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Activities of R&D Network Unit

— Acceleration of Network-Based ICT Research —

Takahiro Ueno, Executive Director, R&D Network Unit

Introduction:

The R&D Network Unit consists of six departments that are Collaborative Research Management, Information and Network Systems, Applied Research and Standards, Wireless Communications, and Strategic Planning. The overall aim of the Unit is to apply R&D networks such as the JGNII in order to promote their development of network and application technologies, based on collaboration among network operators and researchers. The effective operation of these networks allows us to conduct R&D activities in wide ranged fields.

In addition to 64 access points in Japan, the JGNII is connected to the United States of America, Singapore and Thailand. We also operate international communications lines with South Korea (APII) and Hong Kong. The JGNII was built through collaboration between the network-related research section of the CRL (Communications Research Laboratory) and the network operation section of the TAO (Telecommunications Advancement Organization of Japan). The JGNII began operations in April, 2004, when these two organizations merged with each other to form the NICT. Since then, the Network Testbed Management Division and other research groups have been working together to operate and maintain the JGNII as well as to pursue R&D using this network. It would be able to say that the unit represents the product of collaborative activities for many years.

R&D using JGNII:

At the NICT, many groups conduct R&D using the JGNII. Their research subjects include optical networks, high-performance networks, e-VLBI and other various applications. The Unit organically links these groups to promote their research projects. We reported on the Unit's research results at the NICT's Third Meeting for the Presentation of Research Results in July, 2005. In this article, I will briefly explain some of these research projects.

(1) Demonstration experiments on ultra-fast optical transmission at 160 Gbps (Information and Network Systems Dept.)

If we are to address the issue of ever-increasing Internet traffic, we must consider the expansion of network node facilities, control of power consumption by relaying amplifiers, and greater efficiency in network operation and management. Specifically, to establish key technologies for a petabit-class photonic network in the future, we are conducting research into ultrafast optical pulse signal processing, efficient modulation/demodulation and demultiplexing schemes, and ultra-fast optical transmission.

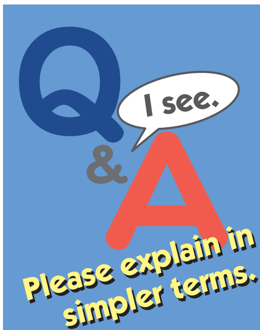
The NICT's Third Meeting for the Presentation of Research Results

(2) Research into GMPLS (Collaborative Research Management Dept., Information and Network Systems Dept.)

GMPLS is gaining attention as a protocol that will be used to control a next-generation photonic network. The JGNII features a GMPLS network utilized for R&D that can simulate a real network environment. Using this feature, we are now researching multi-domain network technologies in terms of configuration, control, operation management, interoperability and coordination with applications. Additionally, we are working more generally to incorporate Japanese technologies into international standards.

(3) Combined operation of test environments to reproduce security incidents (Information and Network Systems Dept.)

It is difficult to reproduce today's increasingly large-scaled and complex security incidents within a single test environment. Therefore we are testing the combined operation of existing environ-



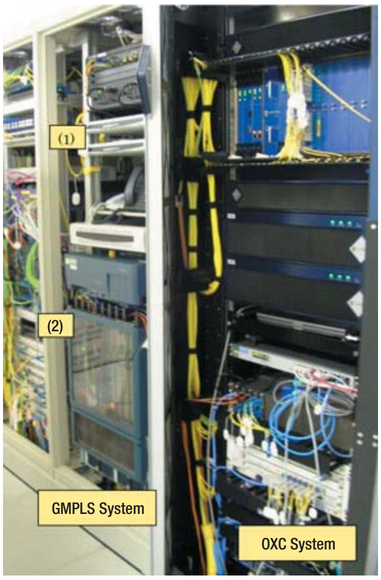
Q What is the JGNII?

A The JGNII is an ultra-fast high-performance R&D testbed network operated by the NICT. It is available for utilization of test and demonstration by researchers in the industry, the academia and the government. Through these JGNII operations, the NICT hopes to provide support for all stages of the investigative process, from basic research to demonstration experiments. The range of utilization extends from the development of increasingly sophisticated next-generation network technologies to the development of applications based on these technologies.

Q What is GMPLS?

A This represents a set of protocols based on MPLS (Multi-Protocol Label Switching) that are used to control IP routers. As an extension of MPLS, GMPLS is intended to use in the optical network equipment such as optical cross-connect (OXC) switches.

ments to handle such incidents at the minimum cost. We are using three test environments in this project: the SIOS, VM Nebula and Hokuriku IT Open Laboratory, which are interconnected through the JGNII.



GMPLS System (middle rack) and OXC (right rack) System
(1) GMPLS Controller (white), (2) GMPLS Main Unit (bottom)

(4) R&D into e-VLBI (Applied Research and Standards Dept., Information and Network Systems Dept.)

e-VLBI describes a technology used to perform VLBI (Very Long Baseline Interferometry) measurement in quasi-realtime. To transmit and merge vast amounts of data gathered at geographically distant locations for scientific measurement, a high-speed network technology is essential. Therefore this R&D will prove to represent a significant element in the development of network technology as well.

(5) Demonstration experiments on international distance learning (Wireless Communications Dept.)

In January, 2005, we performed a distance-learning experiment by connecting Hokkaido University and University of Alaska Fairbanks through the Internet and the JGNII. To create an effective test environment, we used a high-definition videoconferencing system, chat system and a web-based voting system.

Expansion of the JGNII to the rest of Asia:

As mentioned above, the NICT operates R&D networks that are utilized not only in Japan but also in other countries throughout the world. As the first step in these overseas operations, we inaugurated the JGNII Japan-U.S. circuit in August, 2004. Then, with the aim of reinforcing international joint ICT research activities with other Asian countries, in November, 2005, we inaugurated the JGNII circuits in the Asian region in partnership with counterpart institutions in Singapore and Thailand.

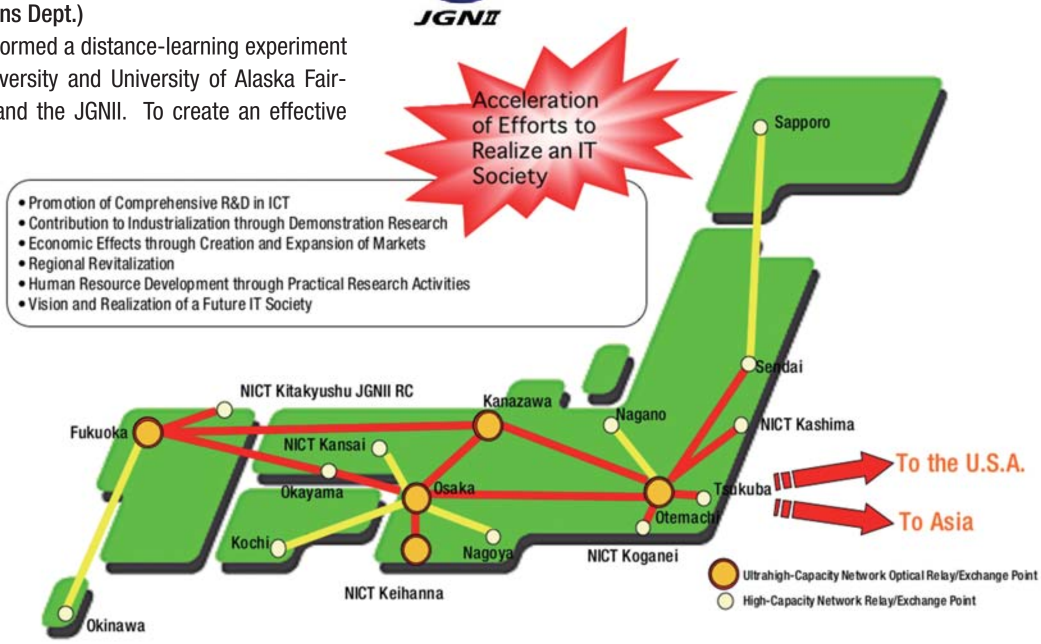
More specifically, we have connected the JGNII to the Singaporean and Thai R&D SingAREN and ThaiSarn networks respectively. In collaboration with governmental organizations, companies and universities connected through these networks, we will promote the international R&D in the advanced network technologies such as IPv6 and large-volume image compression, the R&D that will help us to urge onward a next-generation networked society.

Conclusion:

We utilize these networks in our research activities at the NICT as well as in joint research projects involving collaboration among the industry, the academia and the government. Capitalizing on the advantages of the last year's organizational consolidation, the R&D Network Unit covers a wide range of research subjects, from the investigation into physical layers to the development of applications. In the future, we will expand our research activities to a range of further fields.

In summary, we will continue our efforts to ensure that R&D activities utilizing our testbed networks will help develop the infrastructure for a prosperous, global ICT society.

JGNII R&D Testbed Network



Life & Technology

● High-school students join in experimental researches into a next-generation network society

The JGNII experiment is conducted not only by engineers or researchers but also by technical high-school students in Saga and Hiroshima prefectures, who conducted a number of investigations relating to the upcoming "ubiquitous society" using IPv6. Through the JGNII, the students attempted to exercise remote control of information terminals in a range of devices: a music player, a solar-powered car, a bipedal robot, information appliances, temperature sensors and lighting in a school building. Overall these experiments were a resounding success. The JGNII is made available for such projects in order to increase young people's interest in next-generation networks and to encourage these students to take the initiative in creating their own future society.

R&D of High-Frequency Gallium Nitride Transistors

— Toward the Realization of High-Power Transistors in the Millimeter-Wave Band —

Masataka Higashiwaki

Senior Researcher,
Millimeter-Wave Devices Group,
Wireless Communications Department

Ph.D. in engineering. Joined the CRL (currently NICT) in 2000. Engaged mainly in research into growth of nitride compound semiconductor crystals and device process technology.

Introduction to and current status of R&D

We are conducting R&D of gallium nitride (GaN) transistors offering the potential for various applications in the millimeter-wave frequency band. To increase the operating frequency of a transistor, we must normally reduce the size of its gate electrode, which controls the flow of electric current. Year after year, personal computer performance increases in terms of processor operating frequency, despite the fact that the basic structure of silicon transistors included in the processors has remained essentially unchanged for decades. The increase is achieved through progress in device process technology, which has enabled remarkable reductions in gate size—or, to be more precise, in gate length. In other words, a reduction in the gate length leads to a direct increase in the transistor's operating speed (i.e., in its operating frequency). Figure 1 shows a schematic cross section of a GaN transistor we developed. In the figure, the mushroom-shaped component is the gate electrode, and the horizontal width of its stem represents the gate length. The transistor's operating speed is determined by the time it takes an electron to pass just beneath this gate electrode. Therefore, to improve operating frequency, it is essential to minimize this gate size to the full extent possible. For example, to achieve the ultrahigh-frequency characteristics that will enable operation in the millimeter-wave band of 30 GHz or higher, we must reduce gate length to 0.1 mm or less. However, electric field intensity varies inversely with gate length; thus if the gate size is as small as we are envisioning here, the intensity of the electric field will increase considerably at the same voltage. As a result, we must then reduce the transistor's operating voltage; higher frequency thus comes at the expense of transistor power. In fact, when the transistor's breakdown voltage limit is exceeded, the junction of the gate electrode and semiconductor will burn out due to the heat of the high electric field. Efficient high-power operation in the millimeter-wave band is therefore problematic with the use of conventional transistors made of silicon, gallium arsenide, or indium phosphide. In the case of PC processors, these issues of transistor power and breakdown voltage essentially do not arise. In the case of wireless transmitters, however, the transistor's high-power characteristics are extremely important. Transistors made of GaN deliver high breakdown voltage and are suitable for uses requiring high power because GaN itself is a very stable material. Currently, domestic university and company laboratories are conducting active R&D to arrive at applications for GaN transistors in 2-GHz-band mobile base stations; applications that will take advantage of the higher breakdown voltages and power characteristics of these transmitters. However, very few R&D activities are currently devoted to the development of application in even higher frequency ranges, including the millimeter-wave band.

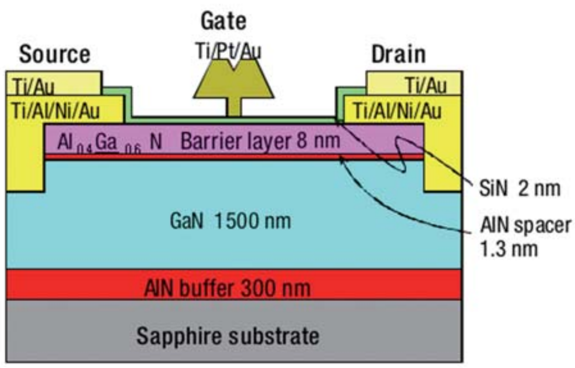
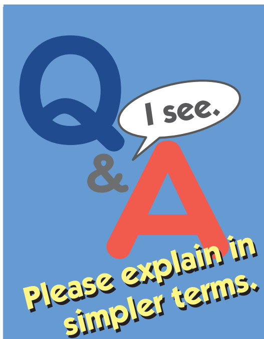


Figure 1: Schematic cross section of GaN transistor developed by NICT



Q What is a millimeter wave?

A A millimeter wave is a radio wave with a frequency of 30 to 300 GHz (corresponding to wavelengths of 10 to 1 mm). The high frequency of millimeter waves allows both for wideband transmission and the miniaturization of antennas and transmission equipment. Due to their high, light-like linearity, millimeter waves are best suited for wideband information communications over short distances. However, these waves are susceptible to attenuation caused by rain, snow, or clouds.

Q What kind of a substance is gallium nitride?

A Gallium nitride, expressed as the chemical formula "GaN," is a compound semiconductor that consists of nitrogen and gallium. GaN has recently leapt into prominence as a material for new blue laser-emitting diodes (LEDs) and blue laser diodes. GaN is a chemically stable substance, and offers a fairly high electron saturation velocity relative to other semiconductors, despite its exceptionally high breakdown voltage. Due to these characteristics, we can expect to see GaN components in a wide variety of electronic devices.

Development of higher frequency GaN transistors

As mentioned above, to improve the high-frequency characteristics of a transistor, we must reduce its gate length. However, when the gate length is 0.1 μm or less, it becomes necessary to address various problems that arise in addition to the reduction in breakdown voltage mentioned above. To fabricate the structure of a GaN transistor, we adopted a crystal growth technique referred to as "RF plasma-assisted molecular beam epitaxy," or RF-MBE (Photo 1). We faced a number of challenges in this endeavor: in the device technology required to fabricate electrodes, surface passivation

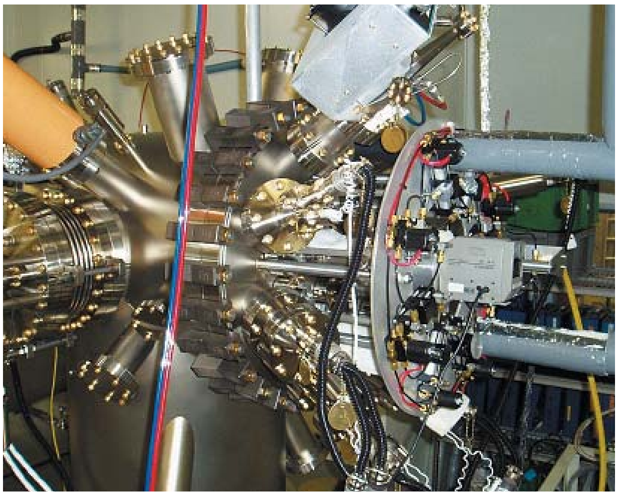


Photo 1: RF plasma-assisted molecular beam epitaxy (RF-MBE) system

films, and othercomponents, all of which we overcame after a great deal of trial and error. As a result, we succeeded in developing a GaN transistor offering a significantly higher operating speed (or operating frequency). To date, this new GaN transistor has achieved the world's highest current gain cutoff frequency (fT), at 163 GHz, and a maximum oscillation frequency (fmax) of 192 GHz (Figure 2). These results indicate that the new GaN transistor offers an operating speed approximately 30% faster than existing GaN transistors. In comparisons with other semiconductor materials in terms of operation frequency, the performance of the new GaN transistor far exceeds that of a silicon transistor (the most popularly used transistor), with results comparable to those obtained with a gallium arsenide transistor (used in automotive radar equipment and the like). In short, we developed a transistor that delivers comparable or higher operating speed and power tens or hundreds of times greater than existing semiconductors. To achieve sufficient

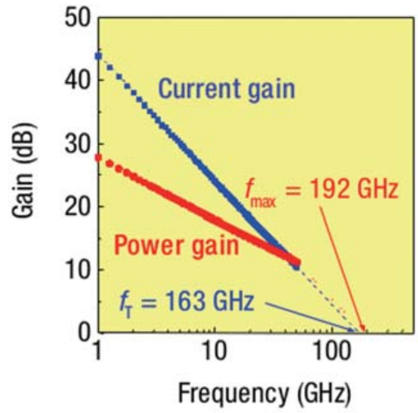


Figure 2: Small-signal characteristics of GaN transistor developed by NICT

gain in the actual operating frequency of transmitter circuits, fT and fmax must usually be two to three times higher than the actual frequency. In this respect, our results show that the operable frequency range for GaN transistors has increased to 50 to 60 GHz or higher. This represents a significant step toward the practical use of high-power transistors in the millimeter-wave band—an innovation that would otherwise be impossible using conventional semiconductor materials.

Research results and new goals

Our research efforts to date have, for the first time, rendered feasible the use of GaN transistors in the V band (50 to 75 GHz), an area currently attracting attention as a particularly valuable segment of the millimeter-wave band—particularly in terms of applications in high-speed wireless LANs, next-generation intelligent transport systems (ITSs), and satellite-borne wireless equipment. We will continue in our R&D in this area in our efforts to add even more power and higher operating speeds to the new GaN transistor, through improvements in the crystal growth technique, device structure, and production process.

Life & Tech-nology

● Expectations for use of gallium nitride transistors in next-generation ITS

The field of next-generation intelligent transport systems (ITS) is one of many fields in which the newly developed GaN transistor holds potential for practical use. Currently, the most popular ITSs include vehicle information and communication systems (VICS), dedicated short range communications (DSRC), and electronic toll collection (ETC) systems. It is widely assumed that we will witness the development of a next-generation ITS consisting of an inter-vehicle communications system using the 60–76 GHz millimeter-wave band. This system will be designed to communicate various types of information—on accidents and the approach of emergency vehicles, for example, or warnings for abrupt braking or children playing nearby. Using the GaN transistor, we are now developing devices for such use in the frequency range of 50 to 75 GHz. In collaboration with various partners in industry, applied research is also underway with an eye to commercialization of such systems within five to six years.

Fumitake Sawada
Expert, Intellectual Property and Alliance Division,
Strategic Planning Department

Venture Support at NICT

— USB Flash Drive is Now a "Key" for Your PC —

NICT's Intellectual Property and Alliance Division helps convert research results to intellectual property, promotes practical use of such IP, facilitates collaborative research, and offer support to researchers. In this article, we will discuss the use of these research results in more detail.

To encourage the practical use of research results, we have established what we refer to as our "Pre-venture Program" (for details, see the November, 2002 issue). This program, launched in 2002, was designed to support the entrepreneurial activities of our researchers at NICT, based on their own research results. A proposal by Mr. Umeno (Senior Researcher), "Development of chaotic cipher chips" was among those initially selected under the auspices of this program. Armed with his chaotic cipher technology, Mr. Umeno established the "ChaosWare Inc." venture business in August 2003, after a year and a half of preparatory activities. ChaosWare's products include file encryption software (VSC-P2P) and a built-in chaotic cipher tool (VSC-SDK). VSC-SDK-based products have now been adopted by major domestic video rental shops and photo studios specializing in children's portraits.

As an extension of VSC-P2P, ChaosWare has developed its "CIPHERON Initiative" (Cipheron), which has been available as a free download from the company's website since October 18.

The main feature of Cipheron is its automatic folder encryption function. This function allows you to decrypt and encrypt files in a folder you specify in advance merely by inserting or removing a commercially available USB flash drive (Figure 1). Unlike a conventional encryption system, which involves some sort of mouse operation each time you encrypt or decrypt a file, Cipheron allows you to encrypt files as easily as locking a safe, a convenient solution now available even to the novice PC user. If you use Cipheron, your USB flash drive will function literally as a key for your PC: you can ensure the security of your data with no required attention to the details of the encryption and decryption procedures (Figure 2). Of course, you can also use this USB flash drive as an ordinary storage medium.

Figure 2: Use of USB flash drive as a PC key (conceptual drawing)

ChaosWare, the first venture business developed by NICT, has been quite successful to date; now near completion of the product-development phase, the company has moved on to full-scale sales promotion. Embarking on a venture business is certainly challenging, but it is much more challenging to keep the business going and to make it grow. Accordingly, the Intellectual Property and Alliance Division will continue to offer its support to venture businesses born at NICT.

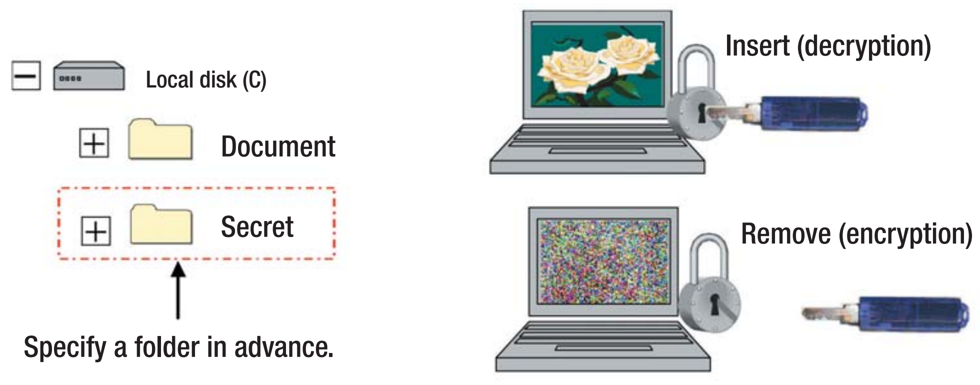


Figure 1: Automatic encryption/decryption using CIPHERON (conceptual drawing)

Female Researchers at NICT vol.4

There are currently about 80 women researchers or staff members at NICT.
NICT News is pleased to feature a series of interviews with our female researchers.

Opening Up a New World of Language Studies through the Integration of Humanities and Engineering

Kyoko Kanzaki, Computational Linguistics Group, Information and Network Systems Department

Dr. Kyoko Kanzaki
Completed a doctorate course at Waseda University Graduate School of Letters, Arts and Sciences (undergraduate majors: linguistics and Japanese) in 1998. Joined the CRL (currently NICT) as guest researcher in April 1998. Awarded Ph.D. (Kobe University Graduate School of Science and Technology) in 2001. Became permanent staff member in April 2005, following long-term engagement as an expert researcher. Mainly engaged in vocabulary research using natural language processing techniques.

Ways to research languages

—What specifically is natural language research? And what made you decide to enter the field of natural language processing?

Kanzaki: A natural language is a language people use in everyday life. The scope of research covers speech, phonology, letters, Lexis, grammar, pragmatics, and discourse. Simply put, the aim of linguistic research is to explain, empirically and theoretically, the phenomena and underlying rules of language comprehension, speech, and conversation. On the other hand, the aim of natural language processing research is to develop an effective way for a computer to process natural language as well as the knowledge or information that this language holds. Take, for example, the expression “the cat is holding a mouse.” With this expression, linguists will syntactically explain “who” has “what,” and why such an interpretation can be made. On the other hand, “the cat is holding a mouse” is merely a character string for a computer in terms of natural language processing. What researchers need to do is to give the computer the rules it needs to understand these words. Then, the computer will extract the information: the agent here is “a cat” (noun); the action is “holding” (verb); the object is “a mouse” (noun); and “holding a mouse” modifies “a cat.” Essential in language processing is the processing of large volumes of documentation in order to extract the necessary information or knowledge. Therefore, linguistic findings and statistical methods are particularly important in the language-processing field.

I studied linguistics at Waseda University, where Japanese linguistic research was conducted using traditional methods: observation of large amounts of real data to form theoretical explanations—as opposed to adoption of the theoretical linguistic approaches proposed by Chomsky. Back then linguists would traditionally organize language data in the form of cards for use in analysis. However, at the same time we were seeing a major transition from this and similar traditional methods toward computer-based methods, which were expected to add a new dimension to linguistic data analysis. In addition, researchers in natural language processing and linguistics were working together to create computerized dictionaries for use in natural language processing. Against this backdrop, I was performing studies relating to Lexicon (which refers to all of the constituent words in a given language), which gradually led me to become interested in natural language processing.

—Could you explain how natural language processing is related to information communications technology?

Kanzaki: Advances in information communications technology are widely believed to have the potential to promote communication between people and machines through language. To give an example of the issues involved, imagine that the person you are speaking to is using synonyms for a given concept. Despite the synonyms, you will probably understand exactly what he or she is referring to. This is because people understand the abstract concept behind the synonyms. However, if you want a computer to understand abstract concepts, you will have to give the computer this information in advance. This is why natural language research is critical to the field of information communications. This sort of natural language processing research is expected to help us arrive at highly accurate Internet-search and translation technologies.

—It seems that your research field represents an integration of the humanities and engineering, doesn’t it?

Kanzaki: Natural language processing is one of the few fields where researchers in both humanities and engineering fields can work together. Since language is the subject of research, we need to have an awareness of both fields—both linguistics and natural language processing. For example, my work involves determining the types of linguistic knowledge and the basic information required for a computer to understand human language and to create sentences like we do. In this sense, my research into Lexicon is related to natural language processing. As a matter of fact, a number of my colleagues in this also come from various departments in the humanities.

Stimulation of both linguistic and language processing research

—You became a permanent staff member after working first as a guest researcher and then as an expert researcher. What are your impressions of this employment process?

Kanzaki: Dr. Isahara, our current group leader, told me about CRL (currently NICT) when I was in my third year of graduate school. I was hired by CRL as guest researcher in 1998. At that time, I was also considering continuing to study at university, but I was keenly interested in natural language processing research and I decided this institute would be the ideal workplace for me.

In universities, postdoctoral fellows and assistants work on a fixed-term basis. I worked on a fixed-term basis as guest researcher and expert researcher before becoming permanent staff member here in a similar way. So this employment process didn’t seem strange to me.

—What is it you most hope to achieve through your research activities?

Kanzaki: I intend to continue to try to stimulate research both in linguistics and in the natural language processing I have been involved in as a researcher to date. I hope that some day in the future I will able to make a linguistic discovery and use it to develop a sophisticated artificial intelligence machine or robot that can hold a conversation with a human interlocutor. I also have a hope for the more immediate future: to develop a system that can automatically build sentences from a large corpus of text data through the systematization of abstract concepts.

Dr. Kanzaki and other women researchers in the Computational Linguistics Group (in a public relations office in Keihanna Center)

Report on Participation in CEATEC JAPAN 2005

Takahiro Komine
Director, Key Technology Research Supporting Division, Key Technology Research Promotion Department

CEATEC JAPAN 2005 took place at Makuhari Messe from Tuesday, October 4 through Saturday, October 8, 2005. This event, hosted by the Japan Electronics and Information Technology Industries Association (JEITA) and two other participating organizations, is one of the largest international trade shows in Asia dealing in imaging, information, and communications technologies. During the five days of this sixth exhibition, the number of visitors reached a record high of 199,000.

At this exhibit, NICT's Key Technology Research Promotion Department ran a booth to publicize the results of its commissioned research activities based on its "Key Technology Research Promotion Program for the Private Sector." We set up exhibits and demonstrations of the results of 16 research subjects (by 11 companies), six of which came to completion in fiscal 2004. We were able to present the results of our commissioned research to the many visitors that came to the NICT booth to view these demonstrations. On October 6, the Parliamentary Secretary Yamamoto (Ministry of Internal Affairs and Communications) himself visited the NICT booth.


NICT booth


Visit by Parliamentary Secretary Yamamoto

NICT's commissioned research results

Commissioned companies	Exhibits
Eizoh Co., Ltd.	Motion picture distribution system using super-high-definition omnidirectional camera
NEC Soft, Ltd.	Electronic voting system using commercially available IC cards
Oki Electric Industry Co., Ltd.	Multilingual translation system
Advanced Telecommunications Research Institute International	Speech translation system for tourists; ad hoc wireless network with built-in private key transmission; a "talking head" that generates animated facial images; artificial brain model; demonstration of the "Robovie" communication robot; intelligent interface technology for patients with minor brain damage; knowledge-sharing system for medical/nursing-care facilities
Sumitomo Electric Industries, Ltd.	Demonstration of video on demand with an ultrahigh-speed packet loss compensation technique
NEC Corporation	LSI module with built-in ultrasmall low-cost optical I/O (10 Gbps/ch)
Victor Co. of Japan, Ltd.	Communications system using small optical wireless modules
Hitachi Kokusai Electric Inc.	Wireless access system enabling transmission at up to 100 Mbit/s over 10 km
Fujitsu Limited	Antenna system using RF-MEMS devices for mobile communications equipment
Mitsubishi Electric Corporation	Technology for network distribution of super-high-definition digital archive images
YRP Ubiquitous Networking Laboratory	Demonstration of ubiquitous communicator (UC)

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