulation and transmission experiments over a distance of 5.8 km [6]. The transmitter's output power was increased by a power amplifier module having a high-breakdown-voltage high electron mobility transistor (HEMT) [7]. Second, we describe 10-Gbit/s phase shift keying (PSK) modulation technologies in the 120-GHz band. We explain the design of new binary PSK (BPSK) and quadrature PSK (QPSK) modulator MMICs [8], [9] in the 120-GHz band and present 10-Gbit/s data transmission characteristics of BPSK and QPSK modules.

2. Configuration and field experience

A photograph of a 120-GHz-band wireless link with the ASK modulation scheme is shown in **Fig. 1(a)**. The wireless transmitter was designed to have usability and configuration equivalent to the field pick-up unit currently in wide use by broadcasters. The transmitter head generates a 125-GHz signal as a radio-frequency (RF) carrier, modulates it with a 10-Gbit/s baseband signal, and amplifies the modulated signal to 16 dBm. The receiver head receives the incoming signal, amplifies it using a low-noise amplifier (LNA), and demodulates 10-Gbit/s data. The controller supplies power, the data signal, and control signals to the head. The antenna used by the wireless link is chosen from four available kinds: three Cassegrain antennas with diameters ranging from 100 mm (gain: 37 dBi) to 600 mm (gain: 52 dBi) and a standard horn antenna with gain of 23 dBi. Photographs of RF modules for generating, modulating, amplifying, and demodulating the millimeter-wave signal are shown in **Fig. 1(b)**. The transmitter module, the first amplifier module, and the receiver module use indium-phosphide (InP HEMT MMICs) developed by NTT Photonics Laboratories. The second power amplifier module uses 0.08-µm-gate-length InGaAs/InP HEMT MMICs, which have higher breakdown voltages. The on- and off-state breakdown voltages are around 4 V and 10 V, respectively. These values are almost double those of conventional InP HEMTs. The devices typically have current-gain cut-off frequency fT of 180 GHz and a maximum oscillation frequency fmax of 650 GHz. The second power amplifier with composite-channel HEMTs has demonstrated maximum output power of 140 mW and output P1dB of 80 mW at 125 GHz [7].

We conducted field transmission experiments using the 120-GHz-band wireless link shown in **Fig. 2**. The data rate was 10.3125 Gbit/s (forward error correction rate: 11.1 Gbit/s) and the transmission distance was 5.8 km in the fine weather during the experiments. The transmitter and receiver antenna gains were 52 dBi and 49 dBi, respectively. The 120-GHz-band wireless link performed error free transmission

Fig. 2. Photograph of experiment on 5.8-km 10GbE transmission using forward error correction.

(bit error rate (BER): less than 10^{-12}) during the experiment. At present, that is the longest reported distance for 10-Gbit/s wireless transmission.

3. PSK MMICs technologies

Our current link uses the ASK modulation scheme; this is the simplest architecture, but it has poor spectral efficiency because it uses binary modulation and it has lower sensitivity than other binary modulation schemes. We need a different modulation scheme with greater sensitivity and better spectral efficiency in order to extend the transmission distance or reduce the occupied bandwidth. For that purpose, PSK is promising. BPSK modulation, which uses two phases which are separated by 180°, has the highest sensitivity among binary modulation schemes so it enables a longer link distance for 120-GHz wireless transmission. QPSK uses four phases and can encode two bits per symbol. QPSK has double the spectral efficiency of ASK for the same bitrate because it is a higher-order modulation. It lets us use the 120-GHz-band 10-Gbit/s wireless link with less occupied bandwidth or increase the capacity of the same occupied bandwidth. The design of a PSK demodulator is more complicated than that of an ASK modulator owing to the need for a phase-comparison circuit. In this section, we present PSK modulator and demodulator MMICs for 10-Gbit/s data transmission in the 120-GHz band.

Two system requirements for a 120-GHz-band wireless link are the ability to handle 10-Gbit/s data with the same BER performance as the ASK system and to have a simple architecture. The ASK used for our wireless link has the advantage of a very simple architecture, which enabled us to design the ASK modulator and demodulator in a small area and integrate each one into an MMIC with other circuits on one chip. This is an advantage for reducing the fabrication cost of MMICs. To make the architecture of PSK MMICs simple, we chose differentially coherent detection for PSK demodulation since the differentially coherent detector does not need carrier-recovery circuits. In addition, we designed the modulator and demodulator without intermediate-frequency circuits. The total size of these circuits should be smaller than those that do have intermediate-frequency circuits, which makes it possible to implement them in a small area. The design goal is to make an integrated one-chip BPSK modulator and an integrated one-chip BPSK demodulator.

3.1 PSK modulator MMIC

Block diagrams of the BPSK and QPSK modulator MMICs are shown in **Figs. 3(a)** and **(b)**, respectively. To implement direct modulation, we chose a simple architecture consisting of 90º and 180º hybrid couplers, switches, and combiners. The gain-control amplifier (GC amplifier) acts as an on-off switch according to the applied voltage level. When the level is high, a signal fed into the GC amplifier is amplified by 10 dB; when the level is low, the signal is attenuated by more than 20 dB, resulting in a 30-dB on-off ratio. The Wilkinson combiner combines the output signals of the GC amplifiers. For BPSK, when the voltage level is high (corresponding to a data bit value of 1), the GC amplifiers amplify the 0º signal and when it is low (corresponding to a bit value of 0), they amplify the 180º signal. For QPSK, when (I, Q) is (1, 1), the GC amplifiers for the I (in-phase) channel amplify the 0º signal, and the GC amplifiers for the Q (quadrature) channel amplify the 90º signal. The phase of the combined RF signals therefore becomes 45º. To decrease the required frequency of the modulator MMIC, we used a doubler circuit, which converts the local signal to the carrier signal. This reduces insertion loss generated at wire-bonding sites. We also designed a differential amplifier to control the GC amplifiers. The differential amplifier divides input data into positive and negative data values and shifts the voltage levels to appropriate values for GC amplifiers.

We evaluated the magnitude of the static error vector of the designed modulators. The S_{21} characteristics of the BPSK and QPSK modulator

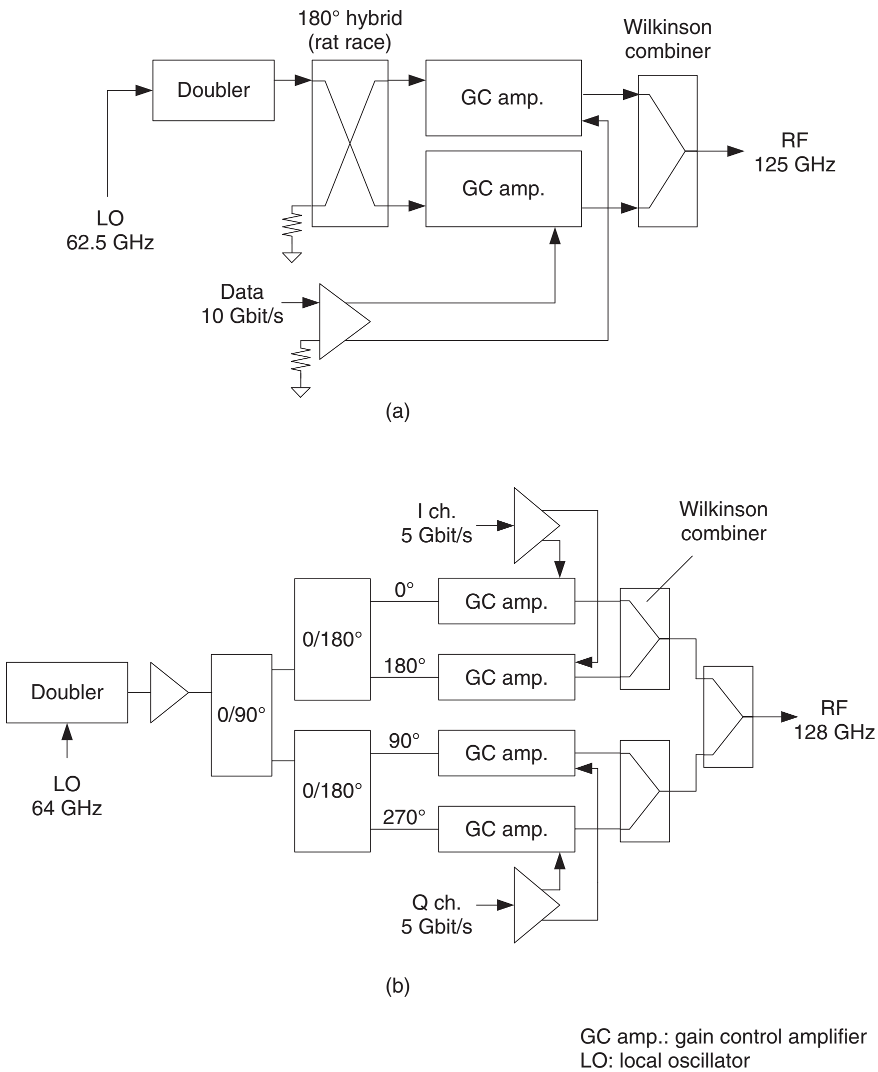


Fig. 3. Block diagrams of modulator MMICs: (a) BPSK and (b) QPSK.

MMICs are shown in **Fig. 4**. S_{21} of the BPSK modulator MMIC had the maximum phase error of 5° and amplitude error of 3% when DC voltages were applied. These errors mainly come from the characteristics of the rat-race circuit. From these values, we estimated the static error vector magnitude to be about 5%. For QPSK, S_{21} for phases of 45º, 135º, 225º, and 315º had a maximum phase error of 8º and maximum amplitude error of 11%. From these values, we obtained a static error vector magnitude of about 10%.

3.2 PSK demodulator MMIC

Block diagrams of the BPSK and QPSK demodulator MMICs are shown in **Fig. 5**. As mentioned in section 3, we selected differentially coherent detection because it has a simple architecture and does not require carrier-recovery circuits. First, the received signal is split into two. One part is delayed by the length of a data symbol. The other part goes through a variable phase shifter. The two signals are combined and mixed by a gate mixer. The main issues in this architecture are the design of the one-symbol delay circuit and control of the phase relationship between the two split signals. In our delay circuit design, the delay line is basically made of a transmission line; this provides an accurate delay time but has the drawback of being very long. The modulators using BPSK and QPSK need to be about 13 mm and 25 mm, respectively, if the delay line consists of only

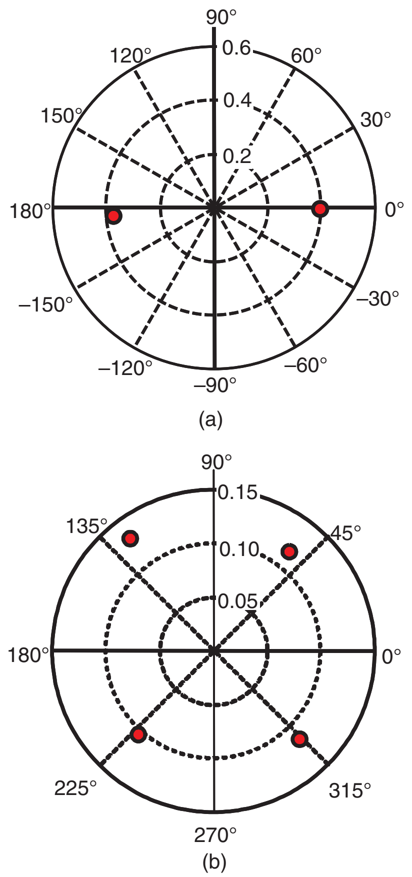
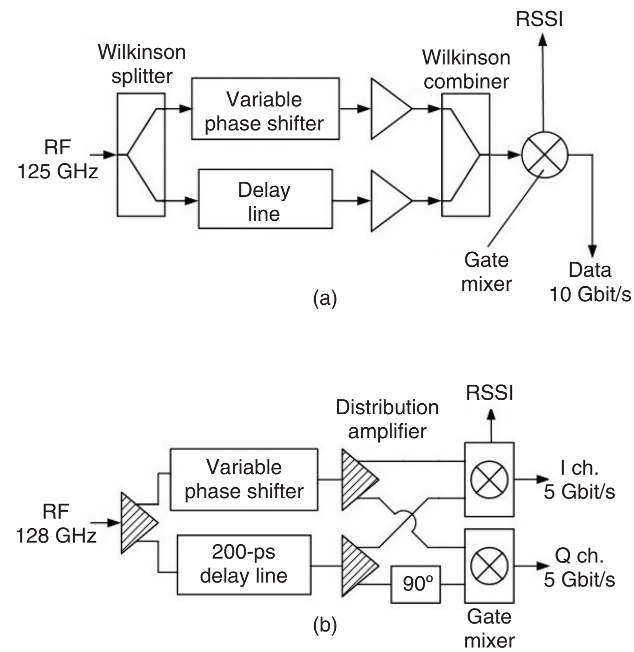


Fig. 4. S_{21} of modulator MMICs: (a) BPSK and (b) QPSK.



RSSI: received signal strength indicator

Fig. 5. Block diagrams of demodulator MMICs: (a) BPSK and (b) QPSK.

a coplanar waveguide with a width of 15 µm and space of 15 µm. To reduce the length, we made the delay line by alternating metal-insulator-metal shunt capacitors and coplanar waveguides. As a result, the actual lengths of our delay lines for BPSK and QPSK are 5 mm and 10 mm, respectively. Next, we designed a variable phase shifter to adjust the phase relationship between the received and delayed signals prior to mixing. The variable phase shifter consists of coplanar waveguides and cold field effect transistors, which are HEMTs. This circuit can adjust the electrical length continuously by changing the capacitances of the parasitic capacitors of the HEMTs. Thus, we can tune the phase of the output signal by means of an applied voltage. The designed tuning range of this circuit is over 180° at 125 GHz, which makes it possible to respond to any phase error caused by variations in process, voltage, or temperature.

3.3 Evaluation for 10-Gbit/s data transmission

We used 0.1-µm-HEMT technology on an InP substrate. The devices have a current-gain cut-off frequency (fT) of 170 GHz and a maximum oscillation frequency (fmax) of 350 GHz. Photographs of the modulator and demodulator MMICs are shown in **Fig. 6**. We succeeded in making a one-chip BPSK modulator and a one-chip BPSK demodulator. Before measuring the BERs, we mounted the modulator and demodulator MMICs in separate packages, as shown in **Fig. 7**. Thanks to the one-chip integration of the modulator and demodulator circuits, we obtained compact modulator and demodulator modules. The package has a WR-8 waveguide for the 120-GHz-band RF signal interface. Transitions from a rectangular waveguide to a coplanar waveguide were needed to transfer the RF energy from the coplanar waveguide to the WR-8 waveguide and vice versa.

We then measured the BER of 10-Gbit/s data transmission. To measure the minimum received power, we set an LNA [10] in front of each demodulator module. The MMIC in the LNA module was the same as that used for our current ASK-based wireless link, and the noise figure was 5.6 dB. For delay detection, input data for the modulator module usually goes through a Gray-code adder, which has a one-

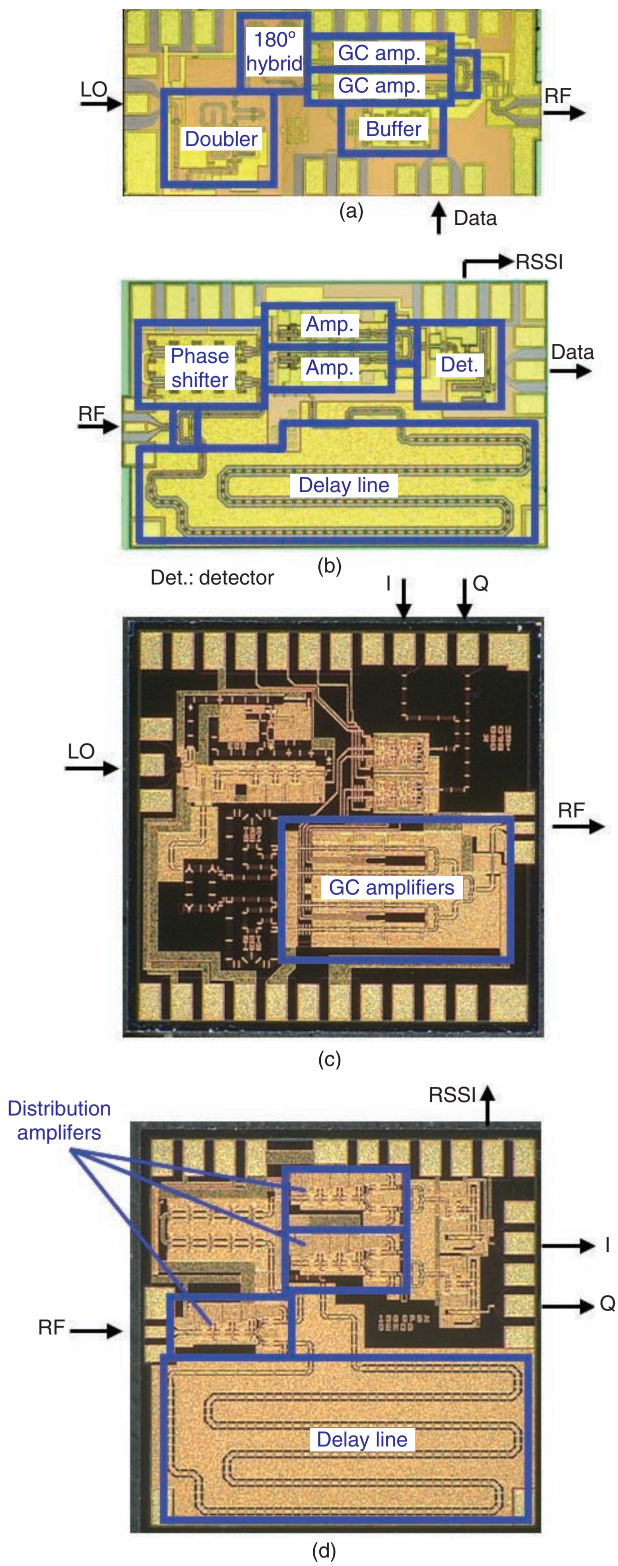


Fig. 6. Die photographs of MMICs:
(a) BPSK modulator (1 mm x 2 mm)
(b) BPSK demodulator (1 mm x 2 mm)
(c) QPSK modulator (2 mm x 2 mm)
(d) QPSK demodulator (2 mm x 2 mm)

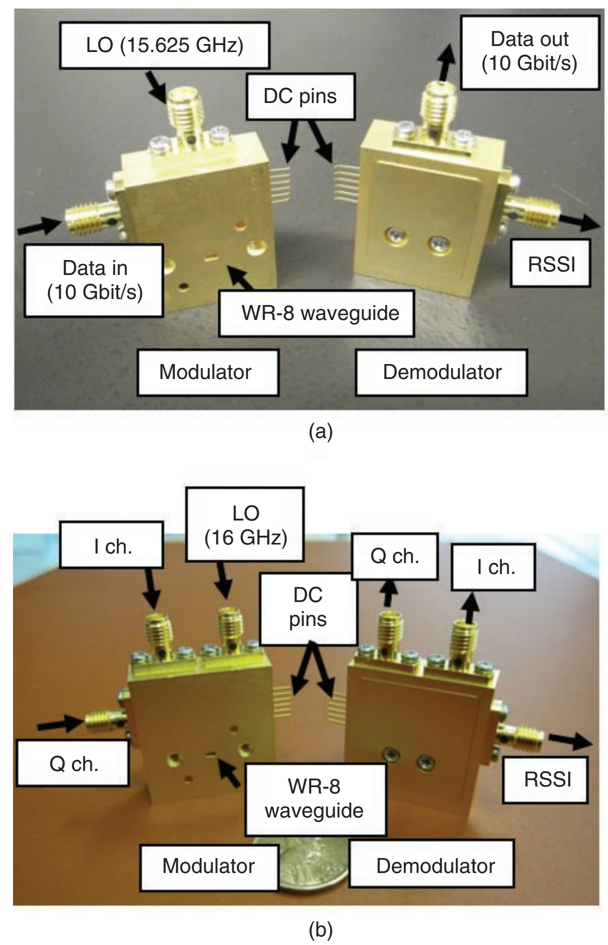
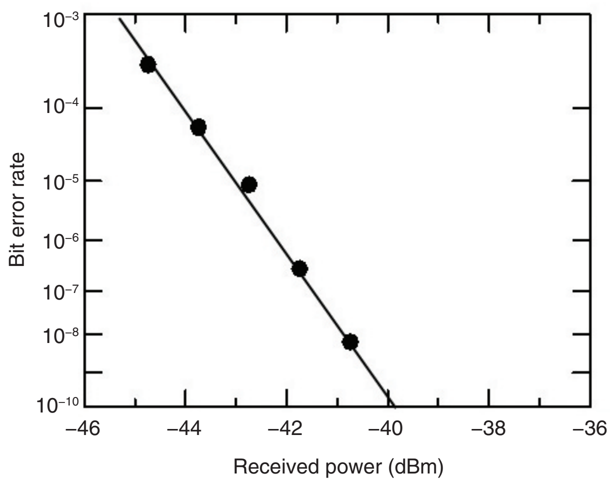


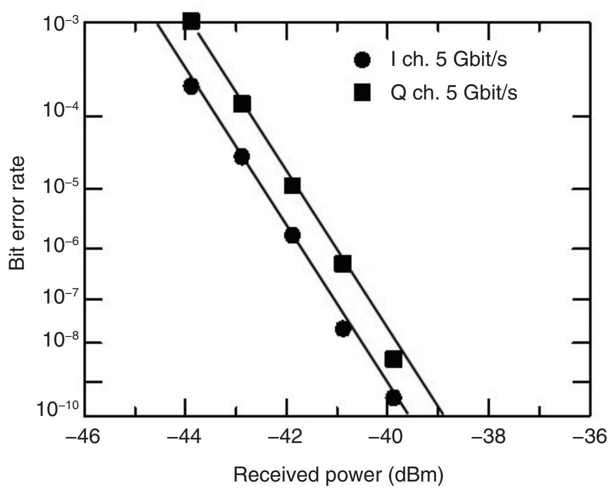
Fig. 7. Photographs of (a) BPSK modules (b) QPSK modules.

symbol delay circuit. In this measurement, a pulse pattern generator directly outputs the data encoded by the Gray-code adder. In addition, a limit amplifier for 10-Gbit/s base-band signals was installed after the demodulator module to satisfy the required power for the error detector.

The relationship between the LNA's received power and the measured BER is shown in **Fig. 8**. BPSK and QPSK modules achieved a BER of less than 10^{-10} at received power of -39.5 dBm and -38.5 dBm, respectively. In the current ASK-based link, the received power at a BER of 10^{-10} is -38.5 dBm. If we simply compare these values, it would appear that we can indeed make BPSK and QPSK systems with the same transmission performance with the ASK system. However, in this measurement, some conditions were different from those for the ASK system. For example, there was no RF filter at the demodulator and no



(a)



(b)

Fig. 8. BER characteristics of (a) 10-Gbit/s BPSK transmission and (b) 10-Gbit/s QPSK transmission.

power amplifier for the modulator. It is possible that using an RF filter in the demodulator will further improve the sensitivity.

Finally, we estimated the transmission distance of the 120-GHz-band wireless link with 10-Gbit/s BPSK and QPSK. To make the link, we need additional RF components, i.e., power amplifiers, antennas, and RF filters. For this purpose, we can use the same amplifiers and antennas as those for the ASK-based wireless link [3] because the operating band for ASK covers those for BPSK and QPSK. By using such amplifiers, we should obtain output power of 10 dBm. Moreover, the antenna gains of the transmitter and receiver are both 48.7 dBi. The relationship between link distance and other characteristics is as follows:

$$P_r(dB) = P_t + G_t + G_r - 20\times\log\left(\frac{4\pi d}{\lambda}\right) - L_1 \times d, \quad (1)$$

where d is link distance, λ is wavelength, Pr is received power, Pt is transmitter output power, Gt is transmitter antenna gain, Gr is receiver antenna gain, and L_1 is atmospheric loss. L_1 at 128 GHz is about 1 dB/km. As shown in Fig. 8, the BPSK and QPSK demodulators need Pr of more than -39.5 dBm and -38.5 dBm, respectively, when the required BER is 10^{-10}. From these values, we estimated that both the BPSK and QPSK wireless links in 120-GHz-band would be able to transmit 10-Gbit/s data a distance of 2 km with a link margin of more than about 3 dB if we used the same amplifiers and antennas as in the ASK system.

4. Future plans

We hope to implement BPSK and QPSK modules in the 120-GHz-band wireless link. We would also like to improve the analysis of the propagation characteristics of 120-GHz-band millimeter-wave signals, especially their dependency on weather, by making use of data from long-term, continuous transmission tests.

Acknowledgments

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References

[1] S. Pinel, S. Sarkar, P. Sen, B. Perumana, D. Yeh, D. Dawn, and J. Laskar, “A 90nm CMOS 60GHz Radio,” Proc. of the 2008 IEEE Int. Solid-State Circuits Conf., Dig., pp. 130–132, San Francisco, CA, USA.

[2] C. Marcu, D. Chowdhury, C. Thakkar, L. Kong, M. Tabesh, J. Park, Y. Wang, B. Afshar, A. Gupta, A. Arbabian, S. Gambini, R. Zamani, A. M. Niknejad, and E. Alon, “A 90nm CMOS Low-power 60GHz Transceiver with Integrated Baseband Circuitry,” Proc. of the 2009 IEEE Int. Solid-State Circuits Conf. Dig., pp. 314–315, San Francisco, CA, USA.

[3] A. Hirata, R. Yamaguchi, T. Kosugi, H. Takahashi, K. Murata, T. Nagatsuma, N. Kukutsu, Y. Kado, N. Iai, S. Okabe, H. Ikegawa, H. Nishikawa, T. Nakayama, and T. Inada, “10-Gbit/s Wireless Link Using InP HEMT MMICs for Generating 120-GHz-band Millimeter-wave Signal,” IEEE Trans. Microwave and Tech., Vol. 57, No. 5, pp. 1102–1109, 2009.

[4] T. Kosugi, T. Shibata, T. Enoki, M. Muraguchi, A. Hirata, T. Nagatsuma, and H. Kyuragi, “A 120-GHz Millimeter-wave MMIC Chipset for Future Broadband Wireless Application,” Proc. of IEEE MTT-S Int. Microw. Symp. Dig., 2003, Vol. 1, pp. 129–132, Philadelphia, PA, USA.

[5] A. Hirata, H. Takahashi, N. Kukutsu, Y. Kado, H. Ikegawa, H. Nishikawa, T. Nakayama, and T. Inada, "Transmission Trial of Television Broadcast Materials Using 120-GHz-band Wireless Link," NTT Technical Review, Vol. 7, No. 3, 2009.
https://www.ntt-review.jp/archive/ntttechnical.php?contents=ntr200903sf3.html

[6] A. Hirata, T. Kosugi, H. Takahashi, J. Takeuchi, K. Murata, N. Kukutsu, Y. Kado, S. Okabe, T. Ikeda, F. Suginoshita, K. Shogen, H. Nishikawa, A. Irino, T. Nakayama, and N. Sudo, "5.8-km 10-Gbps Data Transmission over a 120-GHz-band Wireless Link," 2010 IEEE International Conference on Wireless Information Technology and Systems (ICWITS), pp. 1–4, Honolulu, Hawaii, USA, 2010.

[7] T. Kosugi, H. Sugiyama, K. Murata, H. Takahashi, A. Hirata, N. Kukutsu, Y. Kado, and T. Enoki, "A 125-GHz 140-mW InGaAs/InP Composite-channel HEMT MMIC Power Amplifier Module," IEICE Electronics Express, Vol. 6, pp. 1764–1768, 2009.

[8] H. Takahashi, T. Kosugi, A. Hirata, K. Murata, and N. Kukutsu, "10-Gbit/s BPSK Modulator and Demodulator for a 120-GHz-band Wireless Link," IEEE Trans. on Microwave Theory and Techniq., Vol. 59, No. 5, pp. 1361–1368, 2011.

[9] H. Takahashi, T. Kosugi, A. Hirata, K. Murata, and N. Kukutsu, "10-Gbit/s Quadrature Phase-shift Keying Modulator and Demodulator for 120-GHz-band Wireless Links," IEEE Trans. on Microwave Theory and Techniq., Vol. 58, No. 12, pp. 4072–4078, 2011.

Hiroyuki Takahashi

Research Engineer, Smart Devices Laboratory, NTT Microsystem Integration Laboratories.

He received the B.S. and M.S. degrees in applied physics from Nagoya University, Aichi, in 2001 and 2003, respectively. Since joining NTT Microsystem Integration Laboratories in 2003, he has been engaged in designing and testing millimeter-wave MMICs. He received the 2008 Young Engineer's Prize from the European Microwave Integrated Circuits Conference (EuMIC). He is a member of the Institute of Electronics, Information and Communication Engineers (IEICE) and IEEE.

Akihiko Hirata

Senior Research Engineer, Smart Devices Laboratory, NTT Microsystem Integration Laboratories.

He received the B.S. and M.S. degrees in chemistry and the Dr.Eng. degree in electrical and electronics engineering from the University of Tokyo in 1992, 1994, and 2007, respectively. He joined NTT Atsugi Electrical Communications Laboratories (now NTT Microsystem Integration Laboratories), Kanagawa, in 1994. His current research involves millimeter-wave antenna and photonic technology. He received the 2002 Asia-Pacific Microwave Conference APMC Prize, the 2004 YRP Award, and the 2007 Achievement Award from IEICE. He is a member of IEICE and IEEE.

Jun Takeuchi

Researcher, Smart Devices Laboratory, NTT Microsystem Integration Laboratories.

He received the B.E. and M.E. degrees from Tokyo Institute of Technology in 2006 and 2008, respectively. He joined NTT Microsystem Integration Laboratories in 2008. He is engaged in R&D of millimeter-wave components and wireless systems. He received the 2010 Asia-Pacific Microwave Conference APMC prize. He is a member of IEICE.

Naoya Kukutsu

Senior Research Engineer, Supervisor, Group Leader, Smart Devices Laboratory, NTT Microsystem Integration Laboratories.

He received the B.E., M.E., and D.E. degrees in electrical engineering from Hokkaido University in 1986, 1988, and 1991, respectively. His D.E. dissertation described research for a time-domain electromagnetic wave numerical analysis method. In 1991, he joined NTT Applied Electronics Laboratories in Musashino. His current research involves millimeter-wave and terahertz-wave transmission, as well as imaging systems. He is a member of the IEEE MTT and COM Societies and IEICE.

Toshihiko Kosugi

Senior Research Engineer, High-Speed Devices and Technology Laboratory, NTT Photonics Laboratories.

He received the M.S. and Ph.D. degrees in electrical engineering from Osaka University in 1990 and 1993, respectively. His Ph.D. dissertation addressed characterization of point defects in GaAs and processing of GaAs. He joined NTT in 1993. He is currently with NTT Photonics Laboratories studying the microwave characteristics of HEMTs on InP and their application in MMICs.

Koichi Murata

Senior Research Engineer, Supervisor, Group Leader, High-Speed Devices and Technology Laboratory, NTT Photonics Laboratories.

He received the B.S. and M.S. degrees in mechanical engineering and the Dr.Eng. degree in electrical and electronics engineering from Nagoya University, Aichi, in 1987, 1989, and 2003, respectively. He joined NTT LSI Laboratories, Atsugi, in 1989. He has been engaged in R&D of ultrahigh-speed mixed-signal ICs for optical communication systems. His current research interests include optoelectronic IC design and high-speed optical transmission systems. He is a member of IEEE and IEICE.

Security Device Management Platform

Takeya Takeda† *, Koji Kishi, Keizo Murakami, Hiroki Kawamoto, and Shoko Nishida*

Abstract

NTT Service Integration Laboratories has developed a security device management platform that includes functionality for issuing smart cards, adding applications to cards after they have been issued, issuing temporary cards when a smart card is lost, and linking with external systems. The platform can support the management of smart cards and other tamper-resistant security devices in a wide range of operational scenarios.

1. Introduction

Security and personal authentication have recently become increasingly important in enterprise, academia, and the public sector. The variety of tamper-resistant security devices used for personal authentication also continues to increase: it currently includes SD (secure digital) cards that incorporate an integrated circuit (IC) chip, mobile phones with a subscriber identity module (SIM) card, and other devices in addition to conventional smart cards.

NTT Service Integration Laboratories has developed the Security Device Management (SDM) platform for centralized management of this diverse range of tamper-resistant security devices. The platform enables efficient management and operation of a safe and secure societal infrastructure that uses these tamper-resistant security devices, including configuration and updating of personal identification and authentication information and addition and removal of applications. This platform is expected to be used to generate new business and as a replacement for the Network-based IC Card Environment (NICE) [1]–[3], a platform for managing smart card information that is currently in use by companies.

2. Overview

SDM is platform software that provides integrated management of tamper-resistant security devices, from device issuing through operational functions (**Fig. 1**). Its functionality can be divided into issuing functions, which gather user information for each service and configure tamper-resistant security devices so that they can be used, and operational functions, which add and remove applications from tamper-resistant security devices and manage the multiple devices of different types used by users.

(1) Gathering user information for each service

SDM provides an interface for linking with external systems. Through this interface, user information can be automatically retrieved from an external, corporate information database system. This allows user information accumulated during registration for various services in the past to be used when a tamper-resistant security device is being issued. Thus, SDM reduces the work involved in creating new user information, reduces errors in data entry, and otherwise improves the efficiency of issuing tamper-resistant security devices.

(2) Managing smart cards

SDM can manage all of the smart cards held by each user.

(3) Adding and removing applications from tamper-resistant security devices

SDM allows applications to be added or removed from tamper-resistant security devices that have already been distributed to users. Thus, applications for a variety of services such as a facility entry system, personal computer login, and cafeteria and library systems can be added to a tamper-resistant

† NTT Service Integration Laboratories
Musashino-shi, 180-8585 Japan

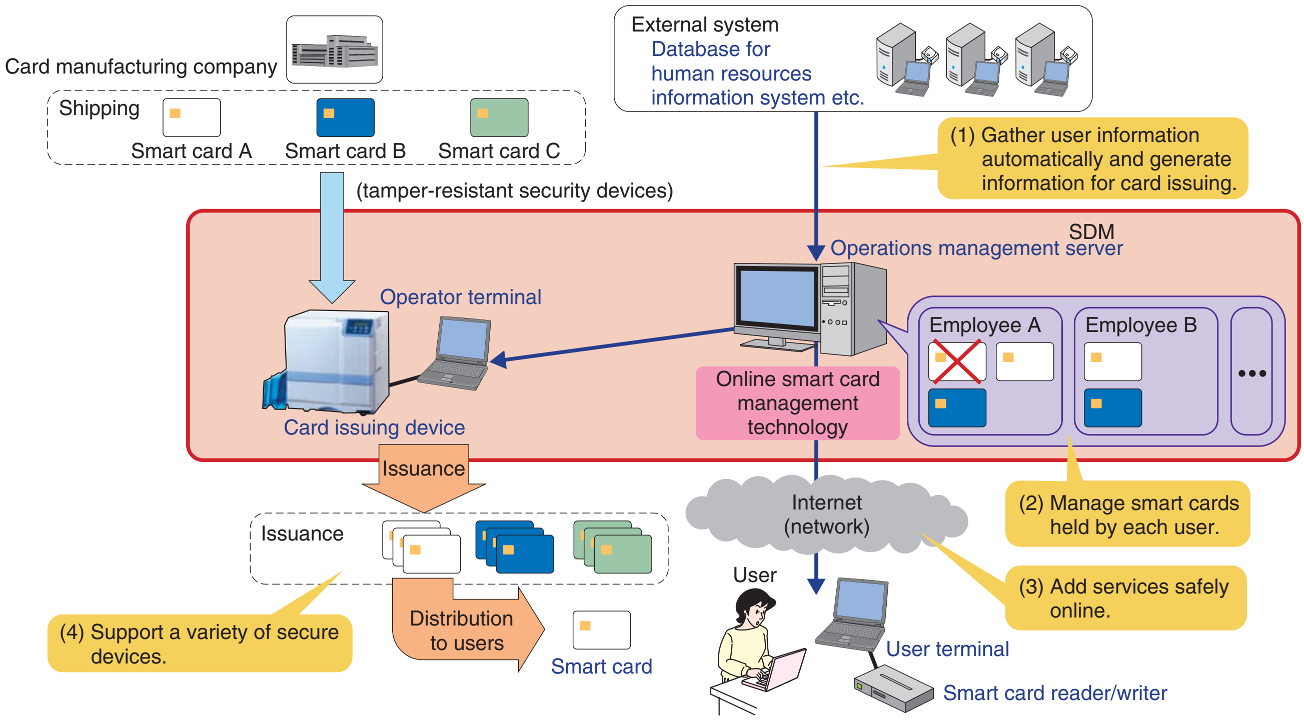


Fig. 1. Overview of SDM functionality.

security device such as a company ID (identity) card that has already been issued and distributed to employees. This allows the range of applications for the tamper-resistant security device ID to be expanded and enriched gradually.

(4) Supporting multiple tamper-resistant security devices of various types

SDM can issue and manage multiple types of devices. The functionality for managing different types of tamper-resistant security devices makes operation easier in the case of migration among tamper-resistant security devices, for example, to update a tamper-resistant security device when encryption has been compromised. The ability to manage multiple tamper-resistant security devices allows a device to be created with the same applications as the employee's original ID card; for example, a temporary ID card can be issued to an employee who has forgotten his or her ID card or the ID card can be reissued if it has been lost. Systems can thus be operated at a higher level of security and aspects such as issue numbers and expiry dates can be managed strictly.

3. Technical features

SDM is implemented as a client-server web service, so operators can perform various operations using a web terminal, such as issuing new tamper-resistant security devices or performing operational tasks. An open source framework was used, so the user interface and business logic can be customized, modified, and maintained easily.

3.1 Script for generating device issuing information

SDM is easily customizable for various solutions owing to the development of an easy scripting language called Apdu Markup Language (AML). AML makes it easy to write task rules, such as rules for generating commands to issue or operate a tamper-resistant security device or to transform data when linking with an external system (**Fig. 2**). Writing and modifying AML scripts not only makes it possible to link with external systems, but also enables systems to handle new tamper-resistant security devices, whether they are a new type of IC card or an SD or SIM card incorporating an IC chip.

3.2 User-oriented data model

SDM uses a data model to manage the number, types, and states of tamper-resistant security devices that users possess, enabling multiple tamper-resistant

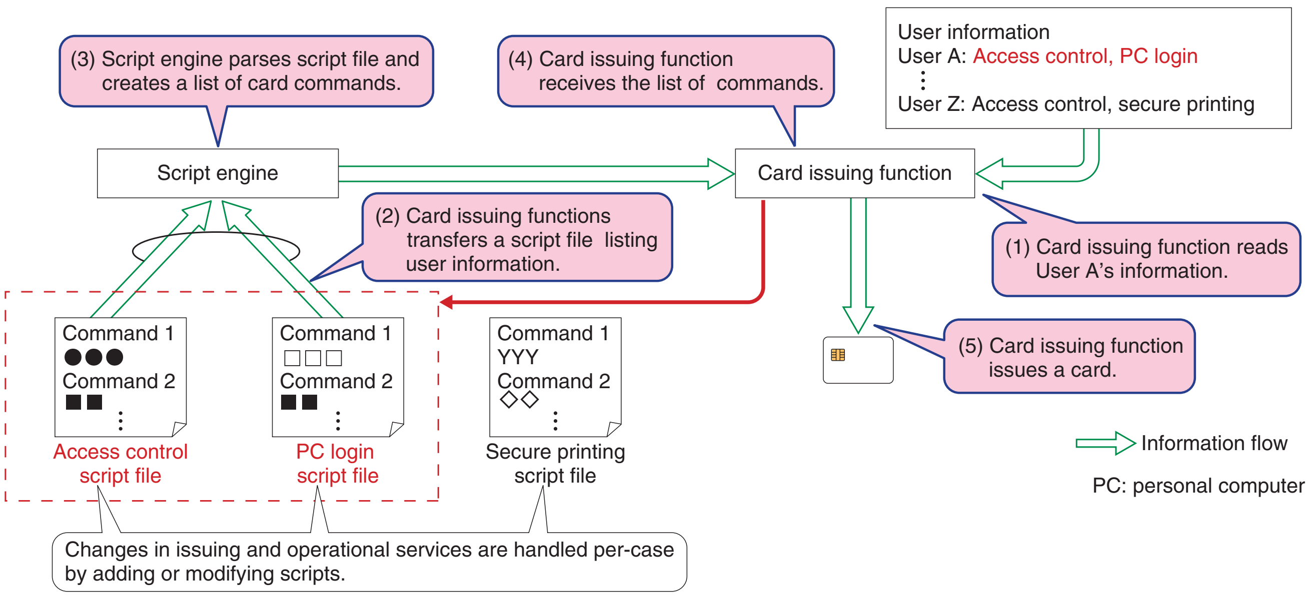


Fig. 2. Script-based generation of card issuing information.

security devices of different types to be issued and managed for each user.

3.3 Secure online tamper-resistant security device management technology adopted in the international standard

SDM can safely add services to a tamper-resistant security device over a network after the device has been issued because it uses online tamper-resistant security device management technology developed by NTT based on a public key infrastructure (PKI) and secure messaging. This technology has been recognized for its ability to add applications safely to a temper-resistant security device through its functions for flexibly managing applications on it and for flexibly handling global geographical regions, and it has been adopted in the Global Platform 2.2 international standard [4].

4. Application to system integration

The flow of a typical SDM application scenario for a company is shown in **Fig. 3** and some specific examples are described below.

(1) University student identification

When new students enter university, the information required to issue tamper-resistant security devices for all new students can be generated from student information in the registration system, and devices for all students can be created at once, by contract with a printing company, for example.

In the past, when a university spanned multiple campuses, students would have to go to another location where there was a card-issuing machine in order to add applications to their student ID card in order to use new facilities or services on another campus. SDM makes this much more convenient because applications can be added, or removed to stop a service being used, wherever there is an operator terminal. Temporary cards can be issued if a student forgets or loses an ID card, which helps prevent unauthorized use of student cards and enables the student to continue using the services on the card.

(2) Corporate identification

When an employee's employment status or location changes or the card's expiry date is approaching, information for issuing a new ID card or reissuing a new version of the existing one is generated. SDM allows the card to be issued immediately, rather than through a processed contracted out to a printing company, for example.

When an employee needs access to in-house thin-client devices or entry to secure areas, the required application can be added to his or her employee ID card. Moreover, when an employee forgets or loses an ID card, a temporary card with only the minimum applications and limited to the required use can be issued. This helps prevent abuse of ID cards and

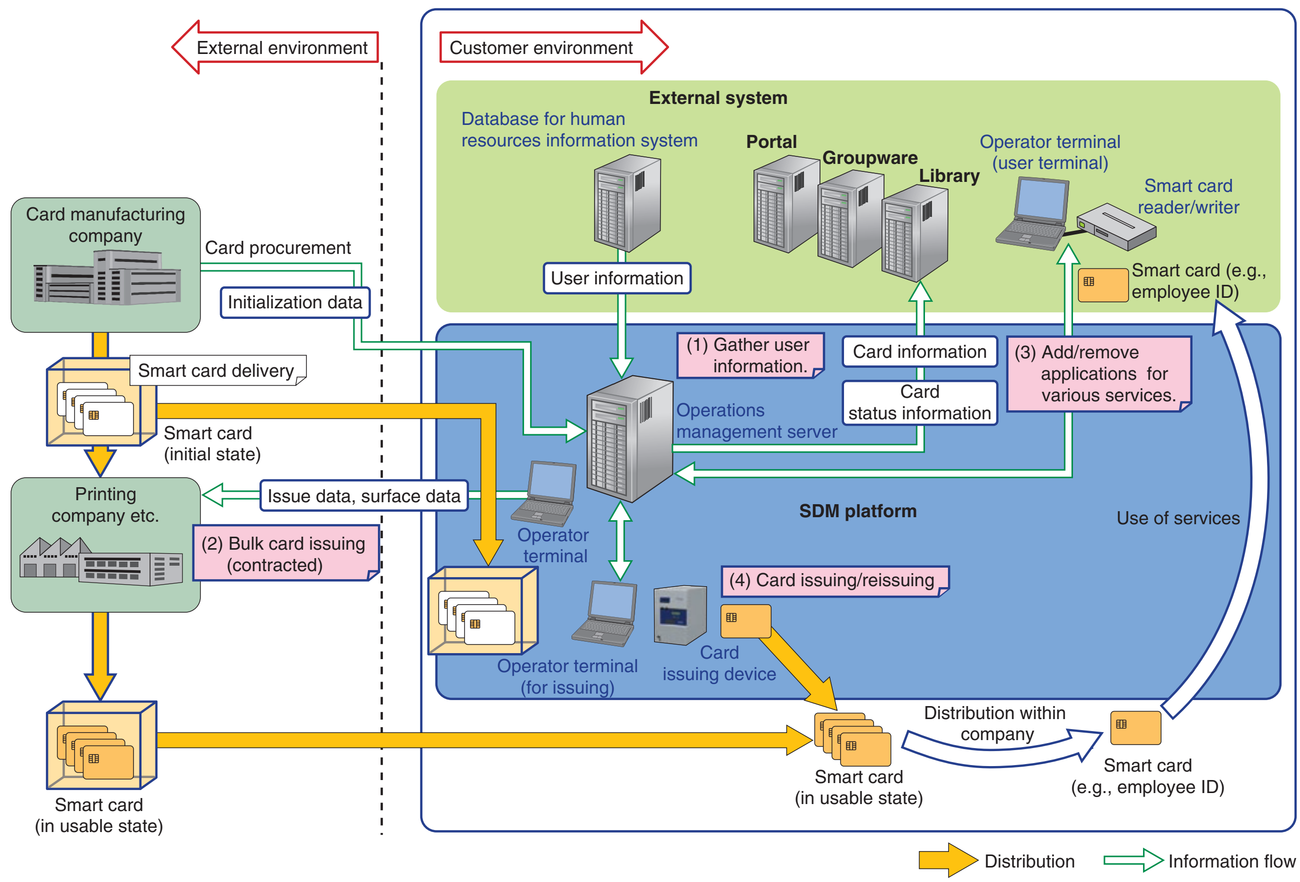


Fig. 3.   SDM application scenario.

allows employees to continue to use the added services.

5. Future development

For some time, we have been working on updating and expanding existing systems such as employee and student ID cards that have been used in environments where they are relatively limited. This has included organizing and streamlining public and other external use of smart cards and extending basic functionality such as gathering user information, issuing cards, and performing other operational tasks.

We will continue to work on needs and issues selected from both domestic and global perspectives, targeting cost reductions and business continuity planning and considering general market trends such as cloud-services business and smartphones equipped with near-field communications, as well as trends toward external use in national and regional governments. As technical development advances, we will also contribute to the development of businesses that offer superior solutions for enterprises.

References

[1] S. Ijuin, T. Yamamoto, S. Hirata, K. Suzuki, Y. Wada, T. Kashiwagi, and N. Kaku, "Development of a NICE-based Smart Card System Conforming to the GlobalPlatform Specifications," NTT Technical Review, Vol. 2, No. 4, pp. 66–69, 2004.
https://www.ntt-review.jp/archive/ntttechnical.php?contents=ntr200404066.pdf

[2] T. Kashiwagi, H. Kawamura, K. Kishi, K. Murai, and T. Yamamoto, "NICE V8.1: Smart Card Management Platform that Can Replace Compromised Encryption Schemes," NTT Technical Review, Vol. 7, No. 4, 2009.
https://www.ntt-review.jp/archive/ntttechnical.php?contents=ntr200904le1.html

[3] Nippon Information and Communication (in Japanese).
http://www.niandc.co.jp/interview/institute/no02.html

[4] GlobalPlatform. http://www.globalplatform.org/

Takeya Takeda

Senior Research Engineer, Smart Card Platform Development Project, Public ICT Solution Project, NTT Service Integration Laboratories.

He joined NTT in 1986. He was initially engaged in research studies on the e-Japan initiative and in consulting and systems engineering for the information and communications infrastructure of local governments. He is currently engaged in the development of an ICT platform.

Hiroki Kawamoto

Research Engineer, Smart Card Platform Development Project, Public ICT Solution Project, NTT Service Integration Laboratories.

He joined NTT in 1991. He was initially engaged in the development of an in-company operation system in NTT WEST. He is currently engaged in the development of an ICT platform.

Koji Kishi

Senior Research Engineer, Smart Card Platform Development Project, Public ICT Solution Project, NTT Service Integration Laboratories.

He received the B.A. and M.A. degrees in basic science from the University of Tokyo in 1994 and 1996, respectively. He joined NTT in 1996. He is currently engaged in the development of an ICT platform.

Shoko Nishida

Engineer, Smart Card Platform Development Project, Public ICT Solution Project, NTT Service Integration Laboratories.

She received the B.A. degree in science education from Fukuoka University of Education in 2007 and the M.E. degree in nonlinear physics from Kyushu University in 2009. Since joining NTT Service Integration Laboratories in 2009, she has studied an ID-management system for e-government and developed an e-government system. She is a member of the Information Processing Society of Japan.

Keizo Murakami

Smart Card Platform Development Project, Public ICT Solution Project, NTT Service Integration Laboratories.

He received the bachelor's and master's degrees in pharmacy from the University of Tokyo in 2008 and 2010, respectively. He joined NTT in 2010. He is currently engaged in the development of an ICT platform.

Overview and Status of Future Networks Standardization in ITU-T

Takashi Miyamura† and Akihiro Tsutsui

Abstract

To overcome the limitations of the current Internet, research and development of future network technologies has been undertaken extensively in the USA, EU, and Asian countries including Japan. This article gives an overview of and describes the current status of Future Networks standardization in ITU-T SG13 (International Telecommunication Union, Telecommunication Standardization Sector, Study Group 13).

1. Introduction

ITU-T SG13 (International Telecommunication Union, Telecommunication Standardization Sector, Study Group 13) established the Focus Group on Future Networks (FG-FN) in January 2009 to investigate possible standardization items for Future Networks including the New-Generation Network (NWGN) and Future Internet (**Fig. 1**). Future Networks are expected to meet changing requirements into the future. The target time frame of the initial deployment or service trials of Future Networks is assumed to fall approximately between 2015 and 2020. FG-FN initiated an information exchange and discussion of the vision and possible key technologies for Future Networks [1]. FG-FN was closed in December 2010 and the discussions were taken over by SG13. The main deliverables, which are the outcome of FG-FN's activities, were published as the Y.3000 series of Recommendations at the SG13 meeting in October 2011.

Y.3001 describes the vision of Future Networks. Furthermore, to identify certain key technology areas, it was agreed in October 2011 that framework documents on network virtualization and energy savings of networks would be standardized as Y.3011 and Y.3021, respectively. In particular, discussions on network virtualization have been initiated from the FG-FN phase. Y.3011 incorporates several contributions submitted by NTT. This article presents an overview of the Recommendations for the Future Networks vision and for networks virtualization.

† NTT Network Service Systems Laboratories
Musashino-shi, 180-8585 Japan

2. Overview of Future Network vision

Y.3001 is the world's first standardization document about future network visions. This Recommendation identifies four types of awareness, twelve design goals, and key enabling technologies corresponding to each goal (**Fig. 2**). One of the twelve design goals is network virtualization, which has been identified as a key technology for achieving resource abstraction and has been standardized as Y.3011.

Service awareness describes some challenges in the creation and management of diversified services including broadband and narrowband services, diversified mobility, security, and privacy.

Environmental awareness addresses energy savings *of networks* and *by networks*. The energy saving of networks has been standardized as Y.3021.

Data awareness describes content-centric and data-centric networking architecture and identification. In identification, a framework document (Y.FNid) is being discussed for future standardization. Y.FNid includes an analysis of existing IDs (identities) and general requirements for future network IDs.

Finally, social and economic awareness addresses the need to reduce barriers to entry network

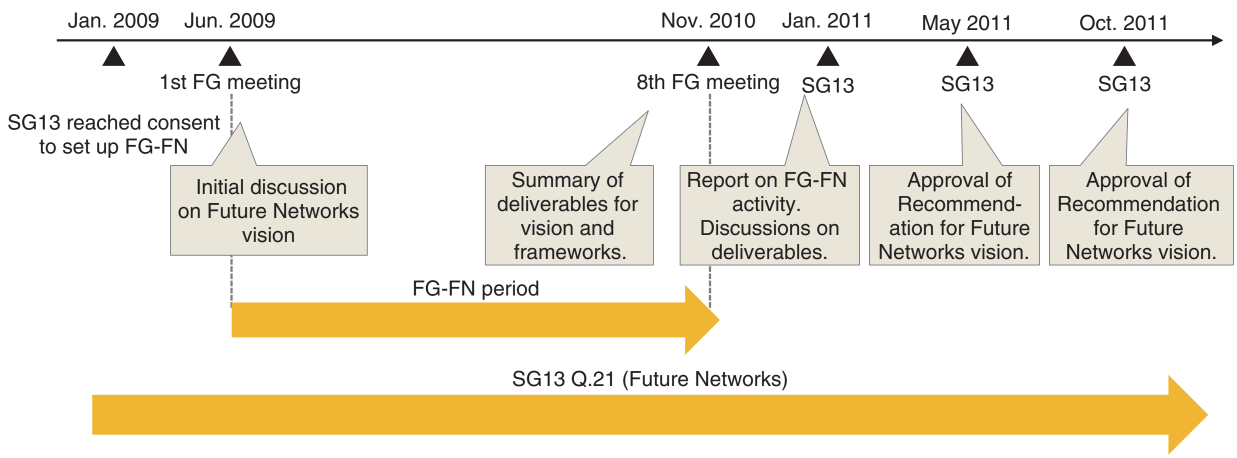


Fig. 1. FG-FN history.

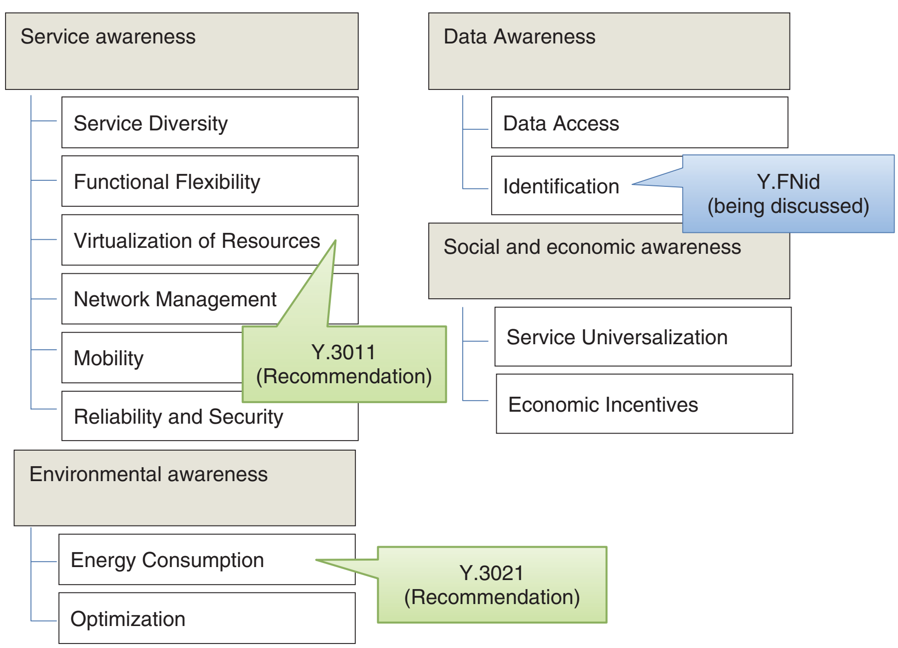


Fig. 2. Future Networks vision.

ecosystems and lifecycles cost for sustainability, which will contribute to service universalization.

3. Standardization status of network virtualization

Y.3011 identifies terminology of network virtualization technologies, technical challenges, design goals, applicability, and use cases. Network virtualization enables multiple service networks to be run over a common physical network infrastructure. It brings improved resource utilization through resource sharing, quick responsiveness to traffic changes and network failures, and simplified network management through resource abstraction. A framework for network virtualization is shown in **Fig. 3**. An

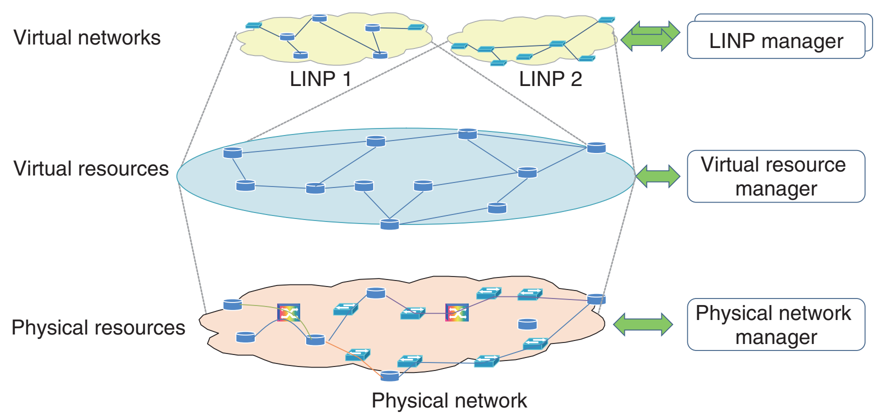


Fig. 3. Framework of network virtualization.

abstraction of physical resources is created by logically dividing and abstracting physical resources composing of physical networks such as nodes and links. The abstracted physical resources are called virtual resources. By combining multiple virtual resources, we can create a logical network called a virtual network or a logically isolated network partition (LINP).

Network virtualization enables the creation of multiple virtual networks which can be independently controlled and managed over the common physical network infrastructure. By creating different virtual networks for each service, we can accommodate multiple services with diversified requirements in the same physical network. Moreover, in network virtualization, the owner and user of network resources are separated, which means that a virtual network user is not required to own and deploy physical network equipment. This enables a virtual network to dynamically add and delete network resources from the common virtual resource pools in response to traffic demand changes and other environmental changes. Since the addition of virtual resources is much faster than the deployment of additional physical equipment, we can construct and operate service networks more efficiently and flexibly.

NTT submitted contributions concerning network virtualization requirements and use cases. For requirements, we proposed hard isolation among virtual networks; for use cases, we proposed the application of network virtualization to a carrier's transport networks. Those proposals have been included in the Recommendation.

4. Conclusion

In this article, we overviewed the Future Networks vision and network virtualization Recommendations in ITU-T. The frameworks of the two remaining types of awareness (data awareness and social & economic awareness) will be discussed to enable the publication of Recommendations. Regarding network virtualization, general requirements and high-level network architecture will be discussed. NTT will continue to contribute to Future Networks standardization.

Reference

[1] A. Tsutsui and N. Morita, "Overview and Status of Focus Group on Future Networks at ITU-T," NTT Technical Review, Vol. 8, No. 9, 2010.
https://www.ntt-review.jp/archive/ntttechnical.php?contents=ntr201009gls.html

Takashi Miyamura
Senior Research Engineer, Backbone Networking Systems Group, Broadband Network Systems Project, NTT Network Service Systems Laboratories.

He received the B.E. and M.E. degrees from Osaka University in 1997 and 1999, respectively. In 1999, he joined NTT Network Service Systems Laboratories, where he engaged in R&D of a high-speed IP switching router. He is now researching future photonic IP networks and an optical switching system. He received the 2001 APCC Paper Award at the 7th Asia-Pacific Conference on Communications. He is a member of IEICE and the Operations Research Society of Japan.

Akihiro Tsutsui
Senior Research Engineer, Supervisor, NTT Network Innovation Laboratories.

He received the B.E. and M.E. degrees in systems engineering from Kobe University, Hyogo, in 1988 and 1990, respectively. Since joining NTT in 1990, he has been researching programmable network devices, high-performance Internet protocols, and home networking. His current interests include terabit-level scalable communication technologies and architectural modeling of the future Internet.

NTT Europe

Shingo Kimata†

Abstract

NTT Europe provides total global information and communications technology (ICT) solutions for enterprise customers in Europe, the Middle East, and Africa. This article describes NTT Europe's cloud services and its collaborative efforts with other companies in the NTT Group.

1. Introduction

Founded in 1988, NTT Europe [1] serves nine countries (the United Kingdom, France, Germany, Spain, the Netherlands, Belgium, Switzerland, Poland, and the United Arab Emirates) in the EMEA region (Europe, the Middle East, and Africa) from a total of 13 offices with its headquarters in London (**Figs. 1–3**). It started expanding its business in the Russian sphere through collaboration with NTT Com Russia and is planning to expand its office presence to Italy and Sweden in 2012.

Since 2010, NTT Europe and NTT Europe Online (formerly Verio Europe) [2] have been integrating their business operations, bringing together the network business of the former with the managed-hosting business of the latter. Under the slogan of ONE! (One NTT in EMEA), they have been providing private networks, Global Tier 1 IP backbone access (IP: Internet protocol), and other network services as well as datacentre and cloud services, information and communications technology (ICT) consulting, and other enterprise solutions in an integrated manner.

Furthermore, in 2012, NTT Europe moved to

Fig. 1. Devon House, home of NTT Europe.

Fig. 2. NTT Europe reception.

† NTT Europe
St. Katharine's Way, London E1W 1LB, UK

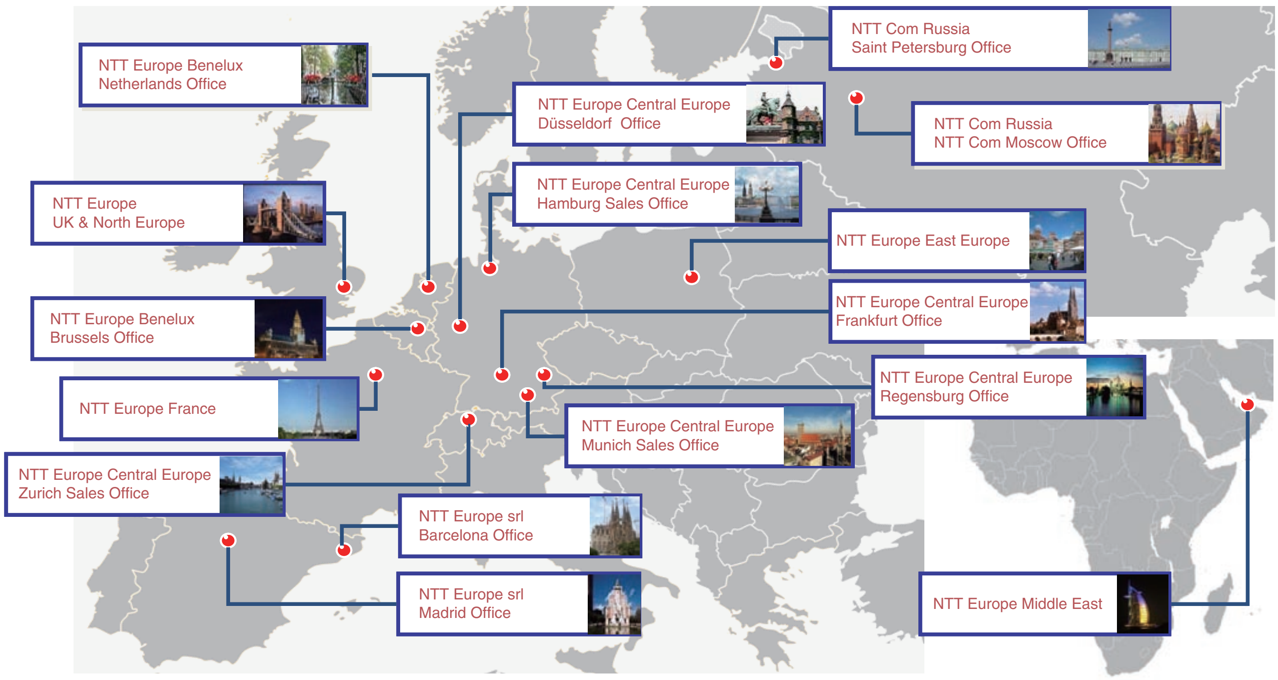


Fig. 3. NTT Europe office locations.

integrate business with Atlas Information Technology [3], a subsidiary of NTT Europe in Spain providing application-management services, as part of a plan to expand business as a core enterprise in the EMEA region.

NTT Europe currently employs about 600 people of which only 20 or slightly more than 3% are employees dispatched from Japan. About 80% of all revenues come from European multinational customers, and the ratio of local staff is increasing yearly. NTT Europe's employees are of diverse nationalities: while some are citizens of the country where they work, others are from various EU, Asian, and African countries. The atmosphere within the company is very international.

2. Cloud services provided by NTT Europe

A key feature of NTT Europe is its provision of cloud services (**Fig. 4**), which has been the most advanced among NTT Group companies outside Japan. NTT Europe provides three types of cloud services as summarized below to serve a wide variety of customer needs:

(1) Private cloud: A secure, high-quality, and easily managed environment enabling enterprise customers to roll out applications on a dedicated server infrastructure.

(2) Compute cloud: A multi-tenant cloud fusing private and public clouds among which computing is allocated according to the customer's business, functions, and provided services.

(3) Public cloud: A shared, multi-customer computing environment that can be easily and quickly provided (in collaboration with OpSource, Inc.).

NTT Europe excels not only in selling individual services but also in making proposals to its customers and providing them with attractive solutions that combine a variety of services. It is a top cloud services provider among overseas subsidiaries of the NTT Communications Group.

Another feature of NTT Europe is its superb operations support system, which is essential to the operation and management of these cloud services. It lets customers themselves monitor and remotely control services running on servers at any location from a customer portal. They can easily and swiftly increase or decrease the number of virtual servers or server resources depending on current business conditions. This support system, developed by NTT Europe, is starting to be used for global cloud services in the

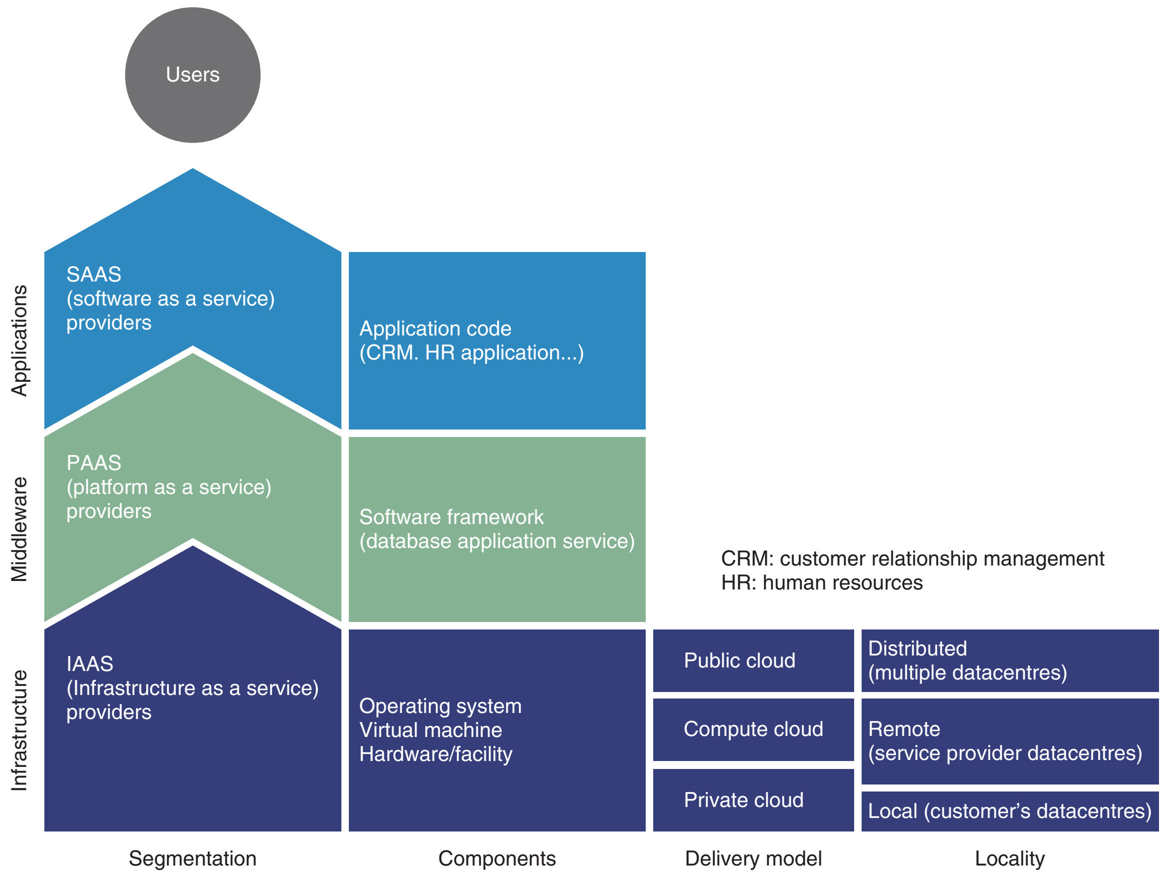


Fig. 4. NTT Europe's cloud services.

NTT Communications Group.

A third feature of NTT Europe is its ability to provide application-management services through its subsidiary Atlas Information Technology. Through these services, NTT Europe monitors and manages a wide range of software for databases, web servers, and other applications on behalf of the customer. This frees the customer from application upgrade management, application monitoring, fault handling, problem management, and other burdens that would normally be handled by an in-house team on a daily basis.

3. Collaboration with NTT Group companies

One challenge facing NTT Europe going forward is how to foster collaboration with Dimension Data, Integralis, and NTT DATA Group companies, which are now expanding in Europe, so as to generate a synergetic effect. Although NTT Europe has only about 600 employees in Europe, the total if counted together with these NTT Group companies would represent a huge business group of about 150 offices and more than 6000 employees in Europe alone (**Fig. 5**). The objective here is to make full use of this large repository of resources.

On the business side, NTT Europe is already providing total solutions by combining its network and cloud services with the security services of Integralis, the information technology support services of Dimension Data, and the consulting services of the NTT DATA Group, and it expects to see a yearly increase in joint orders.

In addition to collaborative connections formed by such joint business, ties are becoming even deeper as some of the new NTT Europe offices such as those in Brussels, Munich, and Milan come to be co-located with these group-company offices and conversely as group-company offices come to be co-located with NTT Europe offices such as those in Paris and Düsseldorf.

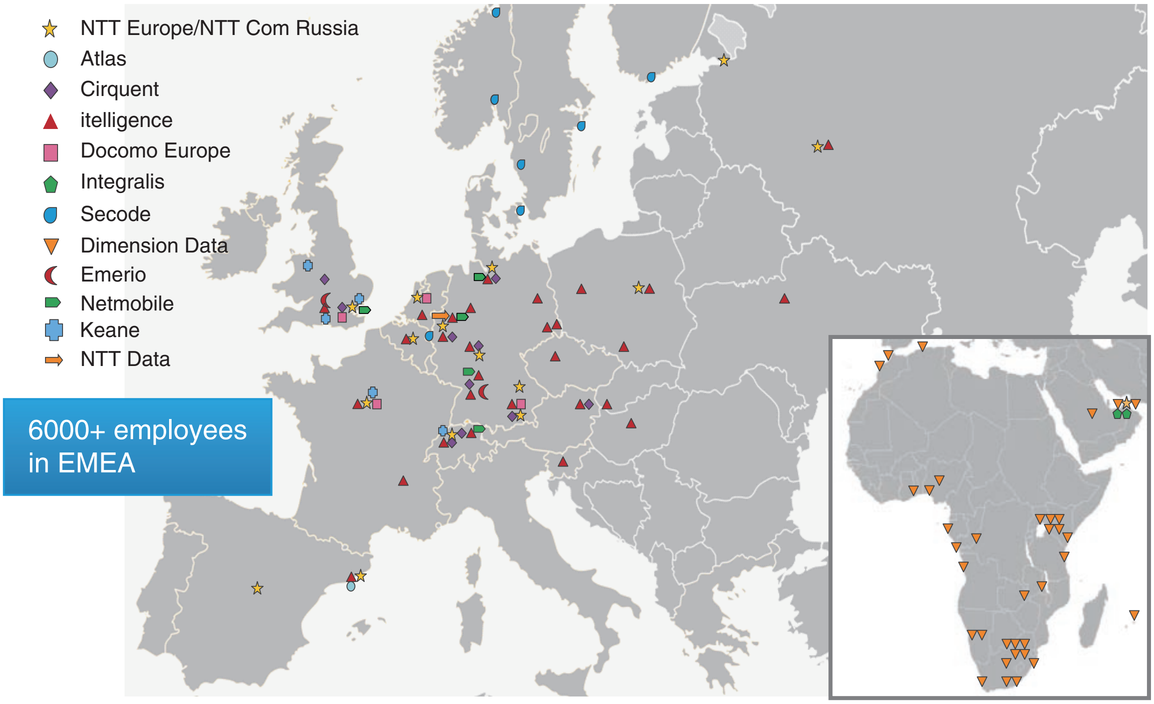


Fig. 5. NTT Group coverage in the EMEA region.

4. Future developments

Looking to the future, NTT Europe expects to further expand its business coverage and service line-up and plans to raise its competitiveness in services by building up its network and datacentre/cloud services within the European region. Creating total NTT Group value and promoting that value in the market is without doubt the key to expanding NTT Group business in EMEA.

References

[1] NTT Europe. http://www.eu.ntt.com/en/index.html

[2] NTT Europe Online, NTT Technical Review, Vol. 8, No. 6, 2010. https://www.ntt-review.jp/archive/ntttechnical.php?contents=ntr201006ov1.html

[3] Atlas Information Technology. http://www.atlasit.com/

NTT Europe—short column

British culture as seen through the Olympics

Amid the many sombre topics in Europe today, such as the Euro crisis originating in Greece and severe economic conditions and austerity policies in various countries, one of the few bright spots is the London Olympics to be held in August 2012.

The Olympics have generated much conversation in the workplace. When tickets first went on sale, for example, there was lots of talk about which events people had been lucky to get tickets to and which were sold out. At the same time, it became apparent that similarities and differences between British and Japanese culture could be seen through the hosting of these Olympics.

To give an example, public transport is predicted to be somewhat chaotic during the Olympics, and the advice given in a newspaper article entitled 'Survival Guide for Commuters' is to have a drink in a pub before going home to avoid the rush. This is about the same as having a drink in an *izakaya* before going home in Japan.

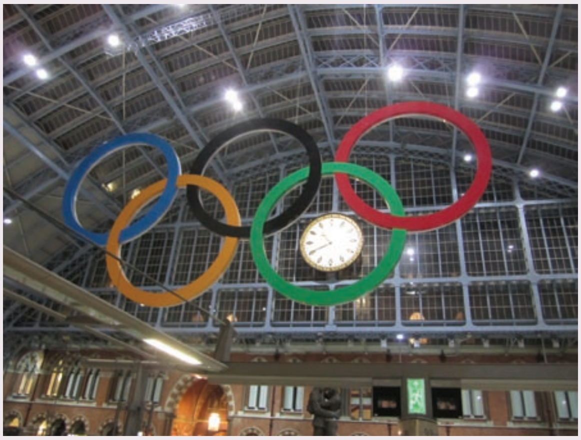
On the other hand, there was a story of London Underground (subway) workers being offered a £500 bonus for their services during the Olympics to prevent a strike during that period and their union contesting that amount as being too low. Using the Olympics as a pawn in labour negotiations is a bit distasteful.

At work as well, some cultural differences could be felt. We held monthly meetings on dealing with the Olympics beginning about a year before the start of the Games, and a business continuity plan for that period was discussed. Various questions were asked such as ‘What should we do if a terrorist attack occurs?’ and countermeasures were studied.

Indeed, opinions were exchanged on a variety of threats that would hardly be thought of in Japan, such as ‘What happens if employees cannot get to work if Underground workers strike?’, ‘What shall we do if employees request holidays en masse to attend Olympic events?’, and ‘How shall we respond to employees viewing a major event during working hours (given that the company’s internal network could crash if many employees start watching a popular event by streaming video)?’. At first, I was somewhat confused, as I was not sure which of these were jokes and which were serious issues for discussion.

Some surprising proposals—at least to me—were offered, such as ‘Why not let employees watch a major event together in the company’s conference room?’ (But in all fairness, such a measure had already been taken during the 2010 World Cup soccer matches, when the England and Japan matches generated great excitement.) On speaking with people at local firms, I learned that this kind of activity was commonplace in England and that human-resource personnel would often provide food from various nations and treat the occasion as an employee event. I was impressed in the way that business continuity plans can differ from one country to another.

This kind of minor cultural difference can make overseas service both fascinating and difficult at times.



Giant Olympic rings at St Pancras railway station.

2012 Olympics countdown clock in Trafalgar Square.

External Awards

WTC2012 Best Poster Award

Winners: Arifumi Matsumoto†1, Masaki Minami†2, and Ichiro Inoue†1

†1 NTT Service Integration Laboratories

†2 NTT WEST

Date: March 6, 2012

Organization: The World Telecommunications Congress (WTC) 2012, Miyazaki, Japan.

For "A Novel Management Method of Carrier Grade NAT for Large Scale IPv4/IPv6 Networks".

IPv4 address depletion is forcing Internet service providers and enterprises to deploy network address translation (NAT) in their networks. At the same time, network providers have to maintain traceability of abuse of and by their users. These two requirements do not coexist easily because NAT makes tracing difficult. The NAT session log is the key to keeping traceability in such a large-scale NAT environment, but the problem is that it can become too large. This paper proposes a method of reducing the size of the NAT session log. The method is evaluated using actual traffic data and confirmed to reduce the session log to almost half. Moreover, the method is analyzed to find several approaches to producing further improvements in the reduction ratio.

The Young Scientists' Prize, Commendation for Science and Technology by the Minister of Education, Culture, Sports, Science and Technology

Winner: Norio Kumada

Date: April 17, 2012

Organization: Ministry of Education, Culture, Sports, Science and Technology

For "Many-body Physics in Two-dimensional Systems Formed in Semiconductors".

Quantum Hall states, which appear in high-mobility two-dimensional systems under a high-magnetic field, show a variety of quantum many-body physics. We investigated many-body states by controlling carrier interactions by using bilayer systems formed in semiconductors. In particular, we developed highly sensitive nuclear magnetic resonance techniques, which revealed low-frequency spin fluctuations associated with spontaneous symmetry breaking in a two-dimensional system.