NTT Technical Review

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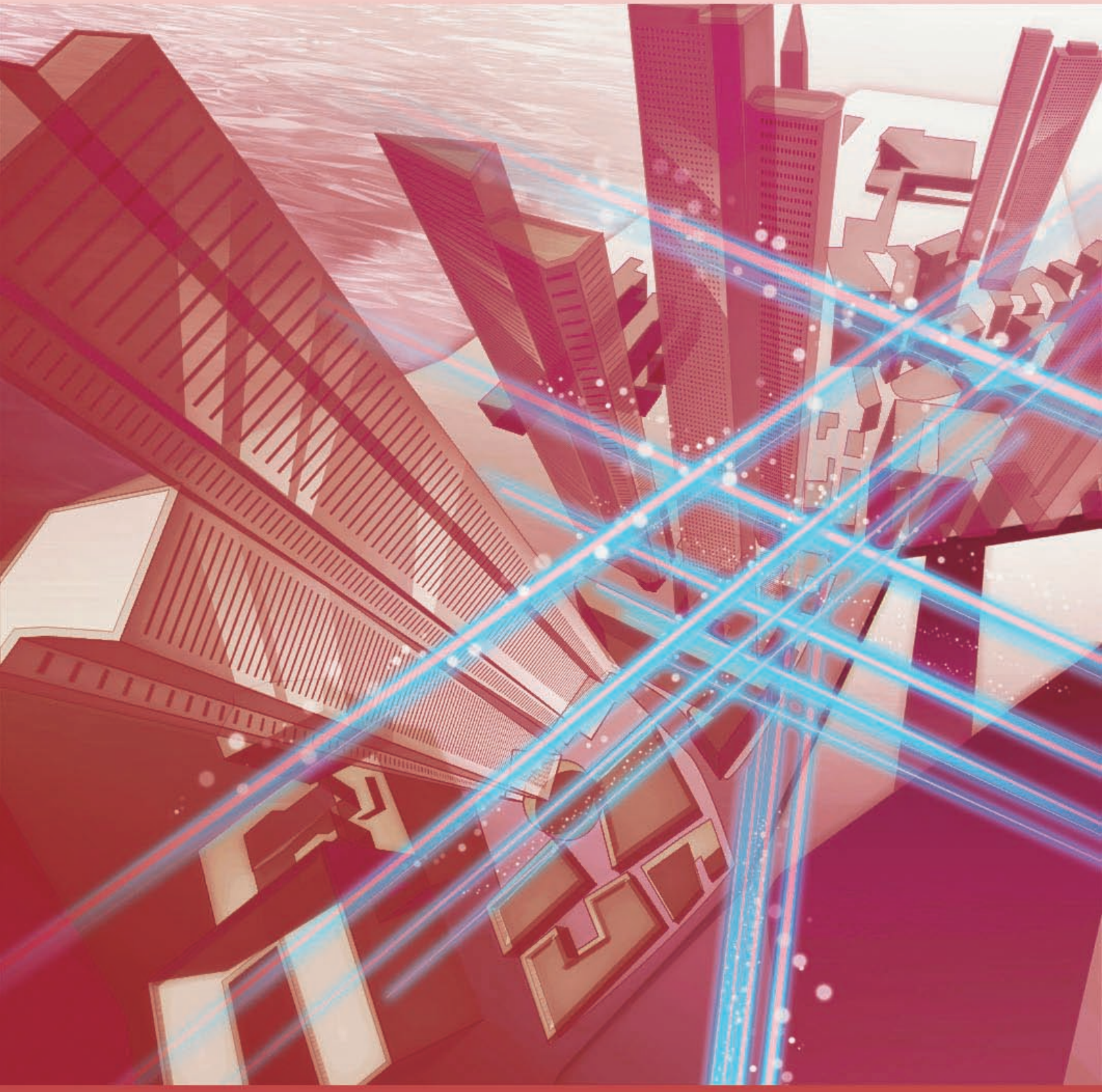

January 2012 Vol. 10 No. 1

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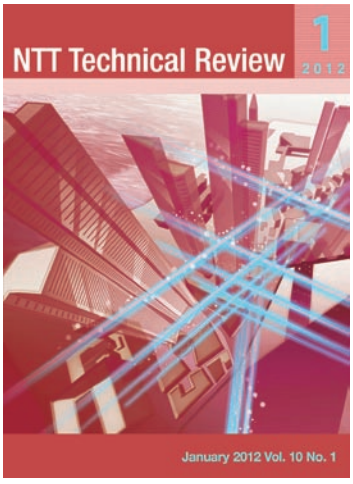


Software-oriented, Speedy, and Globally Minded R&D—Providing Cloud, Smart-community, Fixed-mobile-convergence, and Disaster-recovery Solutions Through the Total Power of the NTT Group

Noritaka Uji
NTT Representative Director and Senior Executive Vice President

Overview

For our first interview of 2012, we had the pleasure of talking again with Noritaka Uji, NTT Representative Director and Senior Executive Vice President. We asked him about this year's strategy toward service creation in the NTT Group including measures for recovering from the Great East Japan Earthquake and efforts to solve social problems through the use of information and communications technology (ICT).

Recognizing again the importance of ICT: Developing an infrastructure and service lineup robust to disasters though a group-wide effort

—Mr. Uji, please tell us how the lessons learned from last year's Great East Japan Earthquake—an unprecedented disaster in the history of Japan—will be applied to this year's technology strategy.

The Great East Japan Earthquake reminded not only us at NTT but also society on the whole of the critical importance of communications. When the earthquake hit, many people had their mobile phones with them just as they would their wallets or purses. Needless to say, there is nothing more important at the time of a disaster than to be able to check on the well-being of loved ones. There was therefore an urgent need to restore disrupted communication services as quickly as possible. This shows that, these days, communications is a vital social infrastructure, at least as important as water and gas.

In response to this need, we are working to develop a network and service lineup robust to disasters along three main directions. First, we are endeavoring to set up a network highly robust to disasters and to develop ways of achieving early service restoration in stricken areas. To this end, we are exploring various means to achieve a highly reliable network resistant to traffic congestion. These include dispersing important communication functions over a number of regions and establishing many transmission routes, installing disaster-oriented mobile-phone base stations that can cover a much wider area than ordinary ones, and upgrading emergency battery capacity in base stations from several hours (the current standard) to 24 hours so that communications can be maintained during extended outages of the commercial power supply. We are also planning to study network architectures that promote the convergence of fixed-line and wireless communication (fixed-mobile convergence (FMC)) and to research and develop highly efficient storage batteries. Moreover, we have been developing

compact and portable, easy-to-use satellite communications equipment as an alternative means of communication that can be set up quickly after a disaster hits. This equipment is scheduled to be introduced soon.

Second, we are working on a means of information distribution after a disaster so that people can quickly check on the well-being of others. To deal with congestion in the network caused by many people attempting to make calls with their mobile phones at the same time, we will be launching a service in March 2012 that enables speech to be converted to digital data for delivery over the packet network. I'd like to mention here that the message board service developed at the time of the Great Hanshin-Awaji Earthquake of 1995 was also used to good effect in last year's Great East Japan Earthquake, but to make it even easier for users to check on each other, we will be developing ways of doing so by multiple means including personal computers, smartphones, and mobile phones.

Third, we aim to provide medical and governmental public services after a disaster hits and during the restoration period. For example, we aim to provide remote health consultations for people in stricken areas and refuge centers using videoconferencing functions, to establish a number-based identification system for use after a disaster, to create a list of people requiring special support during a disaster including disaster victims themselves, and to provide people with effective support in putting their lives back in order. In relation to these efforts, we are already providing local governments with detailed map data that we have been using for managing utility poles, manholes, and other elements of the telecommunications infrastructure to assist them in their restoration and reconstruction efforts. And we are studying ways of linking this infrastructure map data with a hazard map to create communities robust to disasters.

In short, we are working to achieve a safe and secure society through the combined effort of the whole NTT Group including its research and development (R&D) activities.

A drive toward service creation fueled by the cloud, the smart-community concept, and FMC

—This is the final year of the NTT Group Medium-term Management Strategy announced in 2008. Could you update us on its progress?

This medium-term management strategy declared

the NTT Group's intention of becoming a service creation group. To this end, we have been actively pursuing a transition from a business structure centered on legacy systems like the telephone to one focused on IP (Internet protocol) systems, solutions, and new business fields. As a result, earnings from IP systems and solutions are on course to make up about 70% of total earnings by the end of fiscal year 2011. One reason for this is that we have expanded broadband services on both the fixed and mobile networks. On the fixed network, the Next Generation Network (NGN) is now being provided in all existing areas where optical network services are available, and on the mobile network, the high-speed, high-capacity Long Term Evolution (LTE) service called Xi (Crossy) is now in operation and providing a world-class broadband environment. We are expanding user services on these networks as part of the trends for service convergence, such as FMC, and a paradigm shift. For example, the number of subscribers to the Hikari TV and FLET'S TV video services combined reached 2.43 million by the end of September 2011. Moreover, a Home ICT service called FLET'S Joint, which enables home appliances to be controlled over the network, was launched in August 2011, and the NOTTV multimedia broadcasting service for mobile phones is scheduled to be launched in April 2012. As for our globalization efforts, it appears that we will achieve our target of US$10 billion in overseas sales by FY2012: a year ahead of schedule.

Although we are now in the final year of this medium-term management strategy announced in 2008, there are new challenges to face. To move on to the next step, I would like to accelerate our service creation efforts.

—The Medium-term Management Strategy appears

to have been a success, but what will be the strategy for service creation from here on?

To begin with, there's the cloud. Cloud services are being developed through various collaborative efforts among the group companies leveraging their characteristics and strengths of each. In addition to corporate-oriented services now being undertaken by NTT Communications and NTT DATA, there is also a cloud service that can be used by smartphones that was launched by NTT DOCOMO in April 2011. This service has become a case study of how the web platform developed by NTT DATA INTRAMART can be used across the entire NTT Group. NTT EAST and NTT WEST are also expanding cloud services using their own datacenters.

In addition to business, NTT is also promoting use of the cloud in the public sector. In the field of medical care, the NTT holding company and NTT EAST have joined forces to develop a cloud-type remote health consultation service called Hikari Health Consultation. This service was first introduced in Tono city, Iwate prefecture, and then expanded throughout Japan from September 2011. Meanwhile, in the field of education, an education-oriented cloud has been in use since 2011 to provide digital materials and hold interactive classes using tablet devices in ten elementary and junior high schools throughout Japan. And in government, we are promoting local-government clouds with the aim of making operations across multiple municipalities more efficient and administrative clouds to make government services more convenient for users.

Looking forward, we aim to provide an end-to-end one-stop service that includes construction and maintenance support for networks, platforms, and applications from a user terminal. We will also undertake technology development from various perspectives. For example, we plan to expand virtualization techniques beyond servers to the network, enable flexible and speedy service provision combining servers and the network, reduce system construction and operating costs by using open-source-software technologies, and enhance security through cryptographic and trail-management techniques. Furthermore, in collaboration with overseas companies in the NTT Group, we will pursue the global expansion of services using global networks and overseas datacenters.

Parallel processing using the cloud will make it possible to inexpensively and rapidly analyze huge amounts of data, which is known as *big data*. This data might include users' web search histories, data posted on social networking services, and data collected from various types of devices and sensors in machine-to-machine communication. We expect such analysis of big data to create new value in many forms. For example, we can envision the analysis of location information exchanged between mobile phones and base stations to reveal how people behave at the time of an earthquake or other natural disaster. Such knowledge could be useful in disaster prevention planning. The storage and analysis of other kinds of information, such as large quantities of meteorological data and past medical cases and health information, also hold many possibilities. Analysis results could be used, for example, in corporate marketing, urban planning, and the agriculture and medical-care fields. The potential for creating new value is infinite.

—I can see that the cloud is taking on an important role within the NTT Group. What about activities targeting the environment and energy?

As you know, a shortage of electrical power has become an issue in our society in the wake of last year's earthquake. As an ICT operator that uses a considerable amount of power in our business operations, we have a social responsibility to reduce power consumption. At the same time, we are working on

ways of saving energy in society through the adept use of ICT. These efforts will help reduce the load on the environment.

For example, we are working on a variety of environmental solutions taking advantage of the individual strengths of various NTT Group companies. These include a power visualization service for reducing power consumption in homes, condominium complexes, and office buildings, a car-sharing service using electric cars, and a mega-solar solution for constructing and operating a solar power generation system. Likewise, as part of our R&D efforts, we are researching and developing ways of reducing power consumption even further in network equipment, such as in home-installed optical network units (ONUs) that convert optical signals to electrical signals, and we are studying energy-management techniques for controlling air conditioning and power supplies according to the current load on ICT equipment.

In future R&D, we intend to expand upon these activities toward the provision of home energy management and the creation of smart communities. The idea behind home energy management is to interconnect a variety of home appliances, information devices, and power generation and storage equipment in combination with Home ICT services to achieve optimal control of energy use inside the home. The idea behind a smart community, meanwhile, is to achieve optimal control of electrical-power supply and demand throughout a community by linking the energy infrastructure in the community with the ICT infrastructure and using the cloud to analyze and visualize information such as current supply-and-demand conditions. We expect smart-community technology to be useful in creating communities robust to disasters and good at disaster recovery while being environmentally friendly.

—Sales of smartphones and tablet computers are exploding. How will NTT respond to this trend?

About 2.5 million smartphones and tablets were sold in FY2010 in Japan, and while the initial projection for FY2011 was about 6 million units, it now seems that about 8.5 million units will be sold. This change in consumer taste is occurring much faster and on a larger scale than we expected—consumers are saying that they want to use a smartphone or tablet because it enables them to do what they've been doing on their computer anytime and anywhere.

We can expect the spread of mobile terminals to

expand the ways in which the cloud is used in the corporate and public services that I touched upon earlier. And in the home as well, we can envision mobile terminals and the cloud finding use in the kitchen and living room such as for enabling the purchase of products from online supermarkets and visualizing power usage. However, users must be able to use such services in a comfortable, stress-free manner, and to this end, it is essential that fixed and mobile network services be combined in a seamless, transparent manner. For example, we are accelerating the deployment of a service environment in which users automatically use Wi-Fi connected to a high-speed optical line when indoors and the mobile network when outdoors. We are also looking to develop services that support the *multi-device* concept in which users can receive the same service regardless of the type of terminal, which could be a home appliance such as a TV set when indoors and a mobile terminal or even digital signage when outdoors. In the case of IPTV, for example, a multi-device service would enable video content to be viewed with a smartphone or tablet in the same way that it is viewed on TV. At present, however, this would require the content provider to provide different versions of certain content to suit different terminals, which would increase development time and thus drive up costs. A solution to this problem can be found in next-generation web technology (HTML5), which will enable a web browser to absorb terminal differences so that any item of content can be used on a variety of terminals. We are researching and developing applications and platforms that will incorporate this technology, which is now in the process of being standardized.

In this way, by enabling an individual to use the same terminal or service anytime and anywhere, we can compile a usage history, which can be used to create personalized services and new, attractive services such as a concierge function.

Software-oriented, speedy, and globally minded R&D

—Mr. Uji, could you leave us with some words about your aspirations for this year?

First of all, responding to changes in the world in a timely manner is not as easy as it sounds. In R&D, some sort of drastic change is needed to respond to the times. This year, I would like to see our R&D evolve on the basis of the keywords *software-oriented, speedy,* and *globally minded*.

Software-oriented means accelerating service development and improving quality and security through software technology as our business areas expand. Being software-oriented is crucial to keeping up with expanding cloud services and the trend toward service convergence. Speedy refers to the need for accelerating service development to keep up with world changes in a severely competitive mobile-services field and for revolutionizing R&D itself in accordance with social changes. Globally minded includes efforts to increase overseas sales but also means keeping our eyes on overseas trends in markets and technologies and reflecting those trends in service development. In this regard, collaboration with newly added overseas group companies and overseas researchers is essential. In terms of software development, I particularly want to expand research on the west coast of North America from a global perspective.

We must pursue R&D with a sense of urgency as the world moves forward with unbelievable speed. With about 3000 researchers in the NTT R&D Laboratory Group (under the holding company) and about 6000 researchers and developers across the entire NTT Group, NTT R&D is of a world-class level—it is the source of our competitive power and potential for growth. My goal here is to instigate a rapid succession of ICT innovations in the NTT Group.

Interviewee profile

■ Career highlights

Noritaka Uji joined Nippon Telegraph and Telephone Public Corporation (now NTT) in 1973. He handled tasks related to NTT privatization and startup business development. In 1988, he moved to NTT DATA, where he was initially in charge of planning and developing information systems for private enterprises. He then served in various managerial roles including Director of the Next-Generation Information Services Sector, Senior Vice President and Director of Business Planning, and Senior Vice President and Director of Enterprise-related Sectors. Building on these experiences, he assumed the post of Senior Executive Vice President in 2005. He began serving in his present position in 2007.

Research and Development of Smart Energy

Yousuke Nozaki†

Abstract

This article introduces the status of research and development being performed by NTT Energy and Environment Systems Laboratories based on the concept of information and communications technology (ICT) combined with energy called "ICT × energy". This should lead to systems capable of ensuring stable power supply, saving energy, and shifting load peaks as well as to technologies that use smart energy management.

1. Introduction

The smart grid is a concept that is attracting attention as a key technology for improving the stability of power supplies and solving global environmental problems. This concept has mainly been discussed in the USA and Europe, but there has also been active discussion in Japan, China, and Korea. The smart grid, which is outlined in **Fig. 1** [1], connects commercial power plants to distributed generation systems, batteries, and various kinds of industrial and private equipment installed at the sites of power consumers through communication networks. It enables new energy-saving functions not available from the conventional power networks, such as meticulous adjustment of power demand and supply; promotes the implementation of photovoltaic power, wind power, and other renewable energies; and enables the visualization of power consumption. There are global expectations for the smart grid: to run power networks stably by suppressing peak power demand in the USA; to implement wind power and other renewable energies on a large scale in Europe; to improve the energy self-supply ratio and foster new growing export industries in Korea; and to strengthen power networks and utilize thermal, hydraulic, and nuclear power efficiently in China and India.

In Japan, the Great East Japan Earthquake in March 2011 activated discussion about reviewing the basic energy policies and increased the importance of business continuity plans for disasters. The smart grid is now expected to also be a means of suppressing peak power demand and balancing demand and supply. To date, NTT Energy and Environment Systems Laboratories has been promoting comprehensive research and development (R&D) activities from the two viewpoints of Green of ICT and Green by ICT [2] to reduce environmental loads (ICT: information and communications technology). In particular, R&D activities are gaining speed these days to contribute to service development for the smart community that the NTT Group is promoting.

2. Position of smart grid

The smart grid has three purposes: (1) reducing CO_2 emissions accompanying power supply, (2) increasing efficiency by controlling the balance between power demand and supply, and (3) improving reliability by power management. In the power field, the smart grid is an innovation like the Internet in the ICT field. More specifically, the advent of the Internet in 1990s caused a quick evolution of ICT services from the age of communications by phone to the age of business creation via the Internet. This may be why we are aiming at the *Internet of things*. The position of the smart grid in power supply is shown in **Fig. 2**. Power supply used to be only one way from a power plant (supplier) to consumers. By contrast, the smart grid can produce various unique effects from two-way power supply by photovoltaic generation on

† NTT Energy and Environment Systems Laboratories
Musashino-shi, 180-8585 Japan

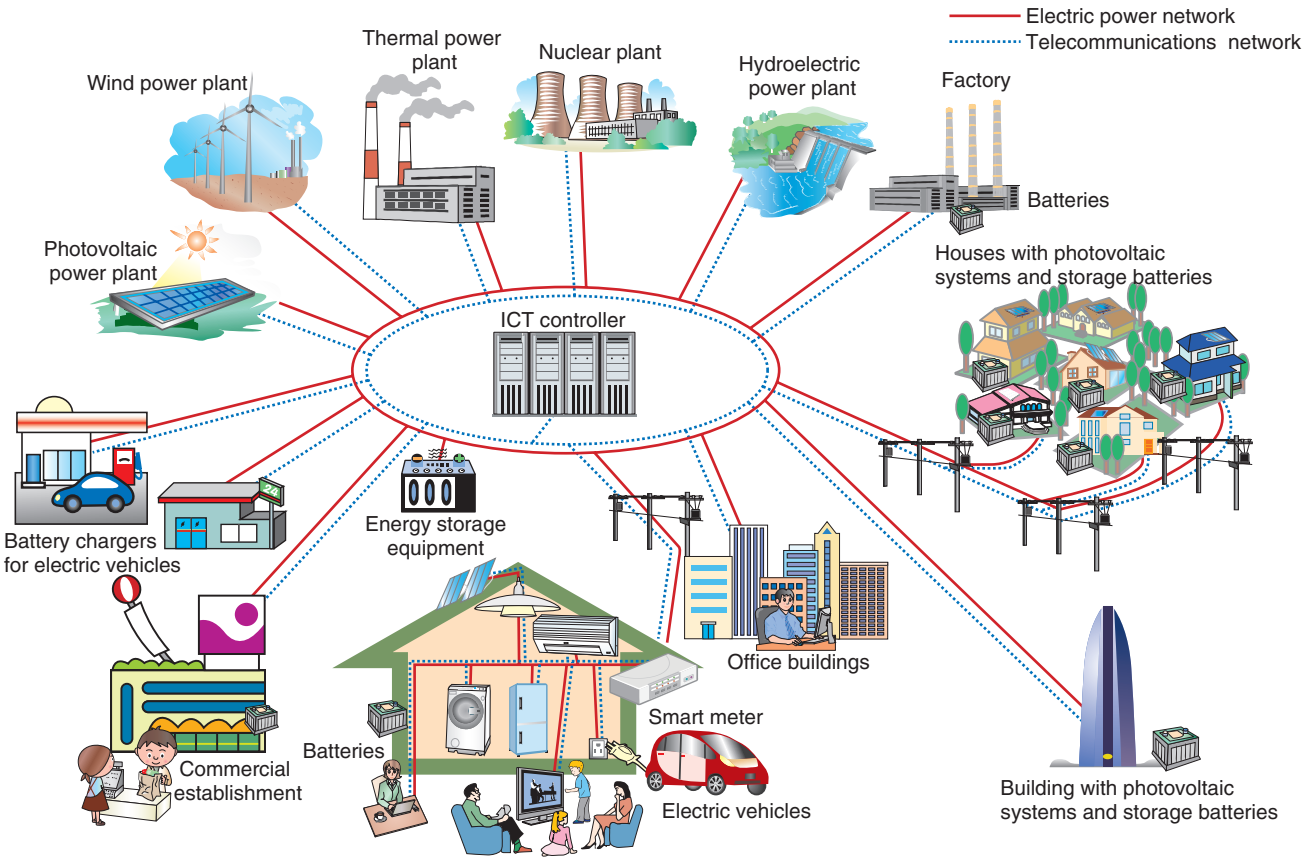


Fig. 1. Outline of a smart grid.

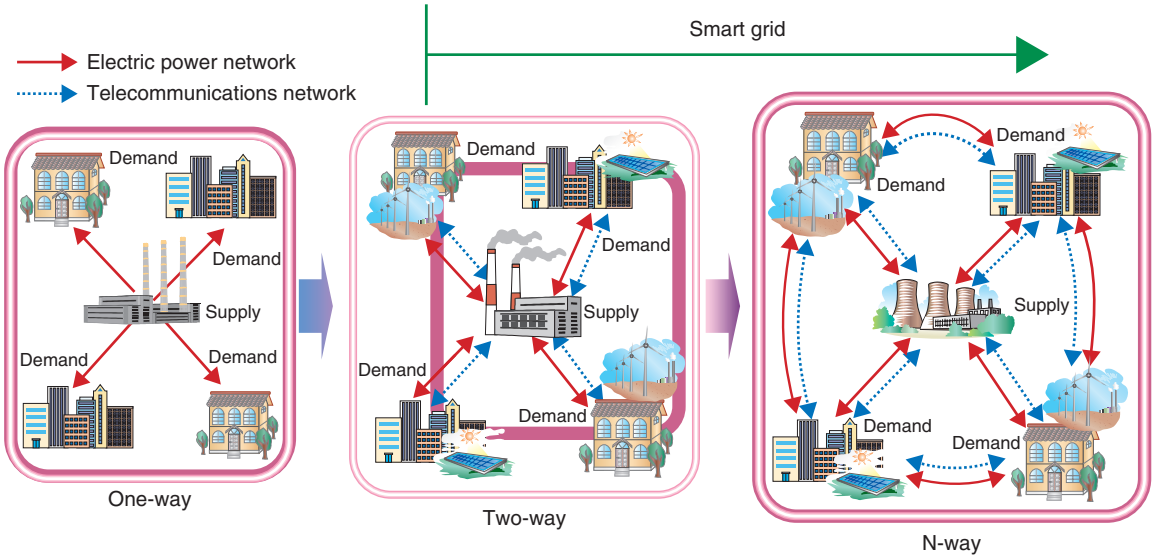


Fig. 2. Conceptual model of smart grid.

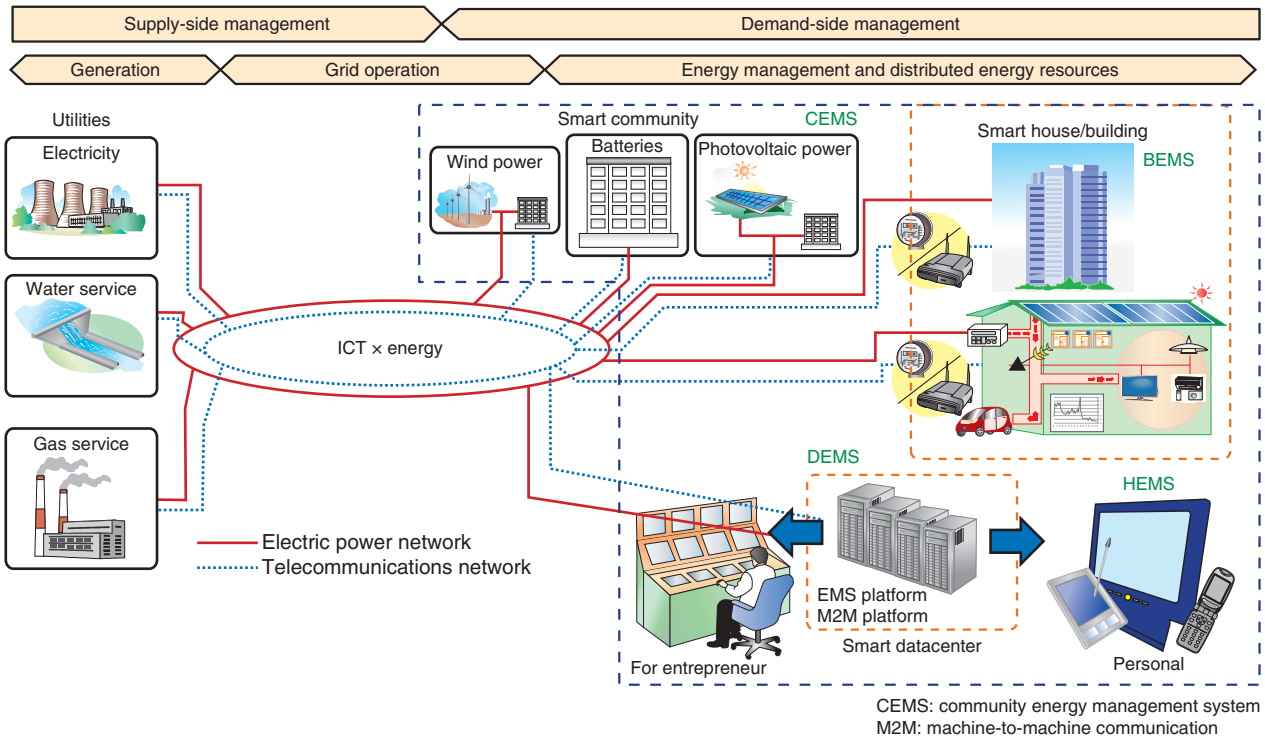


Fig. 3. Energy management systems in the smart grid.

the consumer side, by distributed generation using fuel cells, and by power storage using batteries as well as unique effects from N-way flow (two-way mesh form) by power and information exchange among consumers. This age of business creation arises from this evolution from centralized generation and one-way transmission & generation to distributed generation and two-way transmission & distribution. NTT Energy and Environment Systems Laboratories is tackling the development of technology needed for the smart grid not from the viewpoint of a power supplier by from the viewpoint of users (demand side).

3. Development of smart energy management technology from demand-side viewpoint

The smart grid in its true form will allow information and power exchange in two ways or finally in N ways (mesh form). NTT's business area covers smart communities and smart houses and buildings through close linkage between energy and ICT. The smart grid viewed from the demand side is shown in **Fig. 3**. NTT is developing technologies for smart communities based on the concept of "ICT × energy" by combining ICT (Next Generation Network (NGN), FLET'S HIKARI (optical broadband service), mobile and other network infrastructures, Home ICT, etc.) and energy devices such as photovoltaic and wind-generation devices, batteries, and fuel cells. More specifically, NTT is developing (1) optimum control systems for power- and heat-exchange systems and new energy systems within the smart community and (2) a demand-side management system (demand-based power management system), home energy management system (HEMS), building energy management system (BEMS), and datacenter energy management system (DEMS), and a new energy-producing home appliance control system for using home photovoltaic generation systems, fuel cells, and electric vehicle batteries optimally for smart houses and buildings. Regarding energy devices, NTT is developing solid oxide fuel cells (SOFCs) having the highest generating efficiency and lowest CO_2 emissions among various fuel cells and also next-generation batteries after the lithium ion battery.

For SOFCs, NTT is promoting joint development with Sumitomo Precision Products and Toho Gas, putting priority on the cell and stack as the heart of an SOFC. With the 5-kW-class system shown in **Fig. 4**, we have achieved the world's highest level of power

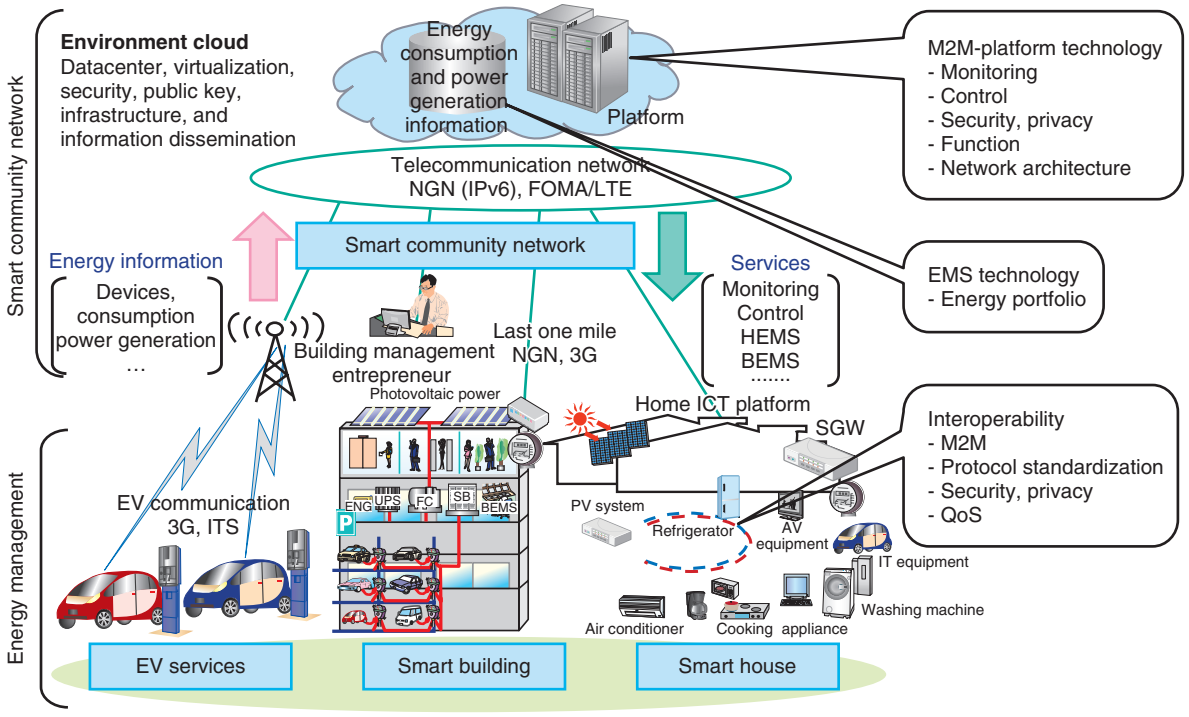
Fig. 4. Prototype system.

generation efficiency of 45% and are now reducing the costs and extending the life for commercialization.

Regarding batteries to come after the lithium ion battery, NTT is studying materials for a lithium air battery to achieve space savings and a lightweight power supply in the future. Considering the theoretical capacity based on the present combination of anode and cathode materials, it is said that lithium ion battery capacity cannot be increased more than 1.6 times. Compared with the lithium ion battery, the lithium air battery is expected to be several times more compact and lightweight.

4. Conceptual model of smart grid

The key points for a smart community are visualizing and optimally controlling the power generation and consumption of various energy devices. The significance of establishing a foundation for visualization and control is self-evident. NTT is advocating the smart conceptual model shown in **Fig. 5**. The total



3G: third generation
AV: audio-visual
ENG: engine generator
EV: electric vehicle
FC: fuel cell
FOMA: DOCOMO mobile system
IPv6: Internet protocol version 6
IT: information technology
ITS: intelligent transportation system
LTE: Long Term Evolution
PV: photovoltaic
SB: secondary battery
SGW: service gateway
UPS: uninterruptible power supply

Fig. 5. Conceptual model of the smart grid.

strength of NTT R&D should be focused to develop technology such as a machine-to-machine (M2M) platform technology, energy management system (EMS) technology (energy portfolio technology) for the optimum control of power supply and demand based on a great volume of power generation and consumption information, and interconnection technology for various devices in smart houses and buildings.

Toward a clean energy network, NTT Energy and Environment Systems Laboratories participated in clean energy demonstration research [3] at EXPO 2005 AICHI JAPAN and provided an energy control system [4], including the algorithm for achieving optimum scheduling of fuel cells and sodium-sulphur batteries based on meteorological information. NTT is also promoting R&D of higher-voltage direct current (HVDC) [5] and other energy-conservation technology [6] for energy-saving devices and systems; clean-energy technology, such as fuel cells [7], new batteries, and solar batteries of ultrahigh efficiency; and also clean-tech R&D technology for zero CO_2 emissions. By further accelerating R&D activities on the basis of these experiences, we wish to contribute to the creation of a smart community through clean technology. From a carrier's viewpoint, the important points of smart grid construction may be controlling the quality of service (QoS) and the class of service (CoS) for *secure and safe network service* and accommodating various protocols and devices. Needless to say, the key to spreading and promoting the smart grid is promoting standardization. With the cooperation of other NTT laboratories concerned, NTT Energy and Environment Systems Laboratories is also promoting standardization related to the smart grid.

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Yousuke Nozaki
Senior Research Engineer, Supervisor, Project Manager, Energy System Project, NTT Energy and Environment Systems Laboratories.
He received the B.E. and M.E. degrees in mechanical engineering from Tohoku University, Miyagi, in 1987 and 1989, respectively. He joined NTT in 1989. Since then, he has been engaged in R&D of switching power regulators, photovoltaic, fuel-cell, and HVDC power systems for telecommunications systems. He is a member of IEEE, the Institute of Electronics, Information and Communication Engineers, and the Institute of Energy Economics, Japan.

Energy Management of Telecommunication Buildings and Datacenters

Kazuhiro Matsuda†*, Tetsuya Tominaga, and Masahide Yanagi*

Abstract

This article introduces work being done by NTT Energy and Environment Systems Laboratories on energy management technologies for datacenters and telecommunication facilities to achieve energy savings by integrating and collaboratively controlling various developed technologies such as low-power-consumption servers and routers, highly efficient air conditioning for communication equipment rooms, and higher-voltage direct current power feeding.

1. Introduction

Considering that over 90% of the total energy consumed by NTT is electricity and that the demand for datacenters is expected to increase as upper-layer services progress in the future, efforts to reduce CO_2 emissions and save energy will become more essential.

An overview of the energy management of telecommunication buildings and datacenters is shown in **Fig. 1**. To achieve energy savings in information and communications technology (ICT) equipment, the latest central processing units (CPUs) have been developed to eliminate unnecessary electricity usage by changing their operating frequencies and core voltages while maintaining their loads [1]. Moreover, routers and switches now feature energy saving capabilities based on varying the operating clock frequencies and stopping power feeding for unused ports and line interfaces [2]. Furthermore, for air conditioning equipment, efforts have been made to achieve higher efficiency in the air conditioning environment through equipment performance improvements, aisle capping* [3], and other means. In power feeding systems, a technology for improving the efficiency of the power supply equipment has been developed utilizing higher-voltage direct current (HVDC) power feeding [4].

On top of all these energy saving technologies, research and development (R&D) has been conducted at NTT Energy and Environment Systems Laboratories on the following: ICT equipment task allocation control, which dynamically controls load allocation and network topology for air conditioning systems to operate efficiently; coordinated control of ICT equipment air conditioning to improve tracking capabilities to match the heat source allocation; power supply control, which stops supplying unnecessary electric power to standby devices; and a datacenter energy management system (DEMS), which integrates and collaboratively controls these technologies. In addition, we are verifying the effects of the DEMS, which reflects NTT's networking technologies, air conditioning guidelines, and power feeding guidelines.

† NTT Energy and Environment Systems Laboratories
Musashino-shi, 180-8585 Japan

* Aisle capping: Airflow control equipment to separate supplied and exhausted air for ICT equipment by partitioning the aisles among racks with side-walls and ceilings.

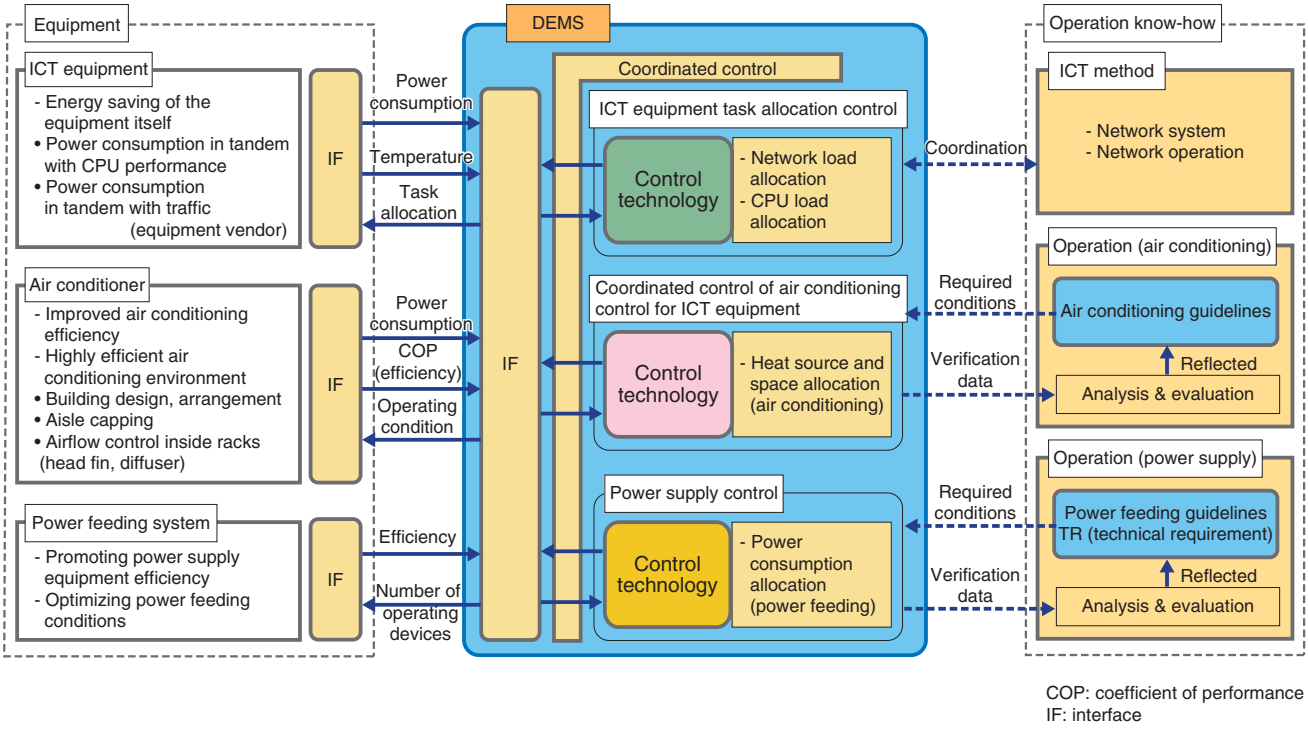


Fig. 1. Overview of the energy management of telecommunication buildings and datacenters.

2. Allocation control of ICT equipment tasks

The leading-edge datacenters of today are equipped with a capability for optimizing electric power by logically varying the working servers in response to load fluctuations by using server virtualization. For example, if the load requires only 25% of the servers in a datacenter to operate in order to provide services, the power consumption can be reduced by concentrating the processes in 25% of the servers and stopping the others.

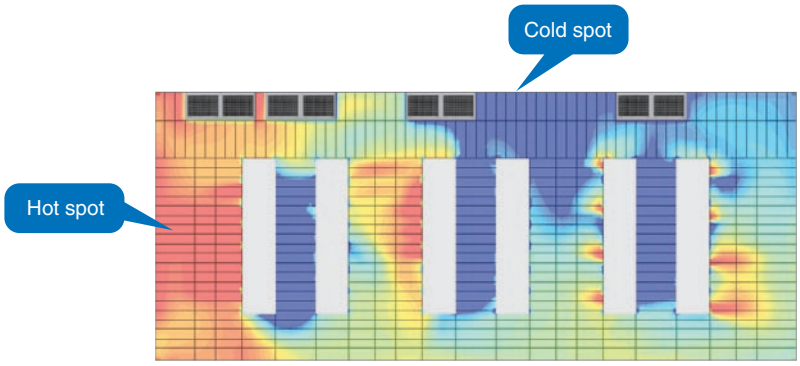
On the other hand, if we regard the servers as a heat load with respect to the air conditioners, if this heat load is distributed evenly rather than allocated spatially in a concentrated manner, then hot and cold spots are not easily formed, so efficient operation can be attained. An example of analysis by thermal fluid simulation is shown in **Fig. 2**. In Fig. 2(a), some hot and cold spots have been formed owing to the unevenness of the heat load, while Fig. 2(b) shows the possibility of air conditioners being operated efficiently without any hot or cold spots through heat load distribution.

The servers still consume some electric power even though their operating system is not running. The coordinated control of servers, air conditioning, and power feeding reduces electric power consumption by stopping power supply to servers that are not providing services and even stopping some of the power feeding equipment.

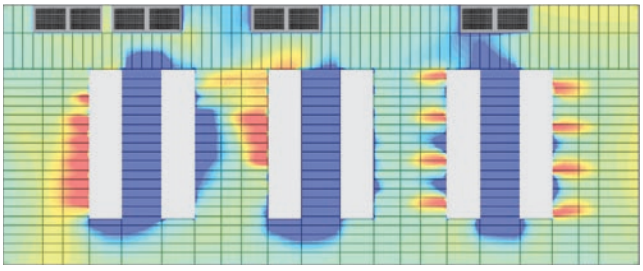
We have also been working on the following. For datacenters, power consumption reduction by wide area relocation has been studied by applying server virtualization among datacenters at many different sites and applying a distributed replication block device [5]. For networks, energy savings have been addressed by performing dynamic routing and by stopping network equipment such as interfaces by through the use of traffic monitoring.

3. Coordinated control of ICT equipment and air conditioners

As a result of recent energy saving efforts, leading-edge ICT equipment can now automatically control its energy consumption in response to the load. This capability is utilized in new air conditioning systems, such as Federspiel Advanced Control System (FACS) from Viglient Corporation, which have been developed to provide efficient cooling without loss by



(a) When the load is allocated in a centralized manner.



(b) When the load is allocated in a distributed manner.

Fig. 2. Analysis of air conditioning environment to improve operation by distributing heat load evenly.

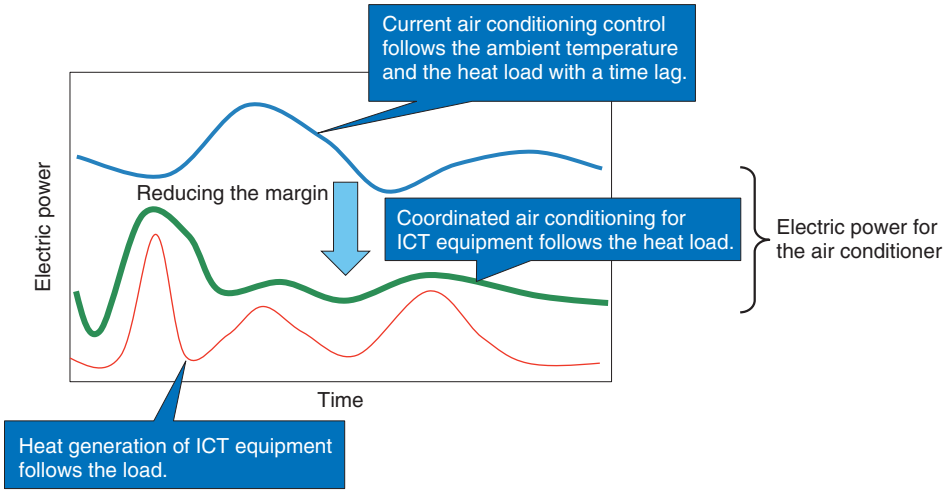


Fig. 3. Concept of proactive air conditioning control.

tracking the amount of heat generation [6]. FACS achieves coordinated operation of multiple air conditioners by collecting information from many temperature sensors placed in the same room to analyze the effectiveness of each air conditioner.

Our R&D has made further advances to achieve *proactive air conditioning control technology* by adding a feature for estimating heat load fluctuations. The concept of the proactive air conditioning control is shown in **Fig. 3**. In temperature-sensor-based air conditioning operation, heat generation varies along with changes in ICT equipment load and the sensors

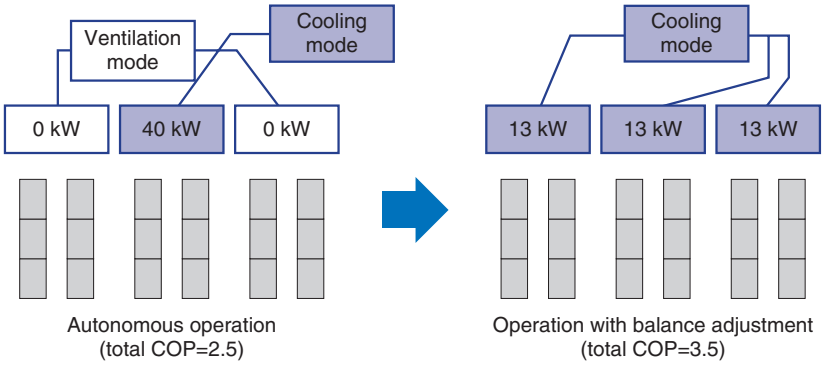


Fig. 4. Effect of balance adjustment in operating air conditioners (efficiency improvement).

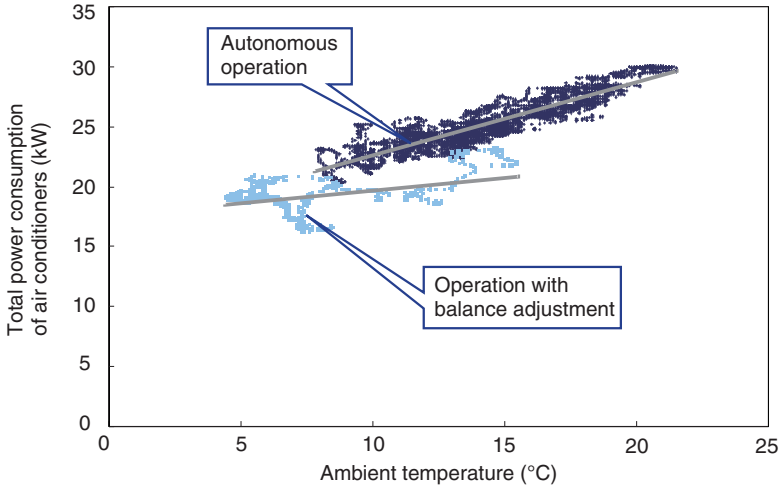


Fig. 5. Effect of balance adjustment in operating air conditioners.

detect the heat load with a time lag. For this reason, we need to allow a margin in the supply air temperature in order to operate the ICT equipment safely. In proactive air conditioning technology, air conditioners are controlled to follow heat generation by collecting the characteristic quantities of ICT equipment such as CPU utilization and traffic and estimating changes in heat generation. Thus, the supply air temperature margin becomes smaller, which enables us to reduce the electric power needed for the air conditioning equipment.

4. Coordinated control among air conditioners

More than one air conditioner is usually installed in a telecommunication machine room. Since each air conditioner is operated autonomously by built-in sensors, there is the problem of lower efficiency due to interference among adjacent air conditioners. Experimental results for both autonomous and coordinated operations using three air conditioners are shown in **Figs. 4** and **5**. When the air conditioners were operated autonomously, only one of the three was supplying cooling air while the rest operated in ventilation mode. On the other hand, when we manually adjusted the load balancing of the air conditioners, total efficiency was improved.

On the basis of the results, we have been engaged in R&D of *coordinated air conditioning control technology* in which multiple air conditioners automatically work in collaboration.

The coordinated air conditioning control is outlined

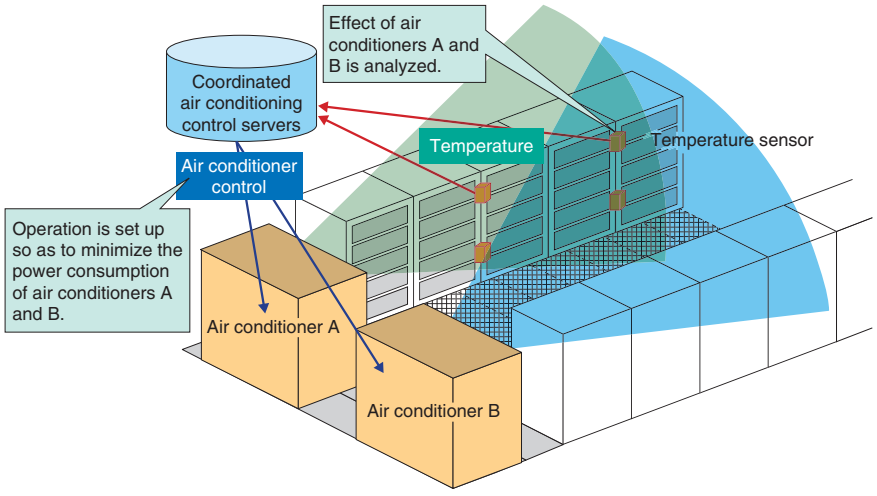
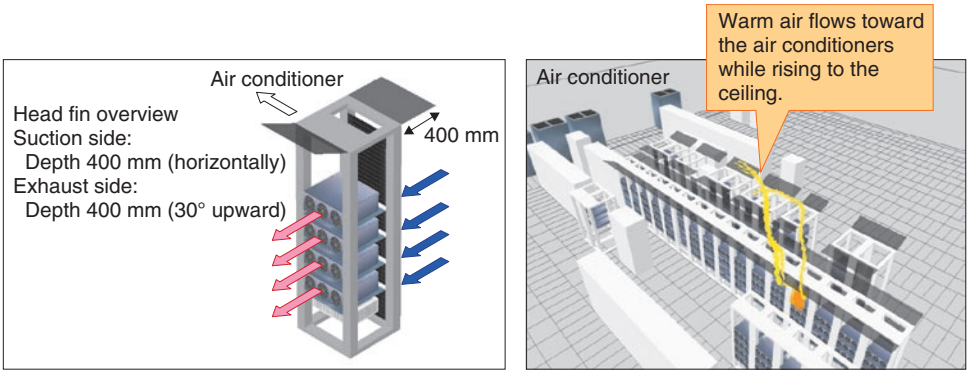


Fig. 6. Outline of coordinated air conditioning control.



(a) Overview of head fins

(b) Result of a thermal fluid simulation

Fig. 7. Airflow control by head fins.

in **Fig. 6**. A coordinated air conditioning server gathers temperature readings from many temperature sensors placed within a telecommunication machine room and assesses the effect exerted by each air conditioner. The server also distributes the load of multiple air conditioners so as to minimize their total power consumption while meeting the set range of target control temperature for each sensor. Efficient cooling of a machine room can be attained by this coordinated air conditioning control technology whereby multiple air conditioners operate ideally in collaboration with each other.

5. Airflow control

For technology such as air conditioning control to function effectively, racks and equipment must be provided in an adequate environment. Most rack-mount servers are of the type with a front air supply and a rear exhaust. On the other hand, network equipment comes in various types in terms of the positions of air supply and exhaust openings, with a mixture of position pairs: front air supply & rear exhaust, bottom air supply & top exhaust, and side air supply & side exhaust.

Since a front air supply/rear exhaust type is preferred for the air supply and exhaust of racks, an additional device called a diffuser is necessary in order for

communication equipment having various air supply and exhaust positions to be mounted on the racks. We are conducting a study on diffusers that enable equipment already installed in racks to be easily worked upon.

Moreover, as for aisle capping, there are some challenging issues such as installation cost and ICT equipment maintenance after installation. We are addressing these issues by utilizing some knowledge of thermal fluid dynamics to develop airflow control technology that attains the same degree of effectiveness but is easier to install. An example of air flow control plates (head fins) to be attached to the top surface of a rack is shown in **Fig. 7**. The head fins control the path of exhausted air so that it does not go round to the air supply side.

6. Future development

We intend to conduct further R&D of equipment control technologies and airflow control technologies such as a DEMS with the aim of achieving a society that has low CO_2 emissions and big energy savings.

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Kazuhiro Matsuda
Senior Research Engineer, Supervisor, Energy Supply Systems Development Group, First Promotion Project, NTT Energy and Environment Systems Laboratories.
He received the B.E. and M.E. degrees in electronic engineering from Hokkaido University in 1983 and 1985, respectively. Since joining NTT in 1985, he has been involved in the design of high-speed protocol processing LSIs, managed L2/L3 VPNs, and the development of optical networks.

Tetsuya Tominaga
Senior Manager, Energy Optimization Technology Group, Energy System Project, NTT Energy and Environment Systems Laboratories.
He received the B.E. and M.E. degrees in mechanical engineering from Doshisha University, Kyoto, in 1989 and 1991, respectively. Since joining NTT Telecommunication Networks Laboratories in 1991, he has been researching and developing electromagnetic environment systems, telecommunication equipment protection against lightning surges, and security technology related to electromagnetic waves. He also has a lot of experience in standardization related to these research topics; e.g., he is the Rapporteur of ITU-T SG5 Question 15 and a member of IEC SC77C and of CIGRE C4.206.

Masahide Yanagi
Executive Manager, Environment & Energy System Development Division, Research and Development Headquarters, NTT Facilities.
He received the B.E. and M.E. degrees from the Department of Architecture of Tokyo Metropolitan University in 1990 and 1992, respectively. He also received the Dr. degree from Tokyo Metropolitan University in 2002 for a study of an optimal design methodology for cogeneration systems taking account of operations planning. Since joining NTT Building Department in 1992, he has been engaged in R&D of building energy systems and air-conditioning systems for ICT equipment mainly in the Research and Development Headquarters.

Power Feeding Interfaces between Household Direct Current Power Feeding System and Household Telecommunication Equipment

Jun Kato and Hidetoshi Takada†

Abstract

NTT Energy and Environment Systems Laboratories has been designing power feeding interfaces to establish direct current (DC) power feeding technology for homes in cooperation with the Green Grid Platform at Home Alliance (GGP@H). A lot of information and communications technology equipment as well as household electrical equipment operates by internally converting mains-supplied alternating current (AC) to DC, so feeding DC to houses from outside should bring various benefits.

1. Introduction

A major issue in discussions about global warming and energy savings has been how to use energy efficiently. The change in Japan's national greenhouse gas emissions over time is shown in **Fig. 1** [1]. Because global warming countermeasures as well as energy saving measures and policies have been addressed in various sectors, efforts to reduce the environmental load have been achieving positive results; for example, the CO_2 emissions in 2009 were less than or equal to those in 1990 for some sectors such as industries and transport. However, the environmental loads in the residential and commercial (commerce, services, offices, etc.) sectors showed an increase of nearly 30% compared with 1990. This might be due to an increase in power consumption in each household resulting from the onset of the information society and acceleration of the aging society [2]. Moreover, highly efficient use of energy has become a major issue in terms of saving power since the Great East Japan Earthquake of March 2011.

† NTT Energy and Environment Systems Laboratories
Musashino-shi, 180-8585 Japan

2. Direct current power feeding technology with high efficiency

In ordinary homes, where the environmental load is increasing, many recent appliances have built-in control systems such as microprocessors for control and communications. Most control systems operate on direct current (DC), whereas the mains electricity supplied from power companies is alternating current (AC), so each DC-powered device converts AC to DC using an internal converter or an AC adapter.

Moreover, electrical equipment used for information and communications technology (ICT) services in telecommunication buildings and datacenters is, in most cases, operated in combination with batteries for backup and uninterruptible power supplies to ensure a stable power supply. Thus, the power that have been converted once from AC to DC in order to charge batteries is converted back to AC to feed power to electrical appliances where the AC is again converted back to DC [3].

Therefore, energy efficiency should be higher for electrical equipment whose internal devices operate on DC if the supplied power is initially converted from AC to DC in the power feeding system and electrical appliances are then fed with DC power.

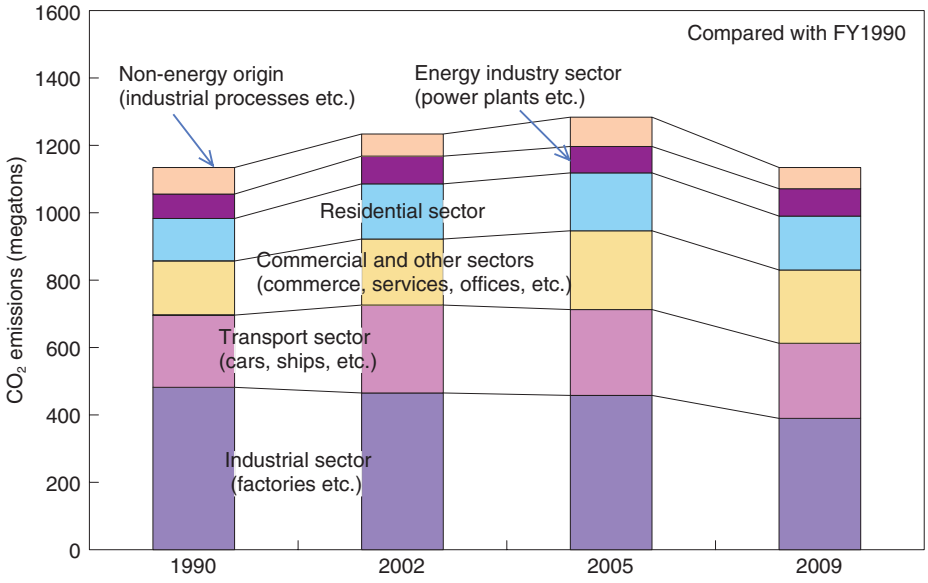

Fig. 1. Change in Japan's national greenhouse gas emissions.

Therefore, interest in DC power feeding systems has been growing.

3. Advantages of DC power feeding systems in homes

About 60% of CO_2 emissions in the residential sector comes from power consumption, which is thus a major component of the environmental load. Since households today tend to have many electrical appliances that convert AC to DC within the appliance, we expect DC power feeding to have a significant effect on reducing the environmental load and saving energy. In addition, generators such as solar panels and fuel cells, which have become more widely used recently in homes, output DC power, so they can be easily connected to a DC power feeding system [4]. Furthermore, in combination with storage batteries, they could act as emergency backup supplies available after a disaster. The many advantages of feeding DC power to homes are summarized in **Fig. 2**.

4. Importance of unified standards for DC power feeding interfaces

Smart houses compatible with DC power feeding have been introduced on the market recently [5]. To promote DC power feeding widely in homes, many power feeding characteristics (voltage, safety, connectors, electrical noise, etc.) for all or many of the electrical appliances need to be compatible with DC power feeding systems. At present, however, a lot of ICT equipment and many household appliances are incompatible with DC power feeding systems. Two major reasons are that some technical issues still remain in the DC power feeding systems and that the price of compatible appliances is still high, but another contributing factor is thought to be the lack of unification of DC power feeding interfaces. A unified standard for DC power feeding is essential to ensure user-friendliness. We think that opportunities for discussion are necessary in order to work on standardization such as the conditions for power feeding interfaces.

5. Activities toward standardization and popularization

The Green Grid Platform at Home Alliance (GGP@H, hereinafter the alliance) [6] is an organization that NTT Energy and Environment Systems Laboratories has been actively involved in since taking on the role of its secretariat. The alliance was established in November 2009 and has 48 members (as of October 2011). The members are listed in **Fig. 3**.

In the alliance, there are two working groups (WGs) for detailed discussions, and many companies joining the discussions come from a variety of business

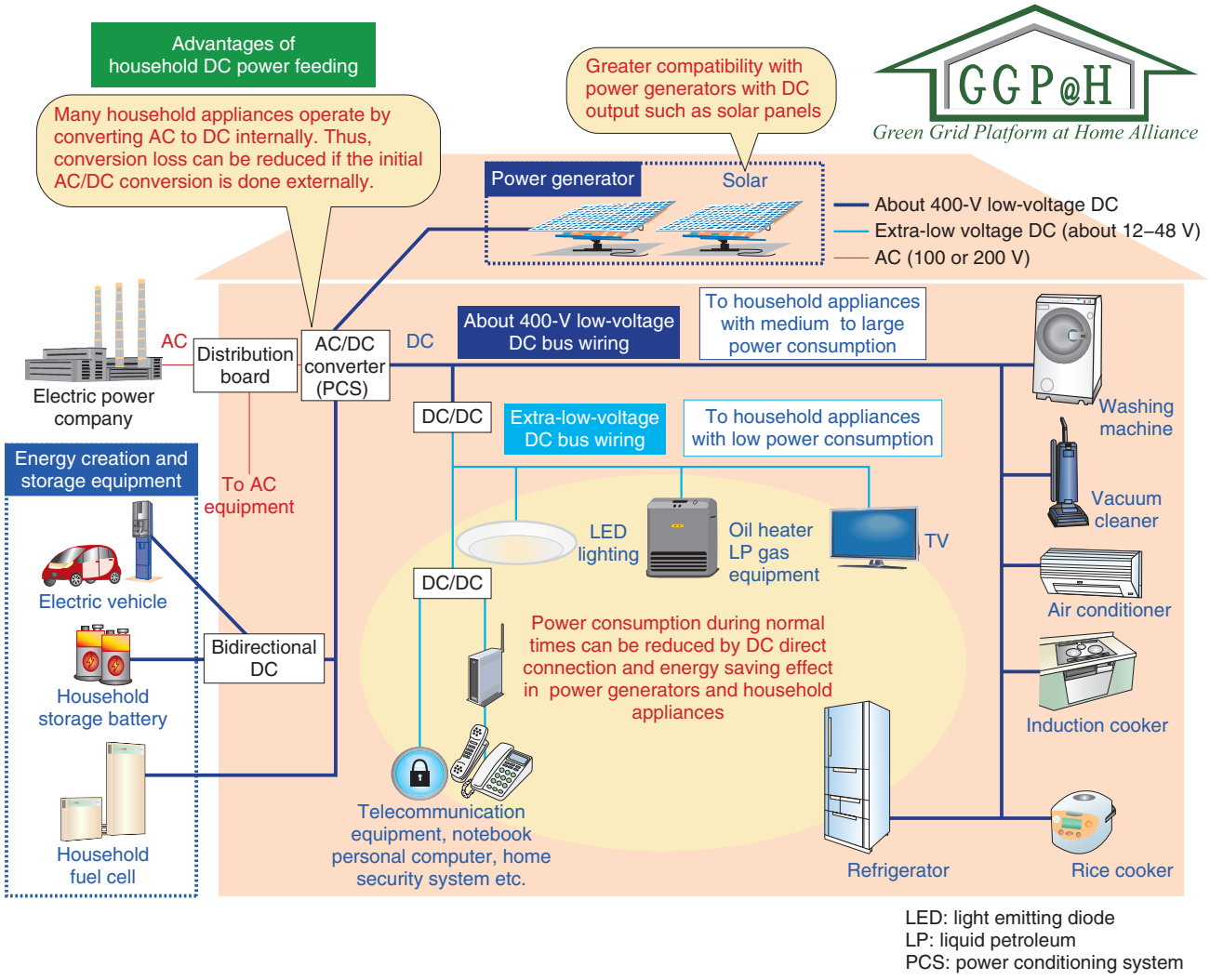

Fig. 2. Advantages of household DC power feeding.

categories such as ICT devices, security, household equipment, and appliances.

These two WGs discuss technical requirements and issues for power feeding in their areas of responsibility and coordinate with each other. WG1 is responsible for equipment with relatively low power consumption and low voltages such as ICT devices, security devices, and lighting equipment and WG2 is responsible for appliances with high power consumption and high voltages as well as power generators and power storage equipment such as solar panels, fuel cells, and power storage devices.

Since low-power telecommunication equipment, such as modems and routers, is commonly used in NTT's telecommunication services for homes, we are paying more attention to such equipment to make it compatible with DC power feeding first; thus, we have been focusing on WG1.

6. Discussions toward standards for various appliances

The power consumption of appliances found in homes ranges from a few watts to several kilowatts. If we were to apply a single power feeding interface to appliances with such widely differing power consumptions, the number of convertible appliances might end up being small. Thus, appliances need to be classified.

The alliance has defined three power feeding

☆Japan Advanced Institute of Science and Technology (Prof. Yasuo Tan)
• I-O DATA DEVICE, INC.
• AICHI INSTITUTE OF TECHNOLOGY
• ALPS ELECTRIC CO., LTD.
• Ishikawa Optics and Design Institute Ltd.
• IWATSU ELECTRIC CO., LTD.
• SMK CORPORATION
• NEC Magnus Communications, Ltd.
• Osaka Gas Co., Ltd.
• Osaki Electric Co., Ltd.
• Oki Electric Industry Co., Ltd.
• Otowa Electric Co., Ltd.
• Origin Electric Co., Ltd.
• Kawamura Electric Inc.
• Kandenko Co. Ltd.
• Sharp Corporation
• Shindengen Electric Manufacturing Co., Ltd.
• Sumitomo Electric Industries, Ltd.
• JX Nippon Oil & Energy Corporation
• SOHGO SECURITY SERVICES CO., LTD.
• Daiko Advertising Inc.
• TDK Corporation
• TDK-Lambda Corporation
• The Telecommunications Carriers Association
• DENSO CORPORATION
• The University of Tokyo
• Toshiba Corporation
• TOMITA ELECTRIC MFG. CO., LTD.
• Nihon University
• NEC Corporation
• HASEGAWA ELECTRIC CO., LTD.
• Haseko Corporation
• BUFFALO INC.
• FUJITSU TELECOM NETWORKS LIMITED
• Panasonic Electric Works Co., Ltd.
• Hitachi, Ltd.
• France Telecom
• Mitsubishi Electric Corporation
• Ricoh Company, Ltd.
• Ruby Investment Research Co., Ltd.
• Renesas Electronics Corporation
• Yazaki Corporation
• NTT Advanced Technology Corporation
• NTT FACILITIES, INC.
• NTT FACILITIES RESEARCH INSTITUTE Inc.
• NTT EAST CORPORATION
• NTT WEST CORPORATION
★NIPPON TELEGRAPH AND TELEPHONE CORPORATION (NTT)

☆: Chairperson
★: Secretariat

Fig. 3. Organizations participating in the Green Grid Platform at Home Alliance.

interfaces (IFs) according to power consumption and device characteristics; namely, IF1 (ICT equipment and security equipment), IF2 (lighting equipment, TVs, etc.), and IF3 (appliances with medium to large power consumption, power generators, and power storage equipment). WG1 is discussing the technical requirements for IF1 and IF2, while WG2 is discussing those for IF2 and IF3. The classification of DC power feeding interfaces by appliances is shown in **Fig. 4**.

It should be noted that not only power consumption but also other requirements need to be considered for the power feeding interfaces. It is necessary to take account of the fact that some appliances with the same power consumption still differ in the electrical characteristics of their internal components. The requirements for power supply equipment (AC adapter and power supply unit etc.) may differ to match the characteristics of each appliance; for example, many personal computers are switched on only when they need to be used, whereas ICT equipment such as modems and routers usually operates in an always-on manner.

Furthermore, there are many cases of AC power being converted to DC at about 300 V for use inside electrical equipment such as air conditioners. When voltage exceeding 300 V is supplied, stricter restrictions are imposed on electrical facilities by law. The alliance has purposely discussed IF3 as the standard corresponding to equipment with voltage exceeding 300 V in order to clarify the problems, and it is aiming to consider any required legal amendments in the future.

Moreover, DC power feeding will not be widely used until both efficiency and safety have been ensured. Thus, we are currently discussing a mechanism for protection coordination that is considered to be necessary to minimize the impact of trouble and to prevent interference with other equipment and the distribution system in the event of failures.

7. Study on power feeding interfaces for ICT equipment

WG1 is working on IF1 and developing the requirements for the power feeding interfaces, in particular, for household ICT equipment such as home gateways (HGWs) and optical network units (ONUs). The maximum power consumption of household ICT equipment is roughly 30 W, and equipment of such a class operates in conjunction with AC adapters that output DC at a voltage ranging from 12 V to 24 V. Considering other factors such as efficiency, many WG1 members are currently discussing whether power at a DC voltage of 24 V or less is adequate, and WG1 is close to reaching agreement to include this as a requirement for the IF1 power feeding interfaces. There are some other suggestions for additional power feeding interface requirements besides voltages: some people think that it is necessary to study technical items such as electromagnetic compatibility (EMC) corresponding to the characteristics of each appliance as well as the required conditions for the protection coordination of appliances and AC adapters.

Furthermore, it is considered to be unrealistic to

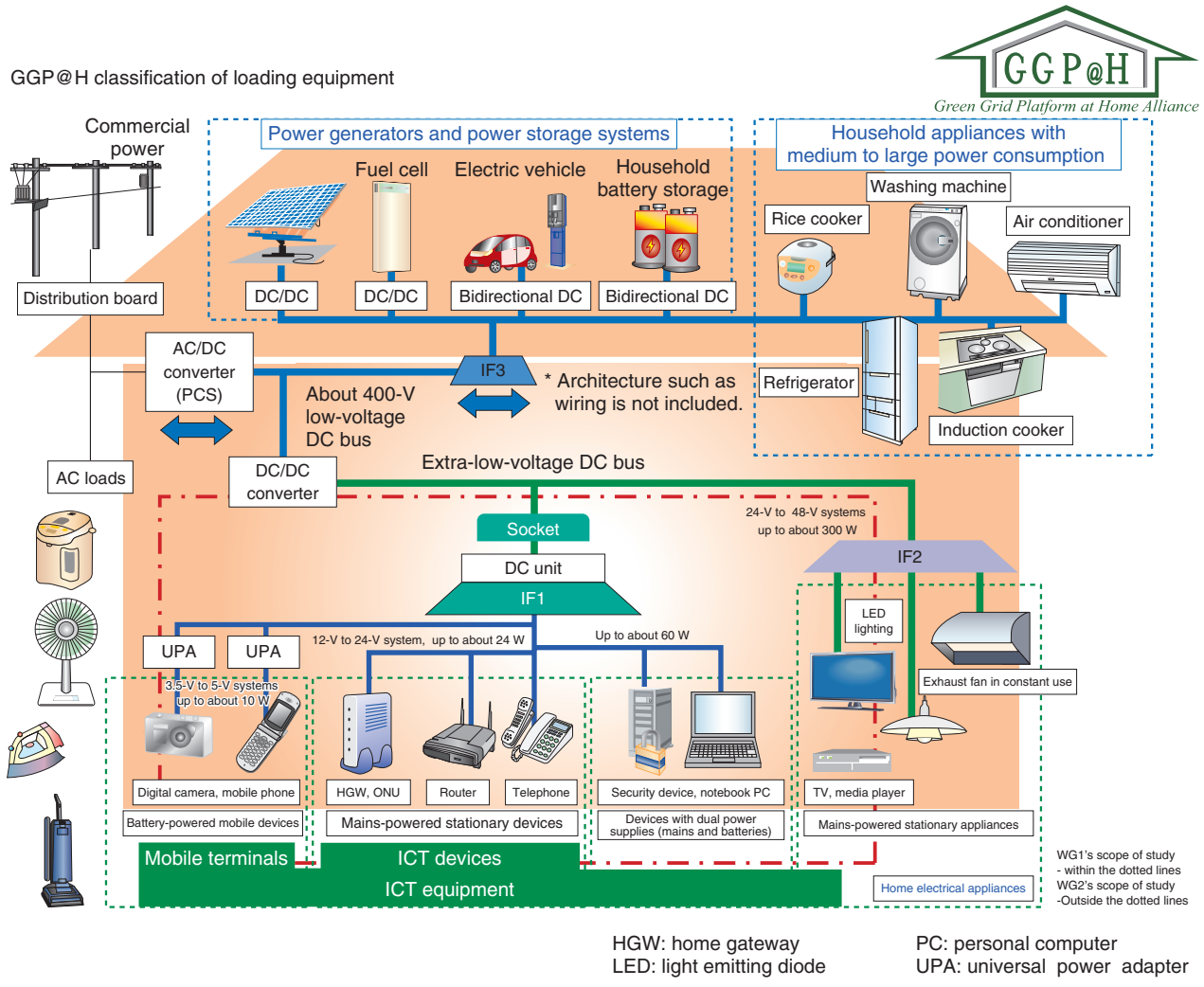

Fig. 4. Classification of DC power feeding interfaces by appliances.

change the power feeding system from AC to DC while most households use AC power supplies at present. Thus, as an intermediate phase between AC and DC power feeding, we have been investigating power feeding interfaces (AC adapters) that convert currents from AC to DC, and we have been studying their requirements.

When the requirements of AC-to-DC conversion power feeding interfaces are determined in the future, the DC power feeding interfaces for appliances will be determined. Therefore, we expect that it will be possible to implement DC power feeding directly in appliances by just removing the AC adapters once the power feeding system to homes is changed from AC to DC.

WG1 is currently working on the power feeding interfaces for adapters that can be used in common among the home ICT equipment that has relatively low power consumption.

8. Widely promoting the advantages of household DC power feeding as a disaster countermeasure

People's interest in a stable supply of electricity as well as energy conservation and power saving has increased greatly since the Great East Japan Earthquake. The alliance has been vividly aware of disaster countermeasure aspects since its establishment. As mentioned above, if DC power feeding to homes is put into practice, it will enable power to be fed from solar panel systems and electric vehicles to household

appliances if the commercial power supply is cut off by events such as disasters. IF2 and IF3 are being discussed in WG2 to achieve this function.

Moreover, the alliance has always clearly recognized since its establishment that fiber to the home (FTTH), which has become widely used in recent years, cannot supply electric power through its communication wires, so optical-based telecommunication equipment will fail to operate when the commercial power supply is lost. For this reason, the initial aims of the alliance included the idea of the DC power feeding system for houses providing an emergency power supply function for telecommunication equipment.

Having seen a rise in social awareness of disaster countermeasures, the alliance intends to disseminate information more actively in order to gain a wider understanding of these advantages. The GGP@H website [6] explains these ideas in an easy-to-follow manner for the public.

9. Future prospects for the alliance

The standardization being undertaken by the alliance is also progressing globally. We have proposed the requirements for IF1 to ITU-T (International Telecommunication Union, Telecommunication Standardization Sector) and have been advancing our activities toward standardization with the goal of contributing to energy savings in supplying power to household communication equipment and to resource savings by reducing the use of AC adapters. The international community has already standardized battery chargers for mobile phones from a waste reduction viewpoint and the alliance's efforts have been attracting more attention. Our proposal includes ideas related to waste reduction, so it has been favorably received and discussed.

IF2 and IF3, by contrast, still face many difficulties such as legal restrictions and protection coordination since their standardization must deal with voltages over 300 V, so they are both still being discussed. We intend to prepare power feeding requirements that are applicable in practice and aim at eventually proposing them as international standards in the same way as for IF1.

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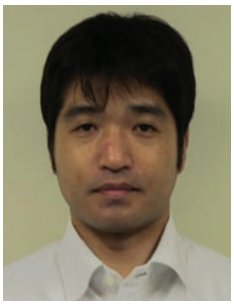
Jun Kato

Senior Research Engineer, Energy System Project, NTT Energy and Environment Systems Laboratories.

He received the B.E. degree in electrical engineering from Shizuoka University in 1992. He joined NTT Telecommunication Networks Laboratories in 1992. He is currently engaged in R&D of AC adapters for telecommunication equipment in homes. He received the 51st Shibusawa Award from the Japan Environment Association in 2006.



Hidetoshi Takada

Senior Research Engineer, Energy System Project, NTT Energy and Environment Systems Laboratories.

He received the M.E. degree in electrical engineering from Iwate University in 1996. He joined NTT Facilities, Inc. in 1996 and studied combined heat and power systems, emergency power generation systems, and power receiving and distribution systems. He moved to NTT Energy and Environment Systems Laboratories in 2010 and engaged in R&D of AC adapters for telecommunication equipment in homes.

Efforts Toward International Standardization for Green Datacenters

Toshihiro Hayashi† *and Tetsuya Tominaga*

Abstract

In this article, we describe international standardization activities for datacenter energy management systems, especially those of ITU-T (International Telecommunication Union, Telecommunication Standardization Sector). International standardization activities have a significant impact on research and development results for smart energy management at datacenters and telecommunication buildings being put into practical use and used widely in the future.

1. Introduction

Demand for datacenters has been increasing each year with the expansion of housing services and hosting services as well as the advent of cloud computing. In datacenters, the amount of information and communications technology (ICT) equipment has increased and the rack density has become higher with the result that power consumption has continued to grow. This trend is observed not only in Japan but also worldwide. Therefore, it is fair to say that energy-saving and greening efforts at datacenters are urgent issues for achieving a sustainable low-carbon society.

Under these circumstances, NTT is researching and developing smart energy management at datacenters and telecommunication buildings, i.e., a datacenter energy management system (DEMS). It is intended to save energy in datacenters and telecommunication buildings by using air conditioning control and power supply control in collaboration with ICT equipment allocation control. More details are given in the Feature Article "Energy Management of Telecommunication Buildings and Datacenters" [1].

Anticipating a future with DEMS-related technologies being used widely, we have also been putting effort to international standardization activities based on activities at the International Telecommunication Union, Telecommunication Standardization Sector (ITU-T). In this article, we introduce the trend of ITU-T standardization related to datacenters and describe the topics on which we are working for standardization toward the spread of DEMSs.

2. Standardization efforts at ITU-T

As shown in **Fig. 1**, Study Group 5 (SG5) is working on theme of environment and climate change in ITU-T. Working Party 3 (WP3/5) on "ICT and climate change", one of three working parties under SG5, has been studying the environmental impact of ICT use [2]. As of October 2011, WP3/5 consists of 7 questions (Qs) (Q17/5 may merge with Q20/5, but this is still under approval). Several work items are set for Q17/5, as listed in **Table 1** and are being studied for the preparation of recommendations and handbooks.

Among these items, the ones currently being studied are energy efficiency measurement and metrics for telecommunication equipment and telecommunication infrastructure. Telecommunication equipment covers broadband equipment on both the network and user sides, and telecommunication infrastructure mainly refers to datacenters. To implement their energy saving and greening, it is necessary to quantify

† NTT Energy and Environment Systems Laboratories
Musashino-shi, 180-8585 Japan

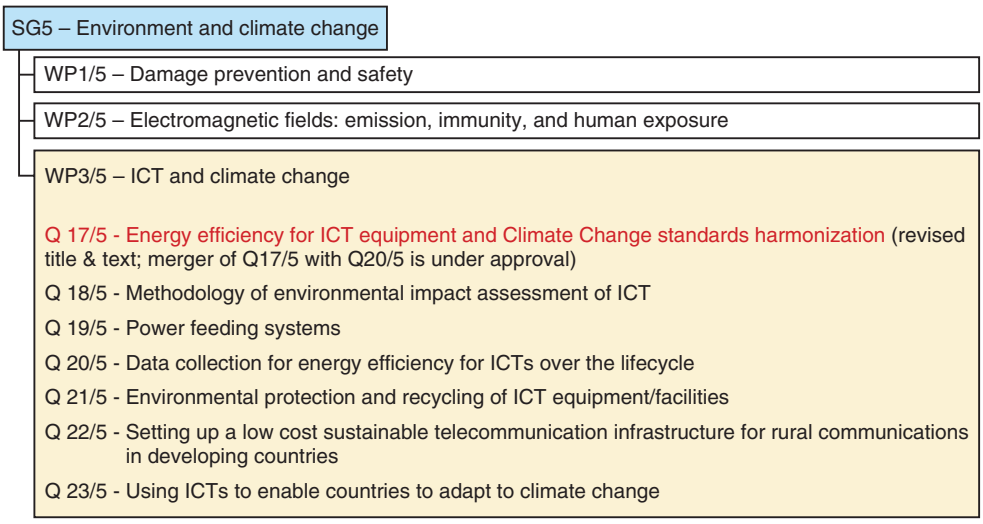


Fig. 1. Structure of ITU-T Study Group 5 (as of December 2011).

Table 1. List of work items under Q 17/5 (as of December 2011).

Work item	Subject/title
L.DC (approved as L.1300)	Data centre development best practices
L.M & M	Energy efficiency measurement and metrics for telecommunication equipment
L.M & Minfra	Energy efficiency measurement and metrics for telecommunication infrastructure
L.ref	Energy efficiency reference values for telecommunication equipment and infrastructure
L.M & Mnetwork	Energy efficiency measurement and metrics for telecommunication network
Handbook on network best practices	Infrastructure solutions available to reduce the impact of networks e.g., power converter solutions, alternative energy solutions (solar, wind ...), and low-impact-cooling solutions.
Handbook on equipment best practices	Energy efficiency solutions for telecommunication equipment
Handbook on architecture best practices	Energy efficiency solutions realized with different network architecture
Handbook on climate change	Overview of ICT- & CC-related Recommendations (CC: climate change)
Handbook on data collection	Collection of energy efficiency data
Handbook on ICT impact reduction techniques	Provides an overview of key mitigation technologies such as teleconferencing, teleworking, e-learning, appliance control for energy efficiency in buildings and their impact on greenhouse gas emissions

the environmental load of equipment and infrastructure in order to develop a plan for environmental load reduction. Therefore, establishing common metrics for energy efficiency and their measuring methods is considered to be essential. Recommendations for metrics and their measuring methods will be prepared first and then target values for the recommended metrics will be discussed.

In parallel with the abovementioned activity, best practices for green datacenters are being documented (L.DC; numbered as L.1300). L.DC is based on the "EU Code of Conduct for Data Centres [3]" published by the Joint Research Centre of the European Commission and has been prepared for the purpose of identifying and introducing measures for improving datacenter energy efficiency. Practices that contribute to reductions in datacenter power consumption are collected and categorized such as utilization, management, and planning of datacenters; ICT equipment and services; cooling; power supply equipment; buildings; and monitoring. L.DC was approved as L.1300 in December 2011.

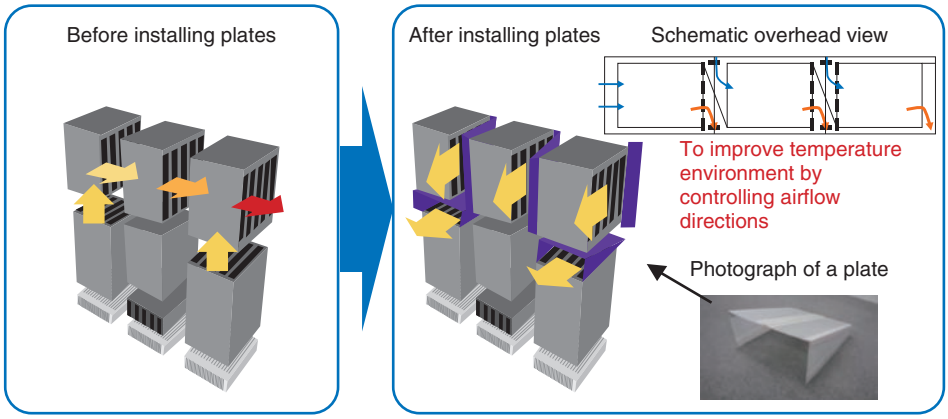


Fig. 2. Airflow direction control for rack-mounted equipment by using plates (ducts).

3. Standardization topics

NTT has been involved in standardization activities on three topics in ITU-T SG5 WP3/5 for spreading DEMS-related technologies: (1) plates and ducts for correcting airflow directions for rack-mounted equipment, (2) a minimum set of internal information for datacenter equipment, and (3) a datacenter evaluation method. These are described in more detail in sections 3.1–3.3.

3.1 Plates and ducts for correcting airflow directions for rack-mounted equipment

In order to gain the full energy-saving effect that a DEMS should provide by its integrated control of ICT equipment and air conditioners, the airflows within a datacenter should be designed to prevent the cold air supplied by air conditioners mixing with hot air exhausted from ICT equipment, and a datacenter environment based on such an airflow design should be created. One common datacenter environment has *cold aisles* and *hot aisles*. Since most servers have an air supply opening at the front and an exhaust opening at the rear, racks are placed with their front sides facing each other and cold air is supplied to form a cold aisle and with their rear sides facing each other to form hot aisles.

However, some network equipment has air supply and exhaust openings in different positions such as air supply at the bottom and exhaust on the top, or both air supply and exhaust at the sides. If ICT equipment with different airflow directions is mounted thoughtlessly on the racks, local hot spots are created because it takes in hot air exhausted from the adjacent equipment, leading to an increase in cooling load and operating power of the air conditioners.

To improve the efficiency of datacenter air conditioning, we have been researching airflow control using plates and ducts, as illustrated in **Fig. 2**, so that each kind of ICT equipment can take and exhaust air efficiently. We submitted this result as a best practice for L.DC, and we proposed specification requirements that plates and ducts should be equipped as standard with rack-mounted equipment that needs airflow direction control. Our proposal was included in the approved L.1300.

3.2 Minimum set of internal information for datacenter equipment

One of the most important aspects of the DEMS is monitoring of the status of facilities and equipment within a datacenter. The DEMS cooperatively controls various kinds of datacenter equipment on the basis of the monitoring information, which enables the load balance of multiple air conditioners to be adjusted and thus improves their energy efficiencies.

However, efforts to promote a multivendor environment with equipment of various kinds have resulted in the internal information that can be acquired from such equipment not being standardized, which leaves difficulties for integrated control at present. The internal information such as power consumption and temperature of ICT equipment is defined by the private management information base (MIB) of each vendor, but no unified format is available. Moreover, some items may not be measured for certain equipment. Therefore, we proposed studying the minimum required internal information data set, i.e., the

Table 2. Organizations and data sets under study.

Studying organization and related documents	Area of study
Ecma international “Smart Data Centre Resource Monitoring and Control”	Data set for monitoring and control of servers and air conditioners
ETSI “ES 202 336: Monitoring and Control Interface for Infrastructure Equipment (Power, Cooling and Building Environment Systems used in Telecommunication Networks)”	Data set and protocol for monitoring and control of servers and air conditioners based on the Simple Network Management Protocol (SNMP)
IETF Eman “Energy Management Requirements” “Battery MIB” “Energy Management Framework” “Energy-aware Networks and Devices MIB” “Power and Energy Monitoring MIB” “Energy Management Applicability”	Battery monitoring MIB using SNMP
ITU-T SG5	Data set (minimum set) of internal information which is necessary for monitoring and cooperative control of equipment for energy saving. Equipment will include that covered in the activities of abovementioned organizations.

minimum set for monitoring and integrated control associated with energy saving for datacenter equipment. It is intended to unify the list of items so that necessary internal information for monitoring and control can be acquired without any dependence on vendors. This proposal was agreed to be included in the approved L.1300.

Other related organizations and their ongoing activities are listed in **Table 2**: European Telecommunications Standards Institute (ETSI) is studying a data set related to the monitoring and control of air conditioning and power supply [4], Ecma International is studying a data set for integrated management and operation of smart datacenters [5], and Internet Engineering Task Force Energy Management is studying an MIB for energy management of equipment within or connected to a telecommunication network [6]. We are promoting the preparation of recommendations in cooperation with these organizations.

3.3 Datacenter evaluation method

Power usage effectiveness (PUE) and datacenter infrastructure efficiency (DCiE) are commonly used as metrics representing a datacenter’s energy saving capability [7]. PUE is obtained by dividing the total power consumption of ICT and facility equipment in a datacenter by the ICT equipment’s power consumption. A datacenter is said to be most efficient if its total power consumption equals that of its ICT equipment, which gives PUE = 1.0. DciE, on the other hand, is the inverse of PUE and is shown as a percentage. Both metrics are recommended by The Green Grid, an industry organization for promoting energy saving at datacenters.

While PUE and DCiE are useful in evaluating the energy efficiency of facility equipment, they are not fully sufficient on their own in evaluating the overall energy saving capability of a datacenter because there could be a case, for example, in which the evaluated value may improve just because there has been an increase in the power consumption of ICT equipment. We need to seek not only better PUE and DCiE values, but also further reductions in the overall power consumption as well.

Moreover, even if ICT equipment tasks are allocated suitably by the DEMS and the power consumption per service becomes smaller through the energy-saving operation of ICT equipment, the PUE and DCiE values could become worse without significant reduction in the power consumption of air conditioners. In order to evaluate the effect of the DEMS quantitatively, we need to take account of the productivity generated by the datacenter.

Furthermore, datacenters have redundant structures as well as backup & restore functions to ensure system reliability corresponding to service-level demand, as shown in **Fig. 3**, but such differentiating factors are not reflected in PUE and DCiE. Although system reliability improves as the equipment structure is made redundant, the energy efficiency could decrease owing to a decrease in the operating rate of redundant

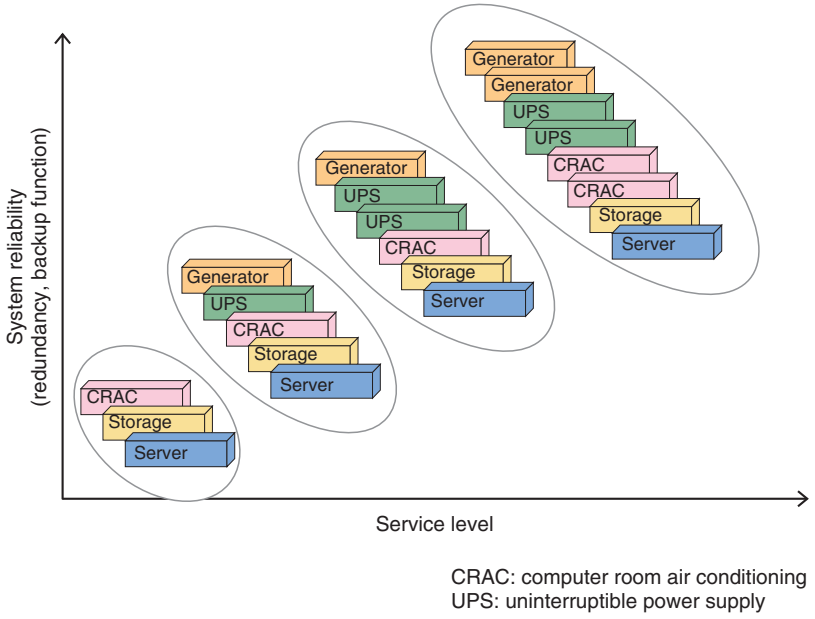


Fig. 3. Service level and redundancy in equipment configurations at datacenters.

equipment.

For these reasons, we proposed a datacenter evaluation method that has an appropriate balance by considering additional parameters representing productivity (capabilities of servers, network equipment, and storage, etc.) and reliability (availability, redundancy of equipment configuration, etc.)

Datacenter productivity metrics are also being studied by The Green Grid, and one issue under discussion is how to define the useful output generated by a datacenter. We will continue to work on recommendations while ensuring consistency with the efforts of The Green Grid.

4. Future development

Monitoring and cooperative control of a datacenter by a DEMS require the control of airflow directions, unification of data sets, and establishment of an evaluation method. We intend to promote international standardization activities based on the activities at ITU-T while working collaboratively with related organizations such as ETSI, Ecma International, IETF Eman, and The Green Grid.

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Toshihiro Hayashi
Energy Optimization Technology Group, Energy System Project, NTT Energy and Environment Systems Laboratories.

He received the B.E. and M.E. degrees in geosystem engineering from the University of Tokyo in 2004 and 2006, respectively. He joined NTT Energy and Environment Systems Laboratories in 2006. His research interests are energy control technologies, optimization techniques, and environmental impact assessment of ICT services.

Tetsuya Tominaga
Senior Manager, Energy Optimization Technology Group, Energy System Project, NTT Energy and Environment Systems Laboratories.

He received the B.E. and M.E. degrees in mechanical engineering from Doshisha University, Kyoto, in 1989 and 1991, respectively. Since joining NTT Telecommunication Networks Laboratories in 1991, he has been researching and developing electromagnetic environment systems, telecommunication equipment protection against lightning surges, and security technology related to electromagnetic waves. He also has a lot of experience in standardization related to these research topics; e.g., he is the Rapporteur of ITU-T SG5 Question 15 and a member of IEC SC77C and of CIGRE C4.206.

Toward Understanding Mechanisms of Sensorimotor Processing in Speech Production

Takemi Mochida† *and Hiroaki Gomi*

Abstract

We report on the online mechanisms of sensory feedback-based speech motor control. The neural processing mechanisms governing human speech production skills need to be understood in order to design a user-friendly and easy-to-use remote speech communication system. We elucidated the contributions of somatosensory and auditory feedback through experimental observation of involuntary responses induced by perturbed sensory feedback information during speech production tasks. The experimental results provide evidence that both the somatosensory feedback and auditory feedback associated with self speech production strongly affect the temporal dynamics of articulatory movements.

1. Introduction

In humans, speech production is a highly skilled aspect of muscular control and is gradually developed as a child matures. During the development, several different sorts of sensory feedback information play important roles in monitoring how well the action is being organized while various types of phonemes are produced. The sources for monitoring articulatory movements consist of cutaneous/somatosensory information related to the status of respiratory, laryngeal, velopharyngeal, and articulatory subsystems and auditory information representing the characteristics of the associated acoustic output.

1.1 Cutaneous/somatosensory feedback in speech production

The role of cutaneous and/or somatosensory feedback for speech motor control has been investigated in a series of studies [1]–[3] on compensatory articulatory movements of the upper lip induced by a perturbation of the jaw or lower lip during the production of the bilabial explosive consonants (/p/ and /b/). The compensatory movements act effectively to achieve the intended acoustic sounds against unpredictable perturbation. One might speculate that an active compensatory mechanism recruited by somatosensory feedback contributes to the generation of these compensatory movements because the corresponding electromyographic (EMG) activity of the primary upper-lip muscle (orbicularis oris superior (OOS)) increased. However, the time delay due to nerve conduction and mechanochemical dynamics might present a problem for explanations of the rapid regulation of fast speech movements by sensorimotor coordination.

We have found that during the production of bilabial fricative consonant /Φ/, which requires precise control of the aperture between the upper and lower lips, the upper lip shifts downward rapidly in response to a sudden jaw-lowering perturbation to maintain the intact labial aperture [4]. Although the initial phase of the upper lip shift is generated by the mechanical linkage of perioral dynamics [4], the later phase will be partly regulated by the reactive muscle response. Actually, the upper lip muscle activity started to increase 48.25±1.2 ms after the jaw perturbation. This latency is longer than that in a perioral reflex (14–17 ms [5]) that is mediated within the brainstem

† NTT Communication Science Laboratories
Atsugi-shi, 243-0198 Japan

alone and shorter than the jaw's voluntary reaction time after a stimulus is perceived (150±13 ms [6]). Considering these findings, it can be postulated that cortical processing is involved in this reflexive compensatory adjustment of speech articulation, as examined in the long latency stretch reflex [7]. We assessed the effect of transcranial magnetic stimulation (TMS) over the motor cortex on the reflexive compensatory adjustments of speech articulation [8]. Note that, in some cases, TMS can transiently disrupt or suspend cortical neural processing [9], [10], but in other cases it can enhance cortical neural excitability [7]. Our experimental results are presented in 2.1.

1.2 Auditory feedback in speech production

With regard to the role of auditory feedback for speech motor control, it is well known that speaking with exposure to a delayed auditory feedback (DAF) leads to various types of speech disfluencies, e.g., increased articulatory error, lengthened duration, augmented volume, and increased fundamental frequency [11]–[15]. Such disfluencies may occur as a result of several different types of voluntary and involuntary responses to DAF. The Lombard effect (or Lombard reflex) is well cited as an example of auditory-induced automatic motor response to a change in background noise level, where speakers involuntarily increase their vocal intensity as the noise level increases [16], [17]. Although these sorts of reflexive mechanisms can be considered as potential sources for such DAF-influenced speech disfluencies, the precise mechanisms of how the delayed auditory input of self-produced speech can adversely affect the speech motor control has not been fully elucidated yet.

Various studies using auditory feedback alteration have suggested that acoustic information is critical for learning and maintaining vowel production [18], [19] and voice pitch control [20], [21]. Evidence has also been obtained from humans and non-human primates showing that neural activity in the auditory cortex is modulated by self-produced vocalization [22]–[25]. However, there is an ongoing debate about whether such neural mechanisms also help ensure stability in rapid and complex speech motor control [26], [27]. Auditory feedback may serve as an immediate source for the dynamic control of speech articulation, analogous to the rapid adjustment of labial constriction based on cutaneous and/or somatosensory information. We examined the online control mechanism for articulatory lip movement during the repetition of bilabial plosives /pa/ by suddenly shifting the auditory feedback timing in the ahead-of-time or delayed direction and/or by replacing the feedback syllable by other syllables [28]. Our experimental results are presented in 2.2.

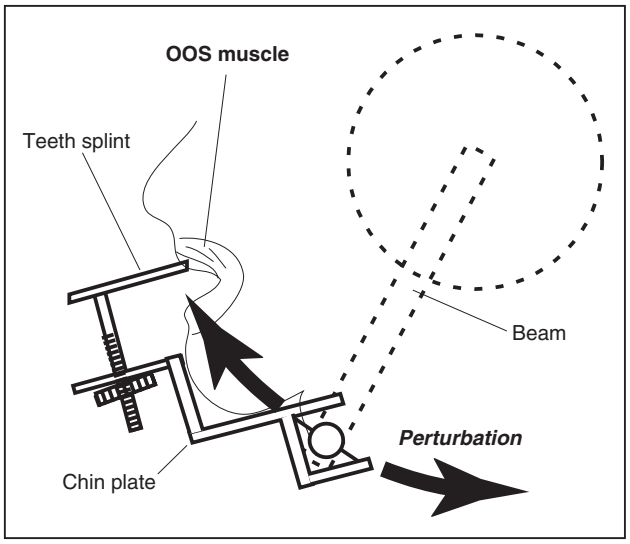

Fig. 1. Configuration of jaw perturbation system.

2. Mechanisms of sensory feedback control: perturbation studies

2.1 Involvement of the motor cortex in reflexive speech motor coordination

We examined the facilitatory effect of TMS on the reflexive compensatory response to jaw perturbation during the production of bilabial fricative consonant /Φ/. The subject's jaw was held in a jaw perturbation system by clamping it between a chin plate and a custom-built splint that was attached to the teeth (**Fig. 1**). Note that this apparatus resulted in little disruption of normal speech and could apply a slight force in the jaw opening/closing direction. To avoid anticipation, a step-wise jaw-opening perturbation (3.0 N) was applied in 20% of the trials. Each session (100 trials) included the following conditions: PT (perturbation with TMS, 10 trials), PN (perturbation alone, 10 trials), and NT (TMS alone, 10 trials), and control (70 trials). There were three subjects denoted A–C. The jaw perturbation elicited a quick downward shift of the upper lip, accompanied by a muscle EMG response (black line in **Fig. 2(a)**) that served to maintain the labial aperture for producing /Φ/. The question here is what neural mechanism generates the EMG response. We compared EMG response

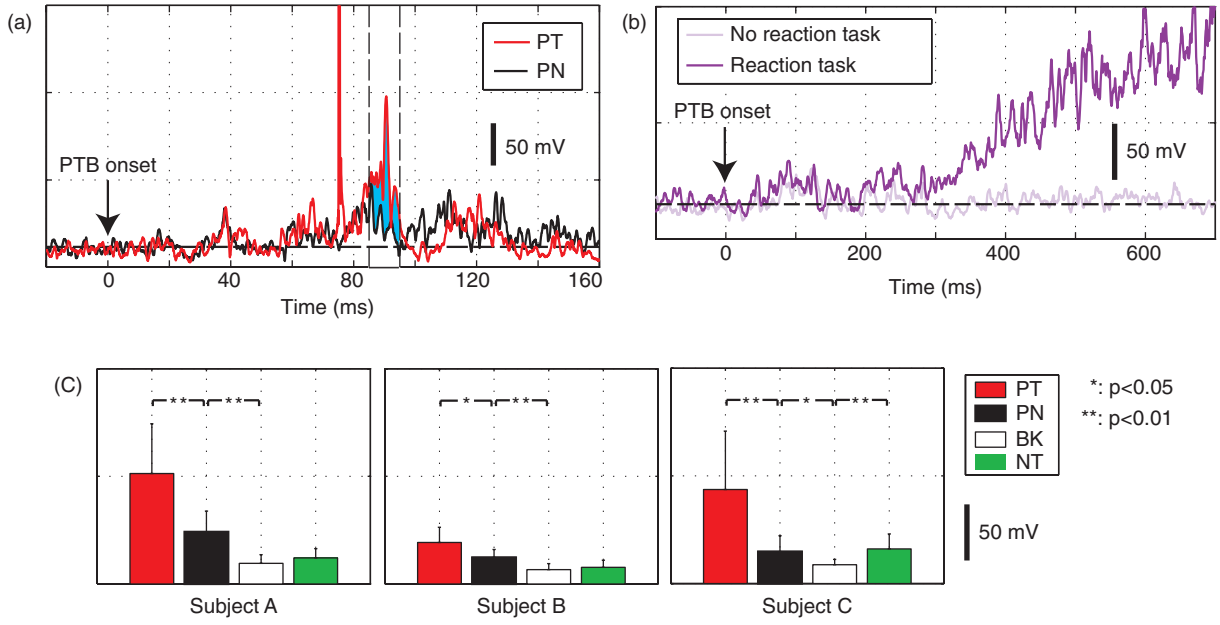

Fig. 2. (a) Typical reflexive compensatory response with or without TMS (EMGs of OOS), (b) EMGs of OOS in reaction or non-reaction task, and (c) comparison of response amplitudes.

latencies caused by the jaw perturbation with those involved in the voluntary reaction. A typical EMG response for the OOS in the reaction task is shown in **Fig. 2(b)**. The voluntary response started at around 300 ms after the perturbation. The mean reaction time for the three subjects (315.7±98.4 SD ms; SD: standard deviation) was obviously longer than the latency of the reflexive compensatory response (48.25±1.2 ms [4]), suggesting that the short-latency (< 100 ms) compensatory response was generated involuntarily.

We applied TMS in order to examine the involvement of the motor cortex in generating the reflexive compensatory response. We expected a TMS over the motor cortex to enhance the EMG activity of the response if the lip region of the motor cortex is involved in the reflexive compensatory response of the upper lip. The typical EMG pattern observed when TMS was applied during jaw perturbation (PT) is depicted by the red line in Fig. 2(a). The first sharp peak 75 ms after perturbation onset was an artifact induced by current spread due to TMS. Compared with the response without TMS (PN), an increase in EMG activity started 10 ms after TMS onset and continued for roughly 10 ms (shaded area). To quantify the amplitude of muscle response, the rectified EMG signal during a 10-ms window (10–20 ms after TMS onset) was temporally averaged and pooled in each condition (PT, PN, and NT). The background muscle activity level (BK) was quantified by temporally averaging the rectified EMG signals for 10–20 ms prior to the perturbation (or stimulus) onset. The response amplitudes in all cases (PT, PN, BK, and NT) are summarized in **Fig. 2(c)**. TMS consistently enhanced the reflexive compensatory response in all subjects, as shown by the difference between the PT and PN cases (statistically significant), whereas there was no significant enhancement of muscle activity in NT compared with BK for subjects A and B. In the NT case for subject C, the muscle activity was slightly enhanced. The enhanced EMG activity in PT, however, was considerably higher than that in NT (difference between (PT minus PN) and (NT minus BK)), suggesting that the facilitatory effect was the primary determinant of the enhanced EMG activity in PT. In summary, these facilitations suggested that the cortical pathway contributes significantly to the production of the reflexive compensatory response.

2.2 Auditory-induced rapid change in articulatory lip movement

We evaluated changes in articulatory lip movement that occurred when a sudden alteration in auditory feedback timing and context was introduced while a subject was speaking the plosive-initial syllable /pa/ repetitively. A schematic diagram of the auditory feedback alteration system is shown in **Fig. 3**. The

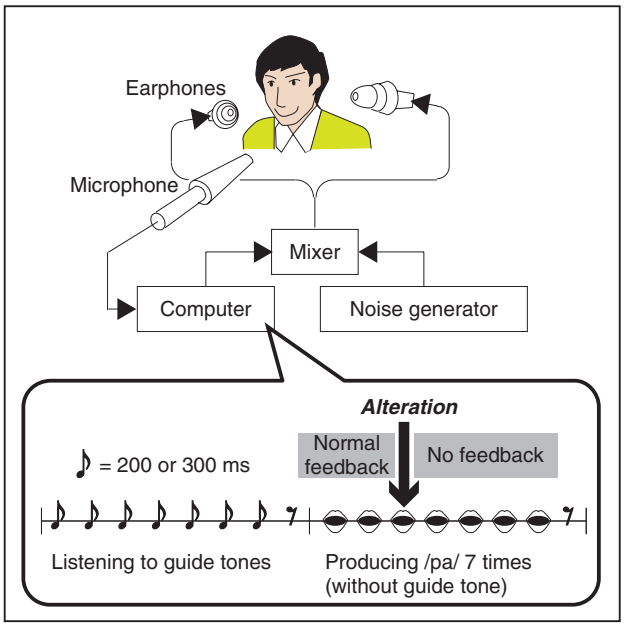

Fig. 3. Configuration of auditory feedback alteration system.

speech sounds produced by the subject were processed by a custom program running on a computer designed to alter the input speech signals. The altered signals were mixed with background noise and fed back to the subject's ears via earphones. Background noise can prevent subjects from hearing their own speech sounds while they are speaking. The subjects were asked to produce an isolated syllable /pa/ seven times while maintaining a constant speech rate. For each trial, the auditory feedback corresponding to the third repetition of /pa/ was altered by shifting the timing and/or replacing the type of syllable, while the subsequent feedback was omitted. Pre-recorded sounds /pa/, /Φa/, and /pi/, spoken by the same subject, were used for the syllable replacement. The timing shift was -150, -100, -50, 0, +50, +100, or +150 ms from the third repetition onset, which was predicted from the interval between the onset of the first and second syllables in each trial. The three-dimensional motion of markers placed on the upper and lower lips was measured with an optical motion capture system, from which the aperture between the upper and lower lips (labial distance (LD)) was obtained. Typical LD trajectory data obtained during the production of /pa/ at a speech rate of 300 ms per syllable is shown in **Fig. 4**. The red curve in each panel shows the mean LD trajectory for five trials over the test blocks. The mean trajectory for ten trials in the control (normal feedback condition) block is shown by a black curve. The LD trajectories in all conditions were temporally aligned at the predicted third syllable onset by referring to the simultaneously recorded acoustic signals. The auditory feedback conditions shown from the top to bottom panels were as follows: pre-recorded /pa/ was presented at -150, -100, -50, 0, 50, 100, and 150 ms from the predicted third syllable onset. The solid vertical line in each panel indicates the onset timing of the auditory stimulus, while the dotted vertical line indicates the predicted third syllable onset. By comparing the two trajectories in each panel, we found that the mouth opening movement subsequent to the auditory stimulus onset quickened by the -50-ms stimulus presentation. While a similar hasty movement was also observed for the -150- and -100-ms conditions, the effect seemed to be weaker. The deviation between the trajectories under each of the delayed feedback (50, 100, 150 ms) and control (0 ms) conditions was much smaller. Similar results were obtained for all ten subjects. The lags (N = 10) corresponding to the maximum cross-correlation between LD trajectories under the altered and control conditions within the post-stimulus period (dark shaded areas in Fig. 4), obtained by subtracting those within the pre-stimulus period (light shaded areas in Fig. 4) are shown in **Fig. 5**. Each pre- and post-stimulus period corresponds to a single cycle of lip closing/opening movement. A negative lag value reflects an ahead-of-time shift of the movement compared with the control. The condition indicated as *normal* refers to a comparison of the normal feedback trials during the test blocks and those in the control block, which reflects the variance in each subject's baseline speech rate throughout the experiment. The statistical significance of the difference from the normal condition ($p<0.05$) was evaluated with a two-sided paired t-test (no. of degrees of freedom = 9 for all comparisons, with the Bonferroni adjustment). An ahead-of-time shift in the movement was found only when the auditory feedback of /pa/ preceded the real syllable production by 50 ms. An excessively early manipulation (-150 and -100 ms) of the auditory feedback did not significantly affect the movement. The delayed feedback (+50, 100, and 150 ms) also produced no significant change. Syllables that were not identical to those of the speech task (/Φa/ and /pi/) had no significant effect even when they were fed back 50 ms prior to the real syllable production. These results indicate that the ahead-of-time and delayed auditory feedback affected the articulatory lip movement in a time-

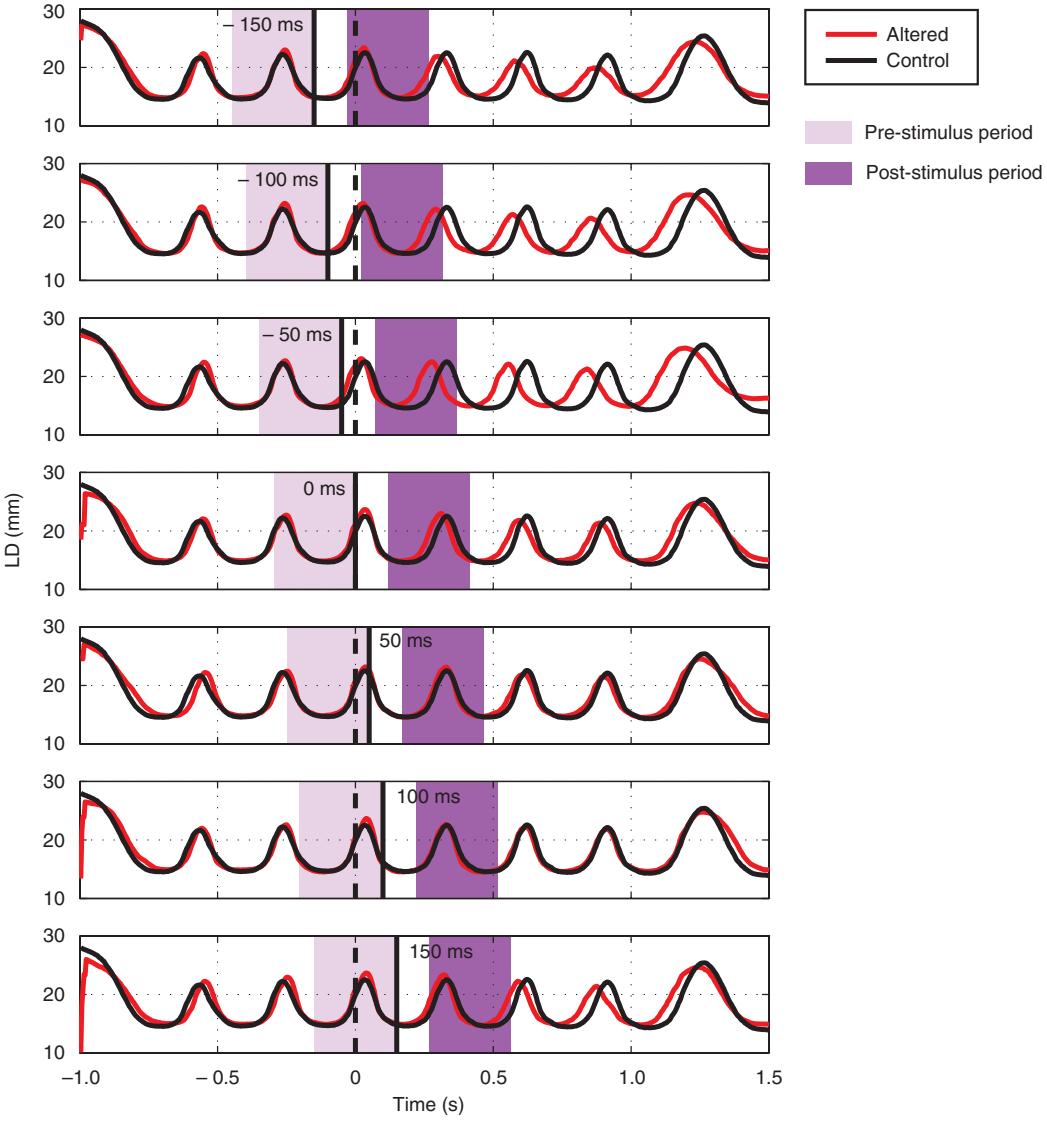

Fig. 4. Typical change in LD trajectories induced by time-shifted auditory feedback.

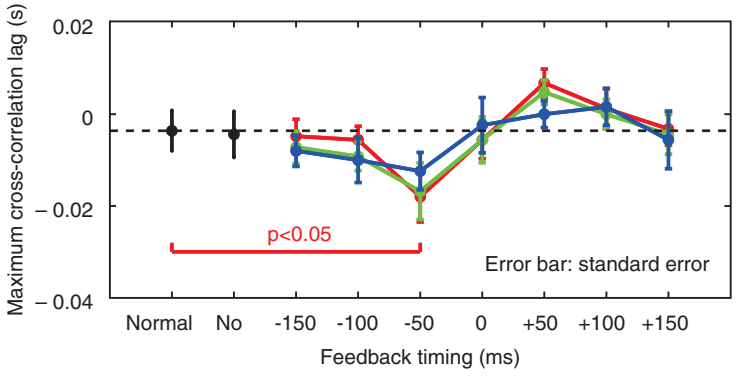

Fig. 5. Comparison of auditory-induced change in LD trajectories.

asymmetric and context-specific manner during repetitive syllable production. These findings suggest the existence of a compensatory mechanism to maintain a constant speech rate by detecting errors between the internally predicted and actually provided auditory information associated with self movement. The timing- and context-dependent effects of feedback alteration suggest that the sensory error detection works in a temporally asymmetric window where acoustic features of the syllable to be produced may be coded.

3. Conclusions

We investigated the contribution of sensory feedback to speech motor control by observing the involuntary response induced by perturbed somatosensory and auditory information. TMS to the cortex was demonstrated to have facilitatory effects on the reflexive compensatory response in lip muscles during labial speech production, and this led us to suggest that its generation involves the primary motor cortex. High-level computation in the cortex would greatly contribute to the organization of complex sensorimotor coordination among articulatory organs in order to achieve robustness in speech tasks. The articulatory lip movement quickened immediately when the auditory feedback preceded the expected timing by 50 ms. Such an articulatory change was not observed when the feedback was presented more than 50 ms earlier or later than the actual timing or when the feedback syllable was replaced by another syllable. These results suggest that errors between the internally predicted and actually provided auditory information detected in a temporally asymmetric window contribute to the compensation for the inter-articulatory timing in the syllable repetition task. Our studies provide evidence that the temporal dynamics of articulatory jaw and lip movements must be correctly maintained with both somatosensory and auditory feedback resulting from self speech production.

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Takemi Mochida
Research Scientist, Human and Information Science Laboratory, NTT Communication Science Laboratories.
He received the B.E. and M.E. degrees from Waseda University, Tokyo, in 1992 and 1994, respectively, and the Ph.D. degree from Future University-Hakodate in 2011. He joined NTT in 1994 and has been engaged in research on speech science. He was involved in JST-CREST projects from 1998 to 2003. His research interests include the sensorimotor mechanisms, articulatory-acoustic properties, and signal processing of speech. He is a member of the Society for Neuroscience, the Acoustical Society of America, the Japan Neuroscience Society, the Acoustical Society of Japan, and the Institute of Electronics, Information and Communication Engineers.

Hiroaki Gomi
Distinguished Senior Research Scientist, Group Leader of Sensory and Motor Research Group, NTT Communication Science Laboratories
He received the B.E., M.E., and Ph.D. degrees in mechanical engineering from Waseda University, Tokyo, in 1986, 1988, and 1994, respectively. He was involved in biological motor control research at ATR (Advanced Telecommunication Research Labs., Kyoto) from 1989 to 1994, in two JST-CREST projects from 1996 to 2003, and in a JST-ERATO project from 2005 to 2010. He was an adjunct professor of the University of Tokyo Institute of Technology from 2000 to 2004. His current research interests include human sensorimotor control mechanisms and interactions between perception and action.

Development of Indoor Single-mode Optical Fiber Cable Using Bending-loss-insensitive Fiber

Naoshi Ogawa, Tomoyoshi Ito†, Yoshitaka Enomoto, and Hisashi Fujimoto

Abstract

In this article, we describe the development of indoor single-mode optical fiber cable using bending-loss-insensitive fiber for use in central offices, which will enable NTT to build a reliable optical network.

1. Introduction

Broadband optical access services have been commercially available throughout Japan for several years. An example of a central office distribution structure is shown in **Fig. 1**. Though optical fiber is suitable for broadband communication, optical signals leak from optical fiber if it is bent excessively because the signal confinement depends on the refractive index of the optical fiber. When a technician connects or disconnects one of the optical fiber cords of an optical fiber cable in a distribution frame where optical cords are congested, the cord could accidentally be bent momentarily, as shown in **Fig. 2**. Since the indoor optical cable between the transponders in a central office multiplexes users' communication signals, any interruption to the communication service will have a great impact on many users. We have made possible highly reliable optical fiber distribution facilities by using single-mode fiber cord with a very low bending loss.

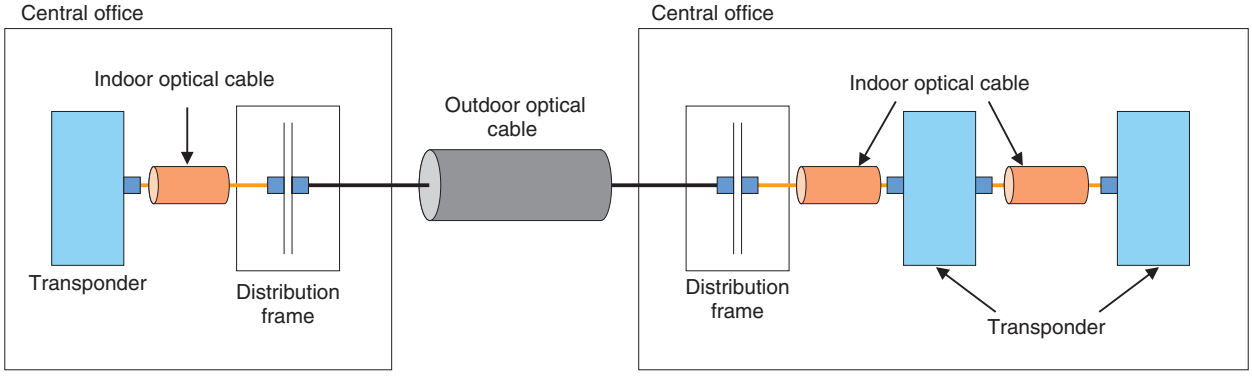

Fig. 1. Central office distribution structure.

† NTT Access Network Service System Laboratories
Tsukuba-shi, 305-0805 Japan

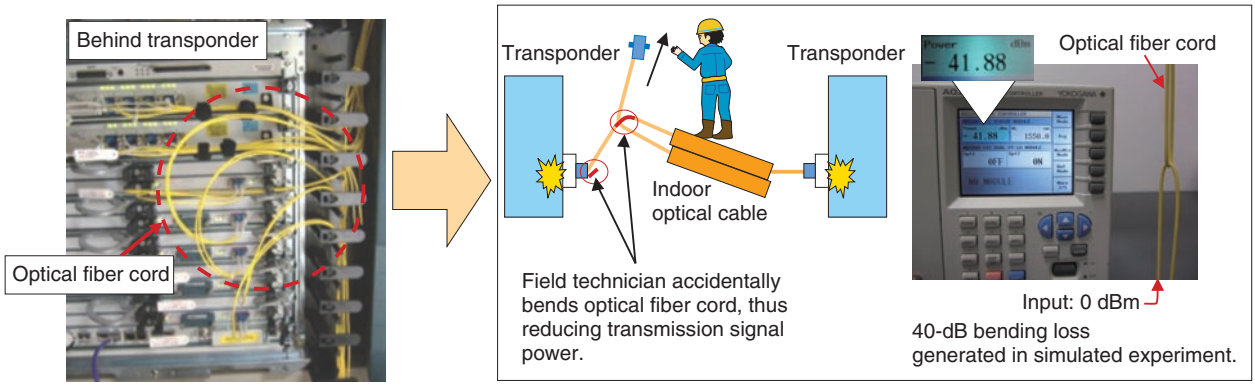

Fig. 2. Example of wiring work.

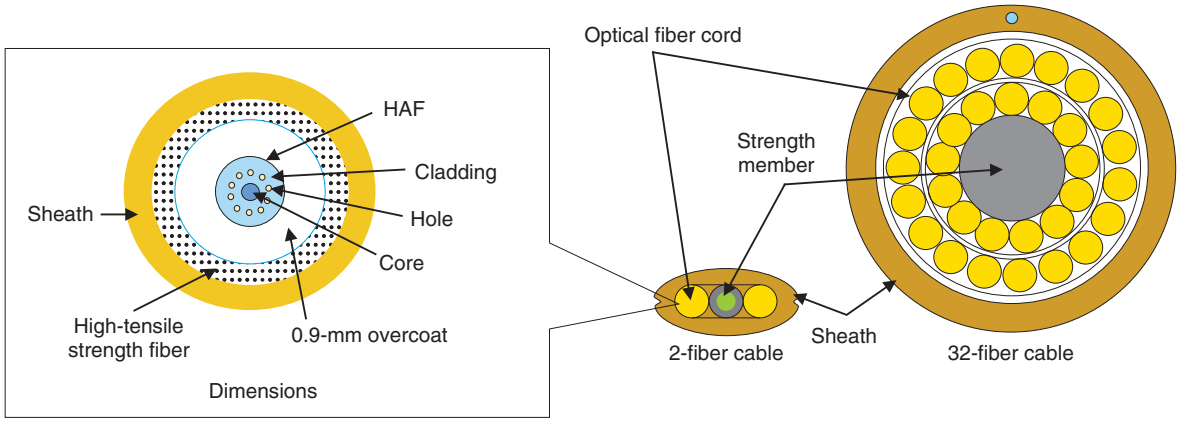

Fig. 3. Structure of indoor optical cable.

2. New development

To solve the abovementioned problem, we considered three points.

(1) Bending loss must not occur when a cord is accidentally bent momentarily.
(2) New tools should not be required; the existing tools should still be usable.
(3) The cord's performance must be at least as good as that of conventional indoor optical fiber cable.

The structure of the indoor optical fiber cable that we have developed is shown in **Fig. 3**, and the three points are discussed in more detail below.

2.1 No accidental bending loss

Hole-assisted optical fiber (HAF) cord is promising for this application because it generates hardly any bending loss when bent with a small radius [1]. An optical fiber consists of a central core surrounded by cladding. Light is confined in the core because its refractive index is designed to be higher than that of the cladding, so it is transmitted along the fiber. However, if a fiber is bent too much, the light may leak out. The cladding of HAF contains holes, whose refractive index is less than that of glass; this increases the light confinement and greatly improves the bending characteristics (**Fig. 4**).

HAF-based free-bending optical cord is a kind of ultralow-bending-loss single-mode HAF cord that has already been installed in the optical fiber to the home network in Japan. However, its applications have been limited because its superior bending-loss characteristics may lead to confinement of higher-order modes, which may result in a cutoff wavelength that is longer than the communication wavelength:

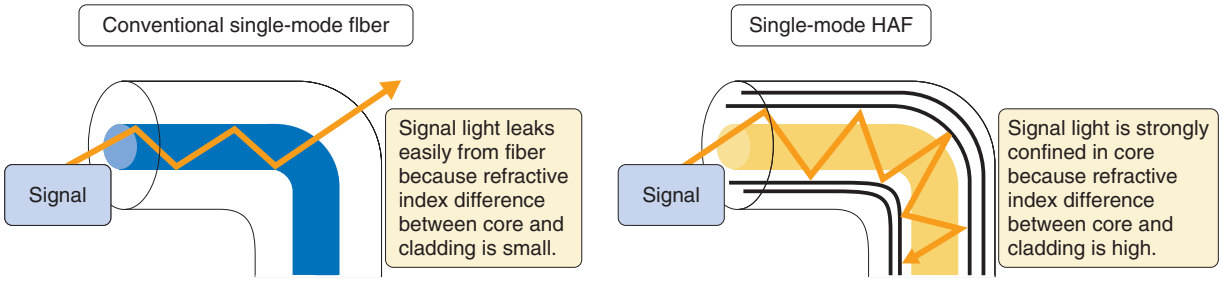

Fig. 4. Principle of HAF.

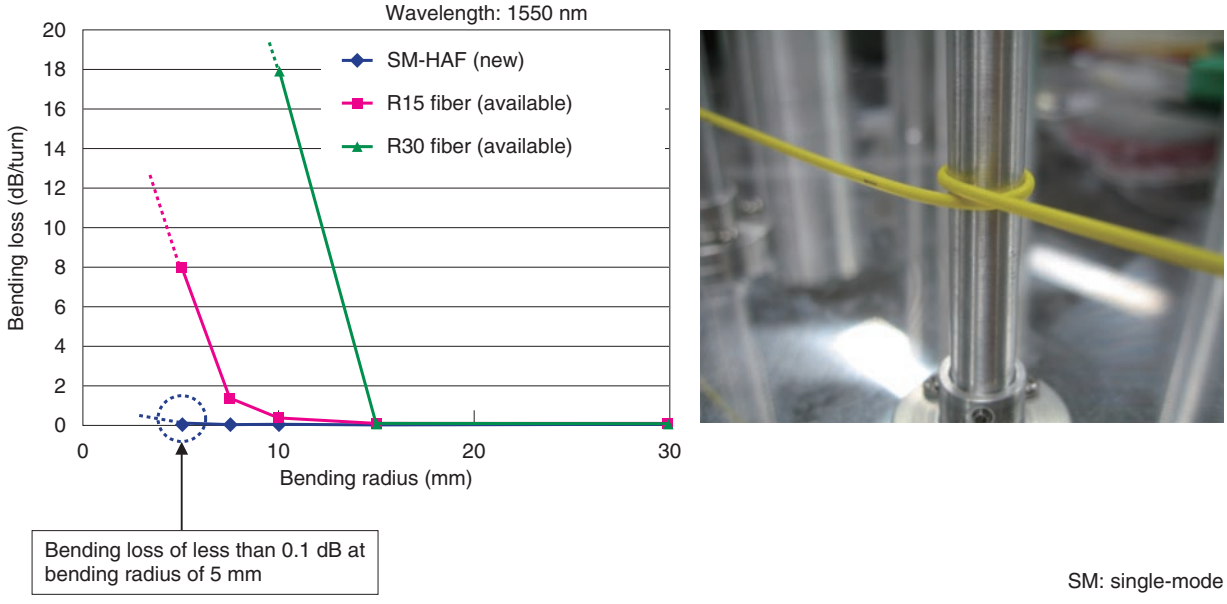

Fig. 5. Bending loss characteristics.

this could degrade the quality of long-distance transmission.

Our newly developed HAF has both low loss when bent and transmission characteristics equivalent to existing single-mode fiber [2]. Therefore, the long-distance transmission quality is not degraded, so our HAF cable is suitable for practical use in NTT's network. The measured bending losses are shown in **Fig. 5**. Even when bent with a curvature radius of 5 mm, our new HAF achieved a loss of 0.1 dB or less (at 1550 nm).

The specifications of ITU-T G.657 A2 and B3 single-mode fiber, which are international standards for loss when an optical fiber is bent, are listed in **Table 1**. The HAF cord satisfies not only G.657 A2 and B3, but also G.652, which is an international standard for existing single-mode fiber.

2.2 Use with existing tools

With the current optical fiber maintenance procedure, to reduce the risk of disconnecting the wrong optical fiber, a technician identifies the optical fiber cord of interest by using an optical fiber cord identifier and a nondestructive macrobending method without interrupting communication. With this method, optical fibers are identified by detecting an identification signal leaking from a bent fiber [3]. Therefore, we were anxious about whether or not light leaking from HAF could be fully detected.

We measured the identification characteristics of the 1.7-mm-diameter single-mode HAF cord when using a conventional identifier and a nondestructive

Table 1. Specifications of single-mode HAF.

		International standard			Single-mode HAF (new)
		ITU-T G.652 single-mode fiber	ITU-T G.657 Bending-loss-insensitive single-mode fiber		
			A2	B3	
Bending loss (dB) (1550 nm)	R30 (100 turns)	≦0.1	–	–	✔
	R15 (10 turns)	–	≦0.03	–	✔
	R10 (1 turn)	–	≦0.1	≦0.03	✔
	R7.5 (1 turn)	–	≦0.5	≦0.08	✔
	R5 (1 turn)	–	–	≦0.15	✔
Cutoff wavelength (nm)		≦1260	≦1260	≦1260	✔
Mode field diameter (μm)		8.6–9.5	8.6–9.5	6.3–9.5	✔
Zero-dispersion wavelength (nm)		1300–1324	1300–1324	–	✔

macrobending method. As a result, although the detection level was not as good as with the conventional optical fiber, we confirmed that the characteristics of the new HAF cord were sufficient for its use in NTT buildings.

2.3 Performance

We have produced prototypes of the indoor optical cables containing from 2 to 32 fibers and developed new indoor optical cables that use new optical cords that achieve almost the same characteristics as conventional optical cable over longer distances.

3. Concluding remarks

We introduced our development of indoor single-mode optical fiber cable using bending-loss-insensitive fiber. This new cable will be applied to optical wiring in the central offices of NTT's network, leading to a reliable and capable optical network.

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Naoshi Ogawa
Senior Research Engineer, NTT Access Network Service Systems Laboratories.
He received the B.E. degree in materials engineering from Waseda University, Tokyo, in 1991. He joined NTT in 1991 and moved to his current position in 2010. Since then, he has been actively engaged in R&D of an optical fiber distribution system for central offices.

Tomoyoshi Ito
Engineer, NTT Access Network Service Systems Laboratories.
He received the B.E. degree in civil and environmental engineering from Saitama University in 2004. He joined NTT Communications in 2004 and moved to his current position in 2009. Since then, he has been actively engaged in R&D of an optical fiber distribution system for central offices.

Yoshitaka Enomoto
Senior Research Engineer, NTT Access Network Service Systems Laboratories.
He received the B.E. degree in electrical engineering from Meiji University, Tokyo, in 1992. He joined NTT Telecommunication Field Systems R&D Center (now NTT Access Network Service Systems Laboratories) in 1992. Since then, he has been engaged in R&D of an optical fiber line testing system and an optical fiber distribution system for central offices. He is a member of the Institute of Electronics, Information and Communication Engineers.

Hisashi Fujimoto
Director, NTT WEST Service Management Department.
He received the B.E. and M.E. degrees in electrical engineering from Nagoya University, Aichi, in 1985 and 1987, respectively. He joined NTT in 1987. He has been mainly engaged in network facility planning. In 2008, he moved to NTT Access Network Service Systems Laboratories, where he engaged in R&D of an optical fiber line testing system and an optical fiber distribution system for central offices. He moved to NTT WEST in June 2011.

SceneKnowledge: Knowledge Sharing System Using Video-scene-linked Bulletin Board

Satoshi Shimada†, *Ken Tsutsuguchi, Akira Kojima, Hiroshi Konishi, and Suguru Higashino*

Abstract

We present an overview and describe trial demonstrations of SceneKnowledge, a powerful new system based on fully exploiting the potential of video for discovering and sharing knowledge.

1. Introduction

Many companies and other entities have become increasingly interested in creating knowledge within their own organizations that can be shared and put to practical use by using network systems. The objective of skill transfer and knowledge management is to foster person-to-person exchanges of opinions, thoughts, ideas, information, and knowledge using an assortment of tools such as bulletin boards, social network services, blogs, and twitter.

However, relying on text alone to convey the practical knowledge and skills required by technical vocations and social activities is extremely limiting. Moreover, it is not easy to compile knowledge using conventional communication tools because knowledge is typically very unevenly distributed among the members of an organization.

One way around this problem is to harness the audiovisual impact and expressive power of video. Knowledge can be represented in a very easy-to-understand, intuitive way by video, so it should be relatively easy to accumulate expertise and knowhow by sharing background information. Of course, video has its own limitations—one may have to watch the video for some time to grasp its message, and the knowledge contained in the video may be elusive—so using simple video by itself is not really appropriate.

Considering these inherent limitations, we propose a method of dividing video into work-related and action-related scenes, then providing bulletin board functions linked to the video scenes. This scene-linked bulletin board approach expresses the knowledge lurking within video and generates a knowledge-creation spiral that can be readily shared and further developed.

† NTT Cyber Solutions Laboratories
Yokosuka-shi, 239-0847 Japan

2. Knowledge creation by video-scene-linked bulletin boards

2.1 Knowledge discovery and sharing processes

We achieve continuous knowledge creation based on the SECI (socialization, externalization, combination, and internalization) model [1] by using the following method. The spiral of knowledge discovery and sharing within an organization is illustrated in **Fig. 1** (for simplicity, only the first loop is shown). Video sharing takes place when the behavior or pattern of performing a skill is filmed, and the implicit knowledge is then shared with others when they view the video.

(1) Knowhow and expertise are then accumulated by setting up a bulletin board to discuss each video scene, and the knowledge provided by all the users—in the form of comments, sketches and drawings, questions and answers, and discussion on the bulletin board—is converted to

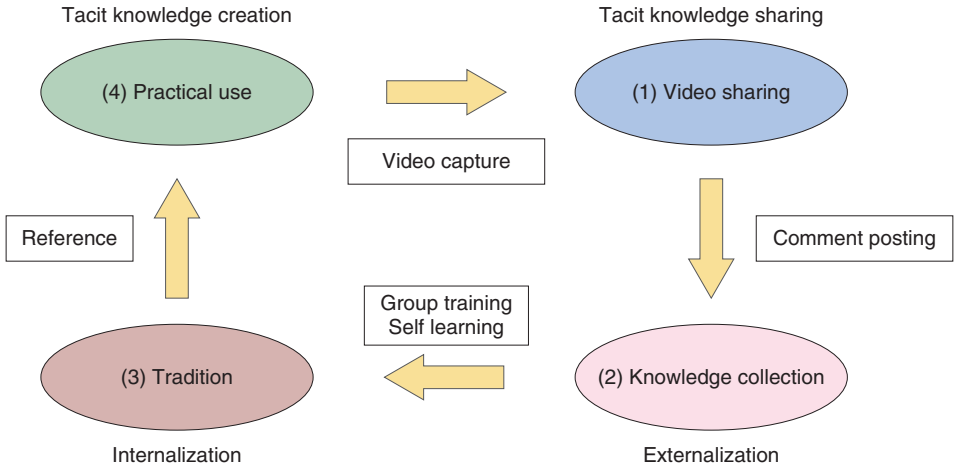

Fig. 1. Spiral of knowledge discovery and sharing within an organization.

explicit knowledge.

(2) Skills are transferred through the acquisition of knowledge obtained by perusing video scenes tagged with comments, and new technologies and ways of doing things are learned through practice. Posted comments and video scenes are organized by topic to enable the bits of knowledge contributed by each user to be combined to form an integrated comprehensive body of knowledge.

(3) This system enables new knowledge to be created by practicing the knowledge that has been mastered. This tacit knowledge that is created can then be shared through the same process.

As this cycle continues, an ongoing knowledge-creation spiral is set in motion that creates new knowledge at the organizational level.

2.2 Developed system

To support this knowledge-creation spiral, we have developed a web application system called SceneKnowledge. As can be seen in **Fig. 2**, the system consists of a SceneKnowledge server that provides video/user registration management and scene-linked bulletin boards, a video indexing server that detects registered video events and supports scene definition, and a video distribution server. SceneKnowledge can be run on a web browser on a personal computer, but can also be viewed on mobile phones (i-mode or Flash Lite) and smartphones (Android 2.2 and higher). Below, we briefly describe the scene definition and scene-linked bulletin board features of the system.

2.2.1 Registration of video with defined scenes

When you access the SceneKnowledge server via your browser and upload videos, the video indexing server automatically detects major scene changes in the content, camera work sequences, speech and sound sequences, and other events in the video. The timeline on the scene definition screen shows the times at which such events are detected. Scene definition is very simple: an interface lets you manually sort and group video scenes by theme while referring to the timeline event data. Bulletin boards are established by adding titles and summaries to each scene and selecting representative images.

2.2.2 Video-scene-linked bulletin boards

A screenshot of a video-scene-linked bulletin board is shown in **Fig. 3**. If you have a question or comment while viewing the video, you simply click on the text box to post comments. This pauses the playback and allows you to type in comments. The comments are then linked to the video on the basis of the playback time. When you move the cursor over the video scene display bar, the title and key images associated with the scene are displayed. Then, a particular scene of interest is chosen and the video is played back beginning with that scene, and posted comments associated with the scenes are displayed on the right. Clicking on the title of a previously posted comment takes you directly to the scene where the comment was originally posted and begins playback from that point. Users can also discuss or respond to comments using the comment reply function. Other functions permit you to draw on the video; bookmark video playback times, posted comments, and scenes; vote for posted

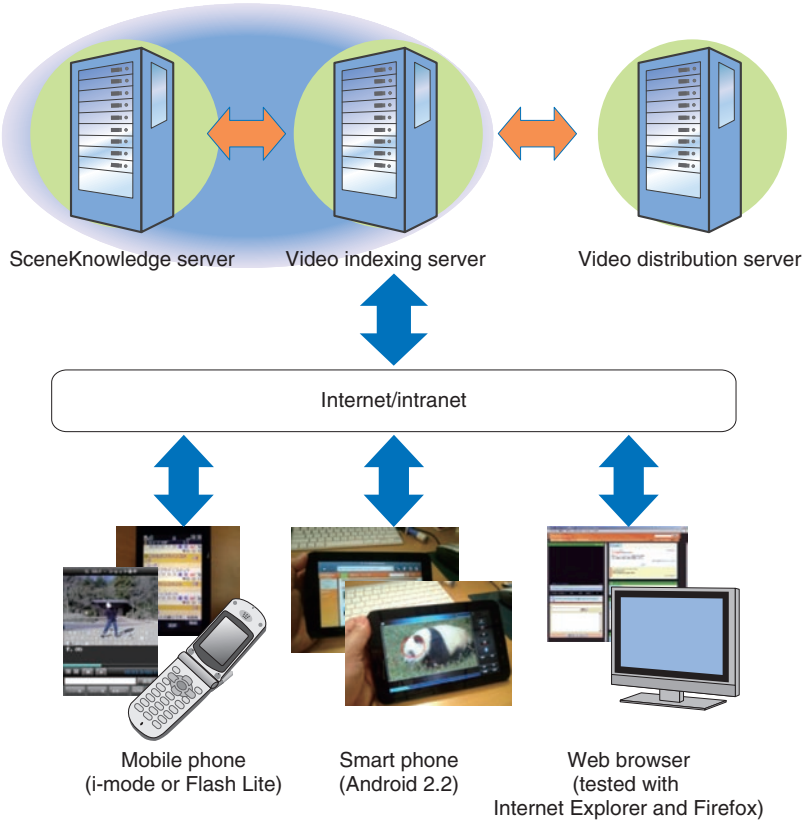

Fig. 2. System configuration of SceneKnowledge.

comments, record private notes, perform text searches, and so on. Using this novel video bulletin board approach, we streamlined three basic capabilities: viewing video, reading comments, and posting comments. These capabilities not only support the aggregation of knowhow and expertise, but also foster introspection and reflection.

3. Field trials

3.1 Pilot study in a practical skill-based field

We conducted a trial to evaluate the system's ability to collect and consolidate expertise in the field of skilled nursing practice, a field that clearly requires technical expertise [2]. For the experimental environment, we registered an instructional video of nursing practice and recruited 1718 nurses employed in four general hospitals in Osaka for the trial, which lasted several weeks. We set up the system so that nurses could access it during their regular shifts as much as possible, and we asked them to post comments offering tips, techniques, and pointers regarding the nursing practices illustrated in the video. A total of 189 comments were posted during the trial as the nurses went about caring for their patients. Analysis of the comments revealed that a good deal of detailed content regarding practical nursing practice was collected over this relatively short trial period, and it confirmed that a lot of nursing knowledge was generated on the basis of the video contents.

Meanwhile, we conducted a one-year trial at another general hospital involving new nursing trainees. The trainees prepared for their actual onsite training at the hospital in advance by using the SceneKnowledge system to air their concerns or address problems by posting comments, and they continued to use the system periodically even after the training period was over. The trial demonstrated that the system worked just as expected: a good deal of practical knowledge and knowhow was accumulated as the more experienced veteran nurses responded to questions raised by the new trainees, and this proved remarkably effective for the transfer of practical techniques and skills to the trainees.

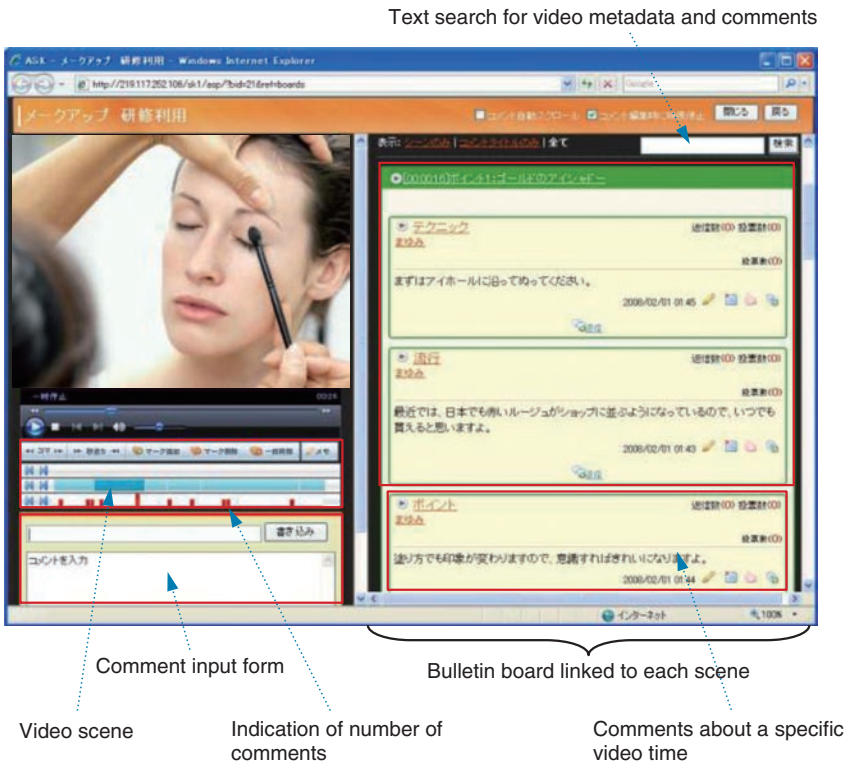

Fig. 3. Screenshot of a video-scene-linked bulletin board.

Turning to a totally different field, we conducted a collaborative trial with Sakuho Township, an agricultural community in Nagano Prefecture. Here, we found that the system helped rejuvenate the local farming community through the use of the intuitive easy-to-understand nature of video to share knowledge and address the basic issue of succession planning in farming communities: how to pass down technical skills to the younger generation.

3.2 University lecture field trials

3.2.1 New approach for creating lecture video content

Shooting and editing video to produce lecture-related content is extremely laborious and time-consuming. This led us to develop a new scheme using a fixed high-definition television (HDTV) camera to film lectures and automatically create clippings from the video stream of key areas in the lecture hall and deliver small quantities of HDTV clipping content for learning purposes [3]. The key areas for creating clippings are (1) the area around the instructor or lecturer that show his or her expressions and behavior, (2) the resource area showing screens, blackboards, or other presentation devices, and (3) the lecture hall area, which represents the overall venue. As illustrated in **Fig. 4**, the three key areas were extracted from the HDTV feed and then edited and synthesized using a predefined editing template to produce a polished video of the lecture. Any perspective distortion in the resource area or brightness adjustments around the lecturer were automatically corrected when the feed was synthesized. Note that scene changes in the resource area are automatically defined, so when a lecture is accompanied by slides or similar electronic media, the output is automatically divided into different scenes as the slides are presented.

3.2.2 Instructional design for better learning efficiency

We conducted a series of trials to see if learning efficiency might be improved by having students prepare weekly assigned reports and final reports on our system [4]. The trial procedure is summarized as follows. First, a class video was recorded; then, students posted their own views and opinions in the form of comments about the content until the next week. During the first half of the class, the instructor reviewed and addressed the students' comments from the

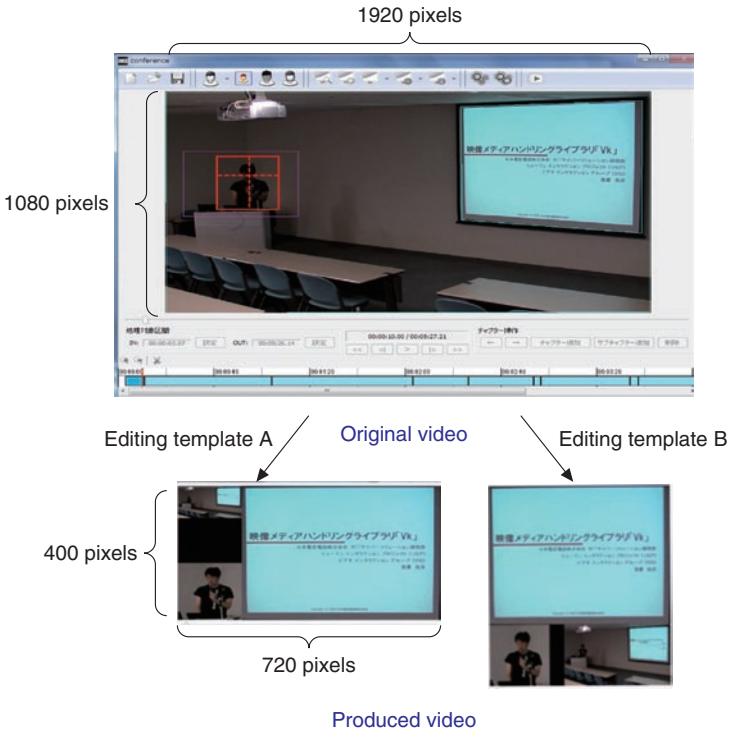

Fig. 4. Principle of video editing.

previous session. Finally, the students were asked to select 3–10 scenes from the previous 12 classes that they found particularly interesting and to write a brief report describing what they learned from the class.

Continuing this approach for six months, we verified a number of interesting findings.

(1) Breaking the class video up into scenes proved to be effective for reading and writing comments, and the summary report of the class video was effective.
(2) Writing comments and reading other students' comments caused students to look back over the course, reflect on their own views, and compare their own ideas with those of their classmates; this clearly raised their interest in the class.
(3) Having the students prepare summaries of the class led them to discover new insights and organize their own thinking and thus deepened their understanding of the class content.

The system clearly has great potential for open education using publicly available lecture videos [5].

3.3 Application to e-learning

In order to assess the system's practicality and effectiveness in a commercial e-learning environment, we teamed up with NTT Knowledge Square Inc. (NTTKS) to conduct a joint trial beginning in October 2010 (**Fig. 5**). During the trial, several free lectures available on the NTTKS e-learning N-Academy website [6] were provided using the video-scene-linked bulletin boards provided by SceneKnowledge. We were confident that the system's features—the ability to add comments to key scenes, quickly locate required scenes, make notations on video images, and so on—would not only deepen student understanding of the subject matter, but also facilitate a two-way dialog between the instructor and the students.

The system's effectiveness was confirmed by a follow-up questionnaire in March 2011; about 75% of the participants said that the system helped them understand the course. The trial was still underway at the time of writing. Anyone can sign up to participate, and we would encourage any interested readers to visit the site and give SceneKnowledge a try.

4. Concluding remarks

SceneKnowledge is a system that partitions video into scenes and then uses scene-linked bulletin boards

Fig. 5. Application to e-learning.

to enable discussions and comments about the scenes. Field trials demonstrated that the system works well for compiling knowhow and expertise and as an efficient learning aid. Building on the results that we have achieved so far, in future work we will focus on upgrading the video indexing technology, video display and processing technologies that can aid in discovering the knowledge that lies within video, and schemes for reorganizing posted video and comments.

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Satoshi Shimada
Senior Research Engineer, Human Interaction Project, NTT Cyber Solutions Laboratories.
He received the B.S., M.S., and Ph.D. degrees from the University of Kanazawa in 1983, 1985, and 1998, respectively. Since joining NTT in 1987, he has been engaged in research on image recognition, video handling, and knowledge management. He is a member of the Institute of Electronics, Information and Communication Engineers (IEICE) and the Institute of Image Electronics Engineers of Japan (IIEEJ).

Ken Tsutsuguchi
Senior Research Engineer, Visual Media Communications Project, NTT Cyber Space Laboratories.
He received the B.E. and M.E. degrees and the Dr. of Informatics degree from Kyoto University in 1989, 1991, and 2001, respectively. In 1991, he joined NTT Human Interface Laboratories and engaged in research on computer graphics, computer animation, computer vision, and video/image processing. He is a member of IEEE Computer Society, the Association for Computing Machinery (ACM), the Information Processing Society of Japan (IPSJ), and IEICE.

Akira Kojima
Senior Research Engineer, Supervisor, Visual Media Communication Project, NTT Cyber Space Laboratories.
He received the B.E. and M.E. degrees in mathematical engineering and information physics from the University of Tokyo in 1988 and 1990, respectively. Since joining NTT in 1990, he has been engaged in research on video databases, multimedia information retrieval, video surveillance, and high-reality visual communications. He is a member of IEICE, IIEEJ, and ACM.

Hiroshi Konishi
Senior Research Engineer, Human Interaction Project, NTT Cyber Solutions Laboratories.
He received the B.E. and M.E. degrees in computer science and information mathematics from the University of Electro-Communications, Tokyo, in 1991 and 1993, respectively. He joined NTT Network Information Systems Laboratories in 1993. From 1995 to 2003, he worked on R&D of e-learning systems. Since 2003, he has been engaged in R&D of audio and video processing, and multimedia handling. He is a member of IEICE and the Acoustical Society of Japan.

Suguru Higashino
Senior Research Engineer, Supervisor, Human Interaction Project, NTT Cyber Solutions Laboratories.
He received the B.S. degree in applied physics from Tokyo University of Science in 1986 and the M.E. degree in information processing from Tokyo Institute of Technology in 1988. Since he joined NTT Human Interface Laboratories in 1988, he has mainly been engaged in R&D of image coding and human interfaces. From 2005 to 2008, he worked in the R&D Strategy Department. Since 2008, he has been engaged in the development of new IPTV services and new digital signage services. He is a member of IEICE, the Japanese Society for Information and Media Studies, and IIEEJ.

Overview and Standardization Trends of LTE-Advanced

Sadayuki Abeta[†], *Tetsushi Abe, and Takehiro Nakamura*

Abstract

This article explains the features of and standardization schedule for LTE-Advanced, which has been approved by ITU-R (International Telecommunication Union, Radio Communication Sector) as one of the IMT-Advanced systems (IMT: International Mobile Telecommunication).

1. Introduction

NTT DOCOMO launched Xi™* (read "crossy"), Japan's first wireless connectivity service based on the extra-high-speed technology, Long Term Evolution (LTE), on December 24, 2010 to increase the data rate, sophistication, and economy of our radio network. It is based on the LTE Release 8 specifications (hereinafter referred to as LTE Rel. 8) [1], for which standardization was completed by 3GPP (3rd Generation Partnership Project) in the spring of 2009. LTE Rel. 8 adopts various high-level radio interface technologies such as orthogonal multi-access, frequency-domain scheduling, and multiple-input multiple-output (MIMO) and provides even higher system capacity and throughput for cell edge users than High Speed Packet Access (HSPA). It also significantly reduces transmission and connection delays, resulting in major improvements in system performance [2]. NTT DOCOMO is playing a central role in advancing the LTE standardization in 3GPP, from proposing the basic concepts to completing the specifications. It is also supporting the standardization of LTE Rel. 9, which will further increase the sophistication of LTE, enabling the economical introduction of many different services and meeting the demands of LTE users in the future. LTE Rel. 9, which was completed in March 2010, provides various new functions including functional enhancement of HeNB (Home eNodeB or LTE femtocell [3]), extensions to network self-optimization, location services, and multimedia broadcast and multicast services (MBMS) [4].

NTT DOCOMO is also promoting the standardization of LTE-Advanced (LTE Rel. 10 and beyond), which will further increase the system performance of radio access networks. This is in consideration of the need to respond quickly to the explosive growth of data traffic caused by new devices such as smartphones and tablet computers together with social network services, web browsing, video streaming, and so on. NTT DOCOMO acted as rapporteur for the LTE-Advanced Study Item [5], which was approved in 3GPP in March 2008, and detailed specifications for LTE Rel. 10 were completed in June 2011.

In addition to achieving major system performance increases over LTE Rel. 8, maintaining backward compatibility with LTE Rel. 8 is an important requirement of LTE-Advanced to enable smooth development of the system [6]. On the other hand, standardization of IMT-Advanced is progressing in ITU-R (International Telecommunications Union, Radio Communications Sector) as the successor to the International Mobile Telecommunications 2000 (IMT-2000) system, and LTE-Advanced is also a radio interface candidate for this new system. Because of this, it is very important for LTE-Advanced that the minimum requirements for IMT-Advanced are attained within the IMT-Advanced standardization schedule.

† NTT DOCOMO
Chiyoda-ku, Tokyo, 100-6150 Japan

*1 Xi™ is a trademark of NTT DOCOMO.

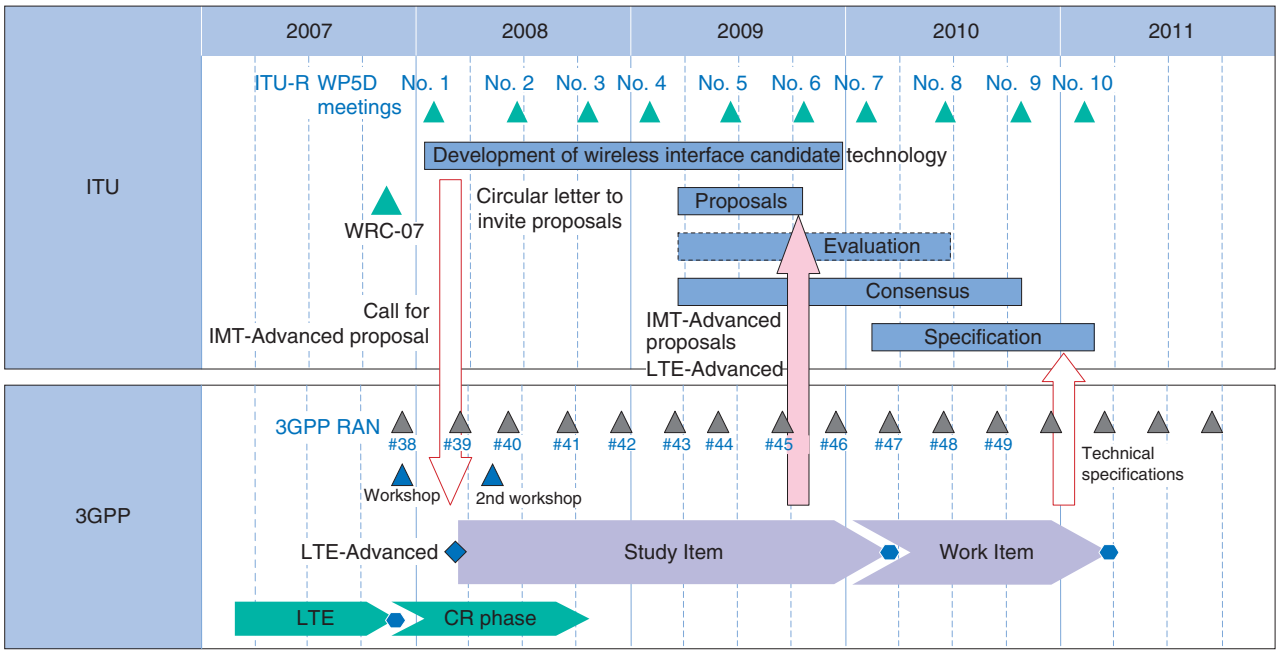

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Fig. 1. Schedules for IMT-Advanced (in ITU) and LTE-Advanced (in 3GPP).

2. Standardization schedule

The schedules for standardization of IMT-Advanced in ITU-R and LTE-Advanced in 3GPP are shown in **Fig. 1**. At ITU-R, new frequency bands for IMT were identified at the World Radiocommunication Conference 2007 (WRC-07) held in November 2007, and a circular letter soliciting radio interface proposals for IMT-Advanced was issued in March 2008 [7], [8]. In the same year, the requirements and evaluation conditions for IMT-Advanced were specified [9], [10], and by the end of the proposal submission period in October 2009, two proposals, based on LTE-Advanced and IEEE802.16m, respectively, were received. After that, external evaluations by evaluation groups registered with ITU-R began, and recommendations for the radio interface specifications are expected to be completed at the beginning of 2012, after final agreement on IMT-Advanced has been reached.

At 3GPP, a Study Item for the LTE-Advanced radio interface was started in March 2008 [5] prompted by the issue of ITU-R's circular letter, and the requirements and evaluation conditions for LTE-Advanced were specified. Then, technical study of the LTE-Advanced radio interface proceeded, and a proposal for LTE-Advanced was submitted to ITU-R in October 2009 [11]. Doing so showed that all of the requirements for IMT-Advanced were satisfied according to 3GPP's self-evaluation results. After the evaluation results had been reviewed by an external evaluation group registered with ITU-R, LTE-Advanced was approved as one of the IMT-Advanced systems by ITU-R working party 5D in October 2010.

A Work Item to draft the detailed specifications for the LTE-Advanced radio interface was started in December 2009 and the technical specifications were completed in June 2011.

3. Requirements for LTE-Advanced in 3GPP

The requirements for LTE-Advanced are given in [6]. The following general requirements for LTE-Advanced were agreed upon. First, LTE-Advanced will be an evolution of LTE Rel. 8. Hence, distinctive performance gains from LTE Rel. 8 are required. Moreover, LTE-Advanced will satisfy all of the relevant requirements for LTE Rel. 8 [12]. Second, full backward compatibility with LTE Rel. 8 is required in LTE-Advanced. Thus, LTE-Advanced user equipment must be able to access LTE Rel. 8 networks, and LTE-Advanced networks must be able to support

LTE Rel. 8 user equipment. Third, LTE-Advanced shall meet or exceed the IMT-Advanced requirements within the ITU-R time plan. The major performance requirements are listed in **Table 1**.

4. Major radio interface technologies for LTE-Advanced

To satisfy the requirements for LTE-Advanced, improvements to the radio interface technologies were studied, with LTE Rel. 8 as the base. These are described below.

Table 1. Major performance requirements of LTE-Advanced in 3GPP.

			LTE	LTE-A
Peak data rate (Mbit/s)	DL		300	1000
	UL		75	500
Peak spectral efficiency (bit/s/Hz)	DL		15	30
	UL		3.75	15
Spectral efficiency* (bit/s/Hz/cell)	DL	2 x 2	1.69	2.4
		4 x 2	1.87	2.6
		4 x 4	2.67	3.7
	UL	1 x 2	0.74	1.2
		2 x 4	-	2.0
Cell edge user throughput* (bit/s/Hz/cell/user)	DL	2 x 2	0.05	0.07
		4 x 2	0.06	0.09
		4 x 4	0.08	0.12
	UL	1 x 2	0.02	0.04
		2 x 4	-	0.07

DL: downlink
UL: uplink

* 3GPP Case 1

4.1 Carrier aggregation

LTE Rel. 8 supports bandwidths up to 20 MHz, but one goal of LTE-Advanced is to support peak data rates of up to 1 Gbit/s on the downlink and 500 Mbit/s on the uplink, so wider bandwidths are needed. On the other hand, LTE-Advanced must also maintain backward compatibility with LTE Rel. 8. Accordingly, wider bandwidths are supported by combining multiple frequency blocks of bandwidth supported by LTE Rel. 8, called the component carrier, as shown in **Fig. 2**.

4.2 MIMO enhancement

With LTE Rel. 8, MIMO multiplexing of up to four layers is supported on the downlink, but MIMO multiplexing is not supported on the uplink. By contrast, LTE-Advanced supports single-user MIMO multiplexing with up to eight layers on the downlink and four layers on the uplink in order to satisfy the peak spectral efficiency requirements of 30 bit/s/Hz on the downlink and 15 bit/s/Hz on the uplink. Multi-user MIMO has also been improved in order to increase system capacity. For Rel. 11, we are also studying the introduction of coordinated multipoint transmission/reception (CoMP), which coordinates communication among multiple cells in order to improve throughput for cell edge users in particular, as shown in **Fig. 3**.

4.3 Interference coordination in heterogeneous networks

Another important requirement for LTE-Advanced is to reduce the cost of the radio access network. The deployment scenario for a heterogeneous network, which deploys small cells of various different types

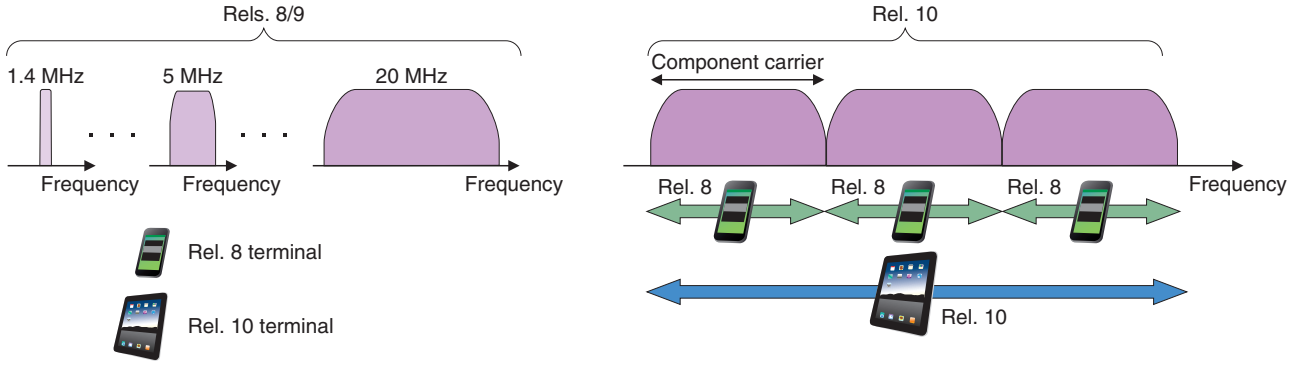

Fig. 2. Carrier aggregation.

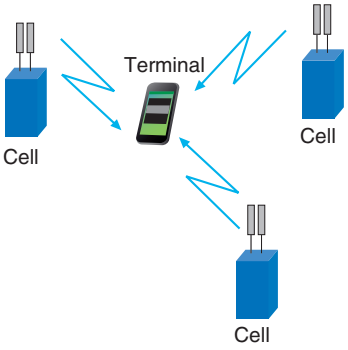

Fig. 3. CoMP.

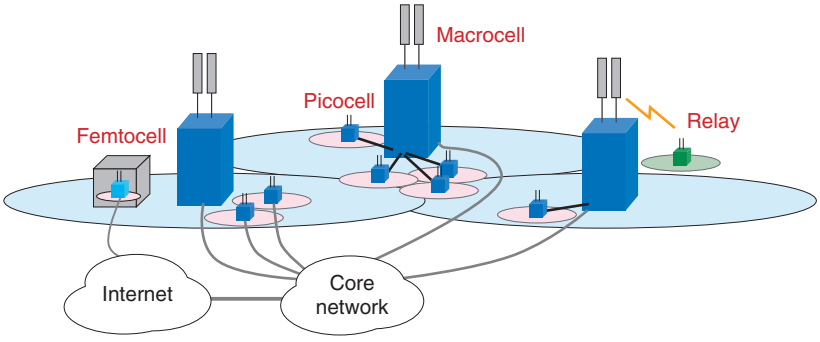

Fig. 4. Heterogeneous network.

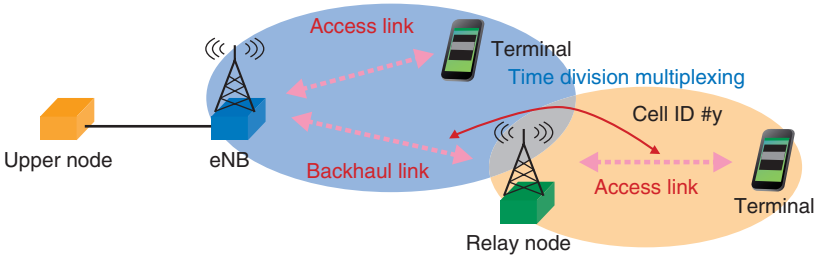

Fig. 5. Relay network.

such as picocells and femtocells in the macrocell's area to increase the capacity in high traffic areas, is shown in **Fig. 4**. To further increase the system capacity and throughput for cell edge users in the area, interference coordination between the macrocell and the picocells is specified.

4.4 Relay network

Another approach to reducing the cost of the radio access network is to reduce the cost of the backhaul potion of the network. Radio relay transmission for the backhaul is being introduced as a low-cost means of expanding coverage in environments where wired transmission is particularly expensive, as shown in **Fig. 5**.

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[9] ITU-R Report M.2134, "Requirements Related to Technical Performance for IMT-Advanced Radio Interface(s)," 2008.

[10] ITU-R Report M.2135, "Guidelines for Evaluation of Radio Interface Technologies for IMT-Advanced," 2008.

[11] ITU-R Document 5D/564, "Complete Submission of 3GPP LTE Release 10 and beyond (LTE-Advanced) under Step 3 of the IMT-Advanced Process," 2009.

[12] 3GPP TR25.913, "Requirements for Evolved UTRA (E-UTRA) and Evolved UTRAN (E-UTRAN)".

Sadayuki Abeta
Director of the Radio System Group, Radio Access Network Development Department, NTT DOCOMO.

He received the B.E., M.E., and Ph.D. degrees in electrical communication engineering from Osaka University in 1993, 1995, and 1997, respectively. He has been with NTT DOCOMO since 1997, where has been working on research, standardization, and development of UMTS/W-CDMA, HPSA, LTE, and LTE-Advanced. From June 2000 to May 2001, he was a visiting researcher at Princeton University, NJ, USA. From 2005 to 2009, he was a vice chairman of 3GPP TSG-RAN WG1 and rapporteur of LTE and LTE-Advanced in 3GPP TSG RAN WG1.

Tetsushi Abe
Manager, Mitsubishi Corporation.

He received the B.S. and M.S. degrees in electrical and electronic engineering and the Dr.Eng. degree in communications and integrated systems from Tokyo Institute of Technology in 1998, 2000, and 2007, respectively. During 1998–1999, he studied electrical and computer engineering at the University of Wisconsin-Madison, WI, USA, under a scholarship exchange student program offered by the Japanese Ministry of Education. He joined NTT DoCoMo in 2000. During 2005–2009, he was with DOCOMO Euro-Labs, Munich, Germany. From 2009 to 2011, he was a vice chairman of 3GPP TSG-RAN WG1. He moved to Mitsubishi Corporation in November 2011.

Takehiro Nakamura
Director, Radio System Design Group, NTT DOCOMO.

He joined NTT in 1990 and moved to NTT DoCoMo in 1992. He has been working on R&D of W-CDMA. He has also been engaged in W-CDMA standardization at ARIB in Japan since 1997 and has been the leader of the IMT-Partnership Group in ARIB since March 2006. He has contributed to standardization activities in 3GPP since 1999. He has been a rapporteur for LTE and LTE-Advanced in 3GPP TSG-RAN since December 2004 and March 2008, respectively. He contributed to 3GPP TSG-RAN as a vice chairman from March 2005 to March 2009. He has been the chairman of 3GPP TSG-RAN since April 2009.

NTT COMWARE America Branch

Toshihide Asano†
Branch Manager,
California Office,
NTT COMWARE America Branch

Abstract

NTT COMWARE Corporation America Branch is focusing on providing new business value by monitoring emerging trends of venture-capital companies and the telecommunications industry in Silicon Valley and disseminating this information to its customers as well as to the NTT Group. This article introduces our business and activities.

1. Introduction

NTT COMWARE Corporation America Branch was established in Silicon Valley, California, USA, in April 1997 as a base for high-tech market research. It began full-scale activities in September 1997. In June 2007, it relocated to San Jose, where NTT Group companies have offices on the same floor of the building. Our main activities can be summarized as follows.

(1) Market research about Silicon Valley ventures.
(2) Surveys of and reports on the trends of the telecommunications industry and related business fields in North America and Europe.
(3) Business planning based on the above findings.

We send to Japan the latest exciting American news, which we gather and disseminate not only by conducting in-house surveys but also by working with and exchanging information with other NTT Group companies based in Silicon Valley. The number of employees is currently six (**Photo 1**).

Photo 1. Staff members of NTT COMWARE America Branch.

2. High-tech mecca

Several remarkable high-tech companies like Google, Apple, Intel, HP, and Facebook and many startup companies aspiring to become the next Google work hard and work with each other in Silicon Valley. In the midst of such innovation, we are trying to see what is going on in technologies and services right now. Below, I mention a couple of our survey themes.

† California Office, NTT COMWARE America Branch
1741 Technology Drive, Suite 320, San Jose CA 950110, USA

2.1 Home ICT

Many actions that are usually performed by people, such as turning lights on and off and locking and unlocking doors, can now be performed at home by remote control from a personal computer (PC). This is known as Home ICT (information and communications technology). There are now services for remotely controlling everything in the home, such as home appliances and electric vehicle charging stations, from mobile devices such as smartphones and tablet PCs. Telecommunications carriers like Verizon are partnering with startup companies in Silicon Valley and this year they are launching new services—home monitoring and control—that will be game changers for home communication services.

2.2 Convergence of Internet and telephone

We see cutting edge services arising from the convergence of the Internet and telephone appearing one after another in Silicon Valley. For example, convenient new services let you have fun browsing the web using a phone without the need for a PC, you can leave voice mail about matters that you do not want to discuss directly, and you can use a voice recorder to create important reminders and receive email notifications when the time comes (**Fig. 1**).

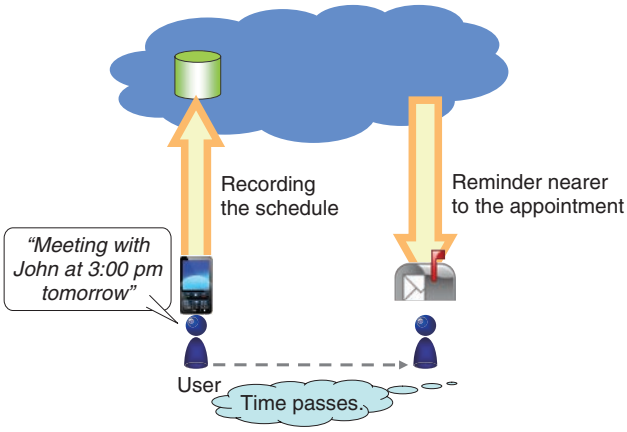


Fig. 1. Convergence of the Internet and telephone.

2.3 Big data analysis

The diversity represented by the proliferation of smartphones and tablets and the changes in Internet usage style due to the expansion of social media are making enterprises try to get a competitive edge or improve services to make them more user-friendly by utilizing publicly available data on the Internet. For example, enterprises can now promote customer retentions effectively by analyzing the behavior of each user and manage the reputation of a company or service by analyzing comments made in social media. In addition to these individual studies, we are conducting joint activities aimed at achieving synergy within the NTT Group by sharing market research findings and conducting joint surveys with other NTT Group companies in Silicon Valley. We also participate in local events to create a diversified network for the Japanese community and hold private discussion seminars in Japan with Japanese organizations based on the investigations that we have conducted in the USA (**Photo 2**).

Private seminar that we held in Japan at the beginning of 2011.

Photo 2. Sharing information for group synergy.

3. Future prospects

ICT is continuously evolving. In recent years, mobile device diversity and social network services have made remarkable progress. Silicon Valley continues to be the leading hub for technology innovation. We recognize that identifying emerging trends in technologies and businesses and informing our customers about them are essential to our commercial success these days. We at NTT COMWARE America Branch strive to be a partner for each of our customers to support their future business.

If you have any business needs for market research about the telecommunications industry or emerging business trends, please feel free to contact us at any time.

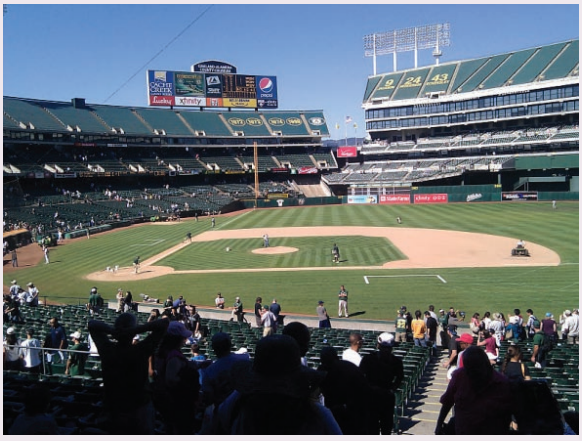
NTT COMWARE—short column

Popular professional teams

To many people, the words Silicon Valley suggest world-famous ICT companies, but in fact Silicon Valley has another facet: sports are very popular here.

In professional sports, Silicon Valley is home to the famous San Francisco 49ers of the National Football League, which are based in San Francisco and named after the gold seekers called forty-niners in the California gold rush that begin in 1848. Also based in San Francisco are the San Francisco Giants, the Major League Baseball (MLB) champions. And based in Oakland, on the other side of San Francisco Bay, are Oakland Athletics, another MLB team, who have the famous Japanese player Hideki Matsui, known as Godzilla Matsui.

Furthermore, San Jose city, where our U.S. office is located, has the San Jose Sharks, a National Hockey League (ice hockey) team. Though ice hockey is not particularly popular in Japan, the Sharks are much loved by local fans and they have won the Pacific Division championship in recent years.



MLB team Oakland Athletics.

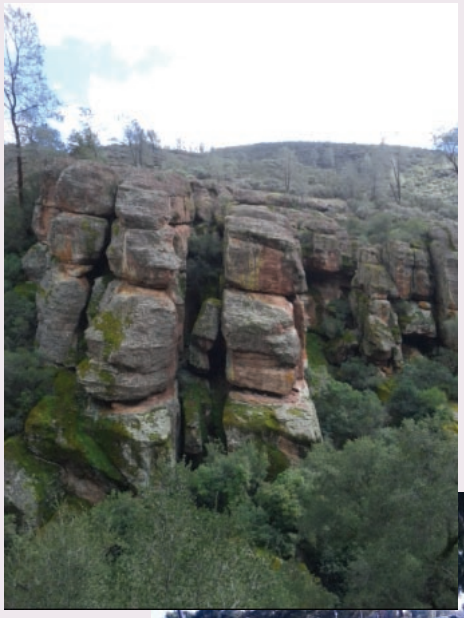
Weekend recreation

People in Silicon Valley love doing sports as well as watching sports because of the good weather and beautiful nature. Cycling on road bikes is one of the most popular sports around here. Cyclists can travel around safely and comfortably because most roads around Silicon Valley have bike lanes, which are marked lanes designated for only cyclists. We can see many people wearing cycling jerseys enjoying cycling on weekends, especially in mountainous areas.

Within an hour's drive or so, there are many State Parks and National Parks, where many people like to go jogging, cycling, or climbing.

You might think that it is a slightly surprising that sports are so popular here in Silicon Valley, where many people are working for ICT-related companies, but physical activity on weekends is good and refreshing for people working at office desks on weekdays.

We are trying to follow the Silicon Valley way of having fun on weekends by doing sports to get refreshed and energized.



Rocky park near Silicon Valley.

Many roads in Silicon Valley have bike lanes.

External Awards

MOC Paper Award

Winners: Toshio Watanabe, Yasuaki Hashizume, and Hiroshi Takahashi, NTT Photonics Laboratories
Date: Nov. 2, 2011
Organization: The Seventeenth Microoptics Conference

For "Double-branched 1×29 Silica-based PLC Switch with Low Loss and Low Power Consumption".

We propose a novel double-branched circuit configuration for a 1×N optical switch. This compact configuration offers a high port count without greatly increasing power consumption. The fabricated 4-arrayed 1×29 silica-based PLC switch exhibits an insertion loss as low as 2.6 dB.

Published as: T. Watanabe, Y. Hashizume, and H. Takahashi, "Double-branched 1×29 Silica-based PLC Switch with Low Loss and Low Power Consumption," Tech. Dig. 17th Microoptics Conf., No. J-2, Sendai, Japan, Oct. 2011.

Thomson Reuters 2011 Top 100 Global Innovators

Winner: Nippon Telegraph and Telephone Corporation
Date: Nov. 15, 2011
Organization: Thomson Reuters

Thomson Reuters has announced the world's 100 most innovative organizations with the launch of Thomson Reuters 2011 Top 100 Global Innovators, an initiative that analyzes patent data and related metrics to identify the world leaders in innovation by using a proprietary methodology based on four aspects of patent-related data: volume, success, extent of global patenting, and influence.

Papers Published in Technical Journals and Conference Proceedings

Zr inclusions revealed by microcomputed tomography observations of the CO_2 laser fusion splicing interface between single-mode optical fibers

S. Koike, S. Asakawa, and J. Kobayashi
SPring-8 Research Frontiers, Vol. 2010, pp. 134–135, 2011.

We detected Zr inclusions through microcomputed tomography observations of the CO_2 laser fusion splicing interface between single-mode optical fibers and report process improvements based on the results.

Robust Method of Estimating Noise Mixture Model for Noise Suppression

M. Fujimoto, S. Watanabe, and T. Nakatani
Proc. of the 12th Annual Conference of the International Speech Communication Association, pp. 697–700, Firenze, Italy, 2011.

Noise suppression based on the Vector Taylor series (VTS) usually uses a single Gaussian distribution for the noise model. However, this is insufficient for nonstationary noise that has a multipeak distribution. It is very complex to estimate a multipeak noise distribution when we treat the noise as random or hidden variables. To solve these problems, we investigate a way of estimating a noise mixture model by using a minimum mean square error (MMSE) estimate of the noise. By iterating the MMSE noise estimation and the noise model estimation, the proposed method simultaneously optimizes both the observed signal model and the noise model. It significantly outperformed the VTS-based approach: the maximum improvement in the word error rate was about 12%.

An Approximately Universal Set Consisting of Two Observables

Y. Takahashi
International Journal of Quantum Information (IJQI), World Scientific, Vol. 9, No. 6, pp. 1393–1412, 2011.

We consider the problem of minimizing the resources required for approximate universality in measurement-only quantum computation. This problem is important not only for realizing a quantum computer, but also for understanding the computational power of quantum computation. The resources that we focus on are observables, which describe projective measurements, and ancillary qubits. We show that, if we are allowed to use two ancillary qubits, then the set of observables $\{\cos(\pi/8)X - \sin(\pi/8)Y, Z \otimes X\}$ is approximately universal for quantum computation. This is the first construction of an approximately universal set consisting only of one one-qubit observable and one two-qubit observable. Using the proof of the approximate universality, we also show that, if we are allowed to use two initialized ancillary qubits, then one two-qubit observable is sufficient for graph state preparation. The use of only one two-qubit observable is optimal in terms of the number of observables available and the number of qubits to be measured jointly.

Auto Bias Control Technique for Optical 16-QAM Transmitter with Asymmetric Bias Dithering

H. Kawakami, T. Kobayashi, E. Yoshida, and Y. Miyamoto

Proc. of the 37th European Conference on Optical Communication (ECOC), Geneva, Switzerland, 2011.

An auto bias control technique for a quadrature amplitude modulation (QAM) transmitter is demonstrated. A 16-state QAM (16-QAM, 10 Gbaud) is generated and controlled using a single IQ modulator and asymmetric bias dithering technique (I: in-phase, Q: quadrature phase). The measured penalty is 0.3 dB.

Advanced Integrated Optical Components for Ultrahigh-speed Optical Networks

S. Suzuki

Proc. of Chitose International Forum 2011, Chitose Institute of Science and Technology (CIST), Chitose, Hokkaido, Japan.

Because of the rapid increase in the Internet traffic, ultrahigh-speed optical network systems with transmission rates of 100 Gbit/s and beyond using digital coherent optical transmission technology have been investigated. This paper reviews recent work on advanced integrated optical component technologies and their applications to digital coherent optical transmission.

Examination of Ion Channel Protein Orientation in Supported Lipid Bilayers

Y. Shinozaki, K. Sumitomo, A. Tanaka, N. Kasai, and K. Torimitsu

Appl. Phys. Express, Vol. 4, No. 10, p. 107001, 2011.

We investigated techniques for regulating the orientation of ion channel-type membrane proteins reconstituted in lipid bilayers. Free ion channel proteins aligned their long axis parallel to the substrate. By contrast, immunochemical and atomic force microscopy images revealed that ion channels reconstituted in supported lipid bilayers oriented upward, with their long axis perpendicular to the substrate. Our data demonstrates that the reconstitution of ion channels into planar lipid bilayers by rupturing small unilamellar proteoliposomes is a promising way of aligning ion channels upward in a membrane and of obtaining ion channels with controlled functions.

Operation of Ultralow-leakage Regulator Circuits with SOI and Bulk Technologies for Controlling Wireless Transceivers

M. Ugajin, A. Yamagishi, K. Suzuki, and M. Harada

IEICE Trans. on Electron., Vol. E94-C, No.10, pp. 1702–1705, 2011.

To reduce the power consumption of wireless terminals, we have developed ultralow-leakage regulator circuits that control the intermittent terminal operation with a very small activity ratio. The regulator circuits supply about 100 mA in the active mode and cut the leakage current to the nanoampere level in the standby mode. The operation of the ultralow-leakage regulator circuits with CMOS/SOI (complementary metal oxide semiconductor; semiconductor on insulator) and bulk technologies is described. The leakage-current reduction mechanism in a proposed power switch based on bulk technology is explained. Measurements show that the power switch using reversely biased bulk transistors has a leakage current that is almost as small as that of conventional CMOS/SOI transistor switches.

Security in Photonic Networks: Threats and Security Enhancement

K. Kitayama, M. Sasaki, S. Araki, M. Tsubokawa, A. Tomita, K. Inoue, K. Harasawa, Y. Nagasako, and A. Takada

Journal of Lightwave Technology, Vol. 29, No. 21, pp. 3210– 3222, 2011.

We address emerging threats to the security of photonic networks as these networks become heterogeneous through being opened up to the upper layers, other operators, and end users. We review the potential threats, which are mainly loss of the confidentiality of user data transmitted through optical fibers and network control disturbances, both of which could seriously damage the entire network. We then propose a novel conceptual model of a secure photonic network by introducing a quantum key distribution (QKD) network to its legacy structure. Secure keys generated by the QKD network are managed by key management agents (KMAs) and used to encrypt not only user data but also control signals. The KMAs cooperate with the generalized multiprotocol label-switching controller for secure path provisioning and drive photonic and modern cryptographic engines in appropriate combinations. Finally, we present a roadmap of a deployment scenario, starting from niche applications such as mission-critical and business applications. As an example of a niche application, we present digital cinema distribution through a photonic network.
