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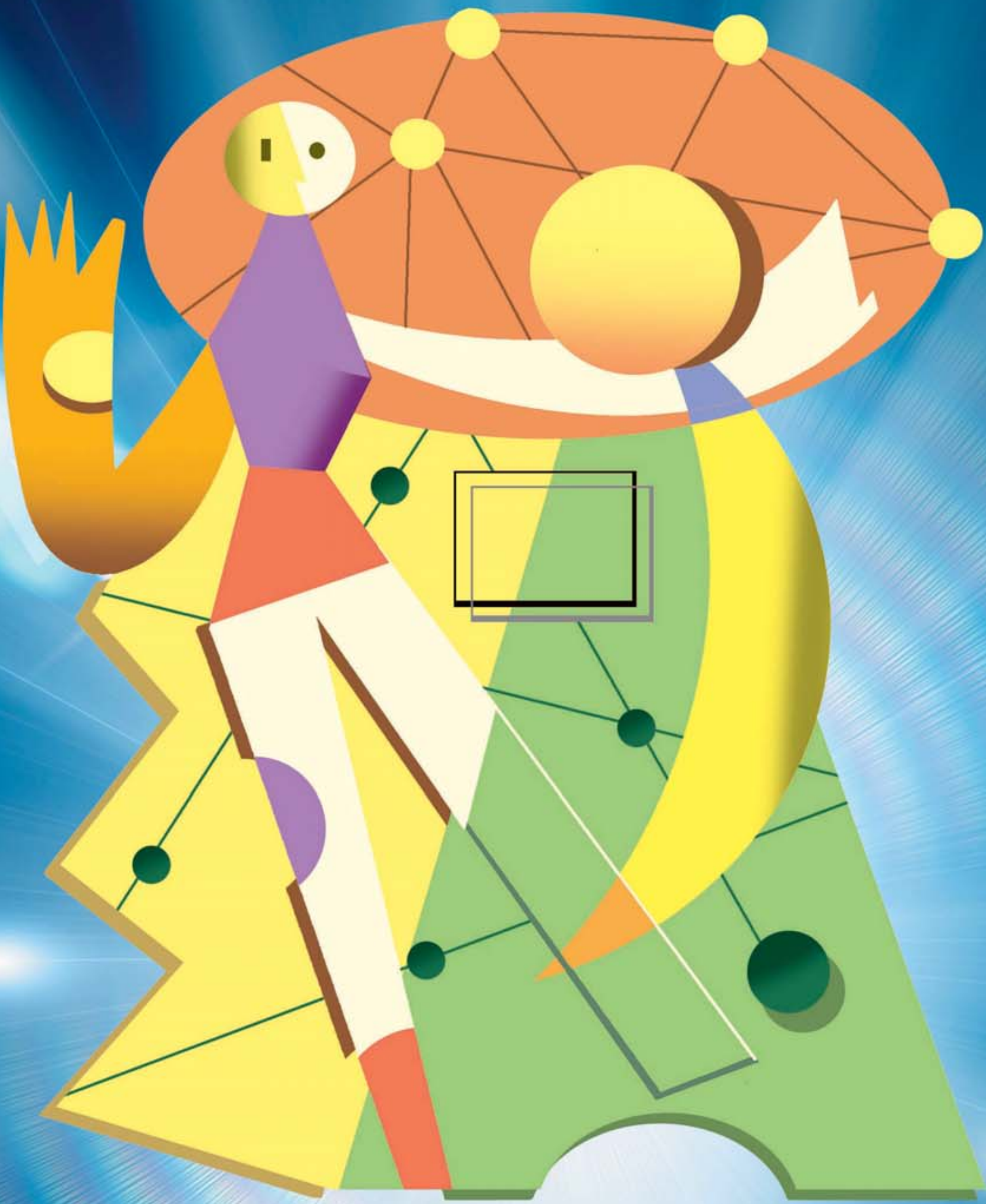
NICT NEWS

National Institute of Information and Communications Technology



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Activities of Optical and Quantum Communications Unit

— Toward the Development of Future Information and Communications Technology —

Hideyuki Oku, Executive Director, Optical and Quantum Communications Unit

Introduction

Facing the advent of the ubiquitous broadband society, we are seeing growing demand for the further increase of communications capacity and ensuring reliability there. We now need to accelerate developing new principles to evolve existing optical communications networks. The Optical and Quantum Communications Unit aims to establish ultrahigh-density lightwave communication technology by controlling the wave-like nature of light to the utmost limit, as well as the quantum information communication technology by even controlling the particle-like nature of light, and conducts activities through industry-academia-government cooperation, utilizing NICT's various R&D promotion methods. Figure 1 shows an overview of these activities.

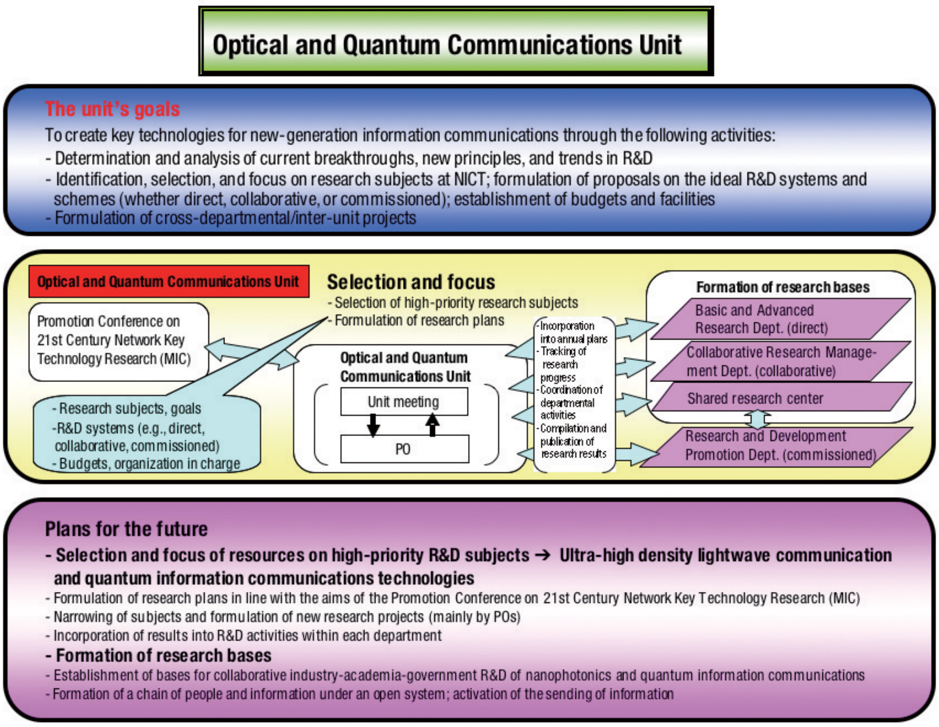
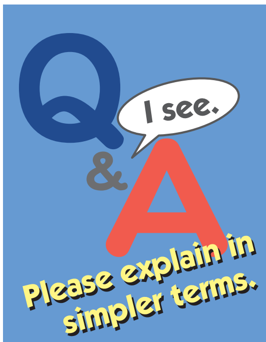


Figure 1: Overall Structure of Optical and Quantum Communications Unit

R&D of ultrahigh-density lightwave communication technology

In existing optical communications, information is transmitted only by controlling the intensity of light, in contrast to wireless communications using radio waves, whose characteristics as waves are fully utilized. Light is also a wave, but it is not easy to control light waves because they have extremely smaller wavelengths than radio waves. The evolution of optical communications networks begins with controlling light waves. A wave is characterized by three elements: intensity (amplitude), oscillation rate (frequency, corresponding to color in the case of light), and oscillation timing (phase). We are developing technologies to control these three elements quickly and stably. In the field of optical communications technology, research has so far focused on amplitude and phase modulations, while frequency modulation has rarely been used due to the lack of technologies to change optical frequencies quickly and stably. To address this problem, NICT has developed the world's first high-speed optical frequency shift keying modulator with a unique device structure. This technology enables us to vary the intensity, color, and oscillation timing of light in a rapid and stable manner. The relating results are contributing to the transfer of technology to companies and to the development of new products. We are now conducting basic research to realize a next-generation ultra-high density lightwave communication technology by integrationally controlling the three elements of lightwaves. In addition, we are not only grappling with the enlargement of transmission capacity, but also actively developing new functions such as advanced signal controls, for example, packet-destination signal processing, signal format conversion, etc.



Q What do you mean when you say "Light is a wave?"

A A sea wave travels, oscillating with a wavelength of several meters, while light travels at a wavelength of about one micron (one-thousandth of one millimeter). Light with shorter wavelengths looks blue, and light with longer wavelengths looks red. A rainbow is formed by light that is separated into lightwaves of various colors after propagating through the air. Existing optical communications simply use the presence and absence of light to express information in terms of ones and zeros. In contrast, lightwave communications technology allows us to express and transmit more complex information through control of light color, amplitude, and positional relations among waves.

Q What do you mean when you say "Light is both a wave and a particle?"

A Let's compare a continuous lightwave to a flow of water from a faucet. When you gradually turn off the faucet, the water will start to flow intermittently, like raindrops. Likewise, when you weaken light, it will become intermittent. This intermittent substance or particle, which cannot be divided further, is called a "photon." Of course, individual photons are too weak to be visible to the human eye. Similarly, electricity is the flow of electrons, indivisible electrically-charged particles. An indivisible particle such as a photon or electron is called a "quantum," which means a "minimum unit of quantification."

R&D of quantum information communication technology

Light is a wave and also an ensemble of energy particles, that is, photons. In the late 20th century, photons' mysterious properties beyond intuition were verified one after another, and proved to have the possibility of introducing great innovations in ICT. For example, by utilizing the uncertainty principle in quantum mechanics, according to which photons behave, the perfect detection of wiretapping and the technology of unconditionally secure quantum cryptography become possible. Additionally, the superposition principle in quantum mechanics allows us to create and control situations in which more than one different states of photons simultaneously exist in parallel Quantum coding using this principle will enable large-capacity transmission unattainable by conventional optical communications technology. These quantum mechanical phenomena, which have simply appeared paradoxes, will develop into revolutionary information-communications technologies in this 21st century.

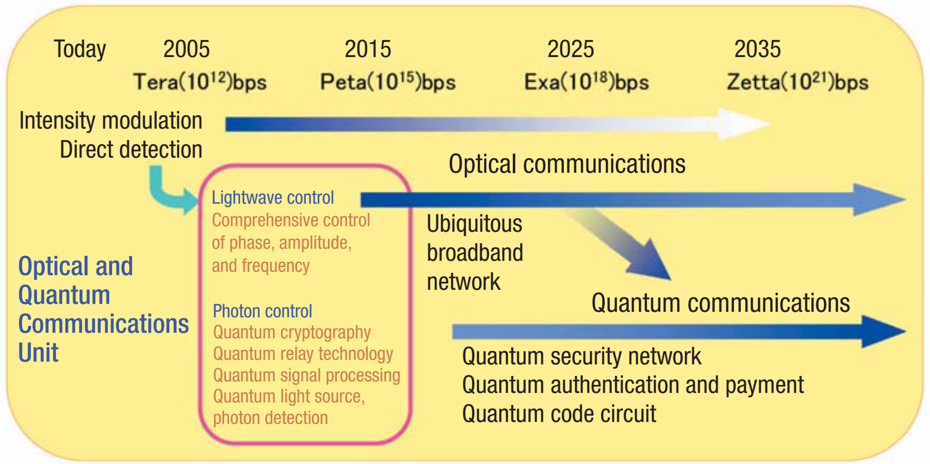


Figure 2: Road map of optical and quantum communications, and strategic subjects for the Optical and Quantum Communications Unit

The Ministry of Internal Affairs and Communications (MIC) and NICT have been conducting strategic and comprehensive R&D of quantum information communications. Research into quantum cryptography, now comparatively approaching practical use, has been carried out mainly by the Research and Development Promotion Department (through commissioned research). Research results have included a successful field experiment of communications over an unprecedented 96 km using an existing fiber-optic line; the development of an on-board quantum cryptography system that operated continuously on a commercial fiber-optic line for 14 days; and the confirmation of maintaining quantum correlation between two points 20 km apart, generating quantum entangled photon pairs at a repetition frequency of 100 MHz. Meanwhile, the Basic and Advanced Research Department has also achieved a number of noteworthy results: the world's first demonstration experiment on the principle of super-additive quantum coding gain that leads to the fact that transmission capacity can be more than doubled by doubling bandwidth and code length; the development of the world's highest-performance photon-number resolving detector, employing semiconductor light-receiving elements; and the generation of single-photon-state with waveforms temporally controlled.

Based on these results, the Optical and Quantum Communications Unit is now studying high-priority subjects hereafter and more effective R&D measures and systems, mainly through the Promotion Conference on Quantum Information Communications Research, attended by representatives of 22 research teams in total from industry, academia, and government. In the next medium-term plan starting in fiscal 2006, we will urge our R&D, focusing on the following four subjects: (1) development of a quantum cryptography system for use in urban areas; (2) development of a quantum relay technology to increase the effective distance of quantum cryptography; (3) research into quantum signal processing required to increase transmission capacity and to create next-generation standard technologies; and (4) development of foundational light-source and detection technologies.

Conclusion

Figure 2 shows a road map for optical and quantum communications in which we position the strategic subjects of our unit, as described above. Adding new technologies by lightwave control to the natural extension of current optical communications, we will build the foundations of realizing a ubiquitous broadband network with transmissions speeds of the order of peta (10^{15}) bits per second. In addition, fusing quantum cryptography technology together will ensure robust information security. Quantum signal processing and quantum relay technologies for longer-distance transmission will then open the door to further advanced networks with transmission speeds at exa (10^{18}) or zetta (10^{21}) bits per second. Eventually, we will see the coexistence of optical and quantum communications, with future networks configured to get the most out of both in response to balance with physical limitations and costs.

We have appointed program officers (POs) in our Unit. POs are in charge of the analysis of R&D trends in related fields, the identification of the most important research subjects for NICT, and the realization of collaboration among different projects in executing and promoting R&D. Based on their suggestions, we are planning to conduct strategic R&D of future information and communications technologies that will eventually enable the comprehensive control of the wave nature of light as well as the properties of photons.

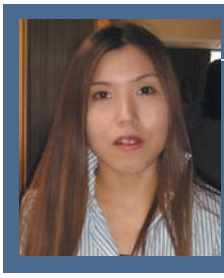
Life & Technology

● Advances from optical communications to lightwave and quantum communications

Fiber-optic communications services already allow you to communicate with people far away as if they were right beside you. It is not hard to imagine that in the future—say, in twenty years—people at home will be able to have consultations with a far-off doctor of repute. To reach this point, we will have to develop technology to provide transmission capacity equivalent to one billion present telephone lines (at a rate of the order of petabits per second) with a single optical fiber thinner than a hair, in addition to technology to perfectly protect personal information against leakage and wiretapping. Lightwave communications technology will enable such large-capacity communication, and quantum cryptography using photons will enable absolutely safe encryption.

Term Acquisition from Web Documents for Retrieval

— R&D at Keihanna Info-Communication Open Laboratory —



Eiko Yamamoto

Expert Researcher, Computational Linguistics Group, Keihanna Human Info-Communication Research Center, Information and Network Systems Department

Ph.D. in engineering. Joined CRL (currently NICT) in 2002. Currently researching automatic extraction of linguistic information from large sources ("text mining") within the Computational Linguistics Group.

Introduction

With the widespread use of Internet search engines, even general users are now familiar with information retrieval and extraction. To support these functions, extensive researches have been conducted in the field of natural language processing, being continuously pursued for the improvement of their accuracy. An example of the information retrieval is, a "net search" on the Internet, in which if you enter "紅葉狩りの名所, the search engine will list web pages related to famous maple-viewing locations. On the other hand, the information extraction means operations to arrange and output information related to the specified matter, such as famous maple-viewing sites' names, and their addresses. In both techniques, it is necessary to analyze the text in target documents, however, such analyses may often be unsuccessful if the text contains newly coined terms. These terms, not yet registered in dictionaries, are referred to simply as "new terms." On the Internet, new terms appear every day, reducing the accuracy of retrieval and extraction processes. To address this problem, research into the acquisition of new terms is now underway, using newspaper articles etc. However, unlike in newspaper articles, terms on the web are less standardized and often spelled differently (for example, "コンピュータ" vs. "コンピューター"); it thus becomes difficult to acquire new terms automatically and efficiently.

To utilizing new terms for information extraction, we need to distinguish their attributes, for example, whether the new term is someone's name, the name of an organization, or a technical term in a specific field. Such attributes can then be used to organize the data. However, it has been difficult to distinguish such attributes automatically with high accuracy.

The Computational Linguistics Group has developed a technology for extracting new terms from a collection of web documents and identifying those new terms' attributes *1. This technology mainly consists of two techniques: acquisition of terms from web documents, and their registration after identifying their attributes (Figure 1). In this article, I will describe the former technique for acquiring terms from a collection of web documents ("Term acquisition").

*1 The development of this technology was one of the results of joint research by Oki Electric Industry Co., Ltd. and NICT at Keihanna Info-Communication Open Laboratory.

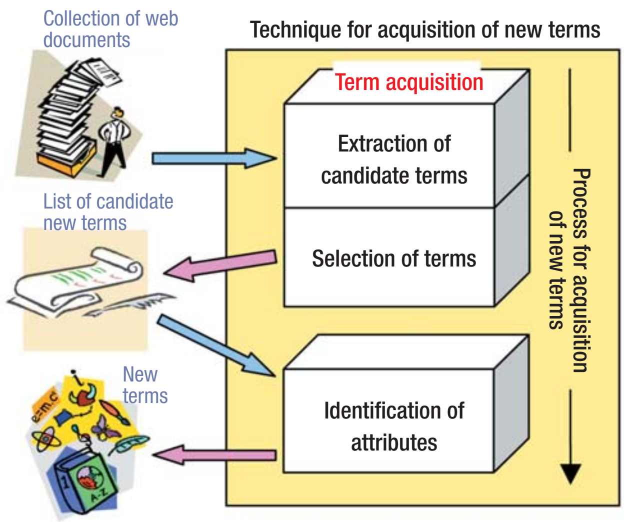
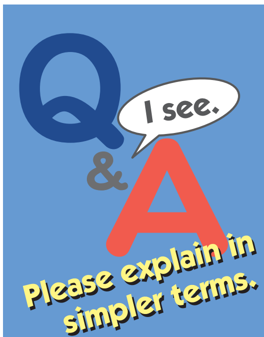


Figure 1: Process for acquiring new terms from web document collection

Term acquisition

This technique involves the acquisition of terms from morpheme strings. A morpheme is the smallest unit of elements constituting a sentence. In other words, a sentence can be considered as a string of morphemes. For example, the sentence "秋は紅葉狩り" will be interpreted as a sentence consisting of five morphemes: "秋/は/紅葉/狩り/。". As you will note, the period is also considered a morpheme. In terms of morpheme groups, this sentence may be divided into, for example, two-morpheme strings: "秋/は", "は/紅葉", "紅葉/狩り", "狩り/。".

Term acquisition consists of two stages: an extraction of candidate terms and selection of terms (Figure 1). First, statistical indicators are



Q What is information extraction?

A This refers to the process of taking out useful information from text based on criteria specified in advance. This technique allows you to extract words with specific attributes from text and obtain an overview of a large amount of information in a short time. This process can also be applied to extract only the necessary information from search results for presenting to users.

Q What is morphological analysis?

A This is the process of dividing a sentence into morphemes, the smallest unit of grammatical meaning in a language, and ascribing information to each (e.g., part of speech kana notation, etc.). Morphological analysis is the most basic text-processing technique, and has a wide range of uses, from keyword extraction for information retrieval and kana-kanji conversion to application in various software programs (including text summarization and machine translation).

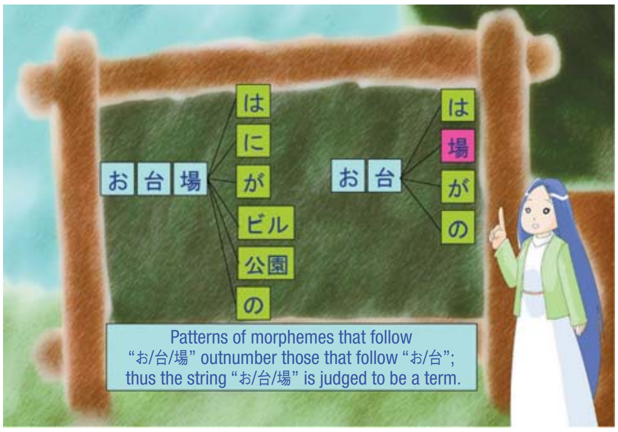


Figure 2: Concept of “selection of terms”

used to select all one-morpheme to five-morpheme strings that appear in a large number of documents, and also appear repeatedly in several documents. In this way, we have enabled a computer to emulate a human sense to recognize and understand unknown terms. Next, the strength of connection between the constituent morphemes of each candidate term is assessed to arrive at a guess as to whether or not it is in fact a term. Figure 2 shows a conceptual diagram of a method of guessing whether “お/台/場” is a term. To do so here, statistical indicators are used to verify the hypothesis that if “お/台/場” is a term, the kinds of morphemes following it will outnumber those following “お/台” or “台/場”. In this way, we have enabled a computer to emulate such a sense as humans can guess the rest of content only

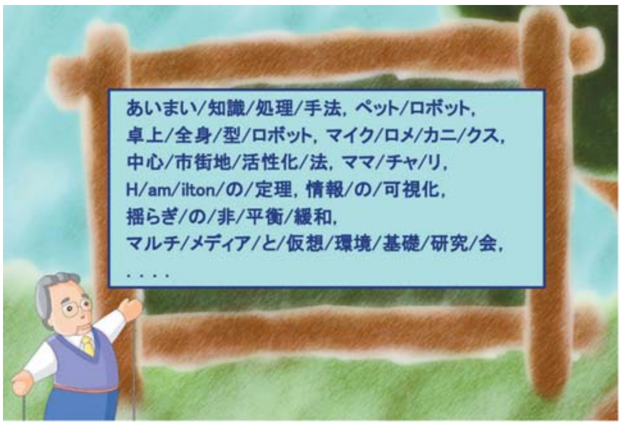


Figure 3: Example of terms acquired actually

on hearing its portion.

Figure 3 shows some of the actual terms that were acquired from web documents using this technique. We collected these documents from the website of a university’s college of engineering. Many methods have been developed to acquire single nouns and complex nouns consisting of two or more nouns as terms. Nouns acquired by these methods are likely to be terms, but these methods cannot acquire terms that have been broken up due to incorrect automatic analysis of text. In contrast, our technique can acquire such divided terms. Designed to acquire all types of morphemes besides single nouns and complex nouns, this technique can acquire even long noun phrases such as titles of technical papers including verbs and particles.

Processing capacity

With an eye to the application of this technique in practical systems, we have been working to enhance processing speeds. While conventional methods extract candidate terms from character strings, this technique acquires terms from morpheme strings in order to shorten the processing time. Currently it takes an average of one day for this technique to acquire terms from 200 megabytes of text in collected web pages (100 million words, comparable to nearly two years of newspaper articles) and to identify the attributes of these terms. This capacity allows for the acquisition of terms from web pages within a specific domain every two months, for example. These terms can then be used to improve the accuracy of retrieval and extraction systems.

Conclusion

We are now working on the application of this technique to reinforce the retrieval support functions of Bluesilk®*2, a tool used in particular in collaboration between industry and academia. Our aims are to improve performance of term acquisition and to apply this technique to a range of other practical systems.

Through research into foundational technologies for linguistic information processing and the development of practical systems based on these technologies, the Computational Linguistics Group continues aiming at making the Internet and computers easier to use.

*2 Bluesilk® is a registered trademark of Mitsubishi Research Institute, Inc.

Life & Tech-nology

● Toward the improvement of retrieval accuracy in web

When someone is seeking information on a particular subject, the Internet now seems more convenient to turn to than traditional resources, such as consulting a dictionary or asking another person. However, the language we use is constantly changing, with the continual emergence of new terms and phrases. As a result, our attempts to find information by entering a number of known words are occasionally fruitless. We hope that, as a result of the R&D described in this article, search tools will become “smart” enough to solve this problem and to ensure that we can find the desired information.

Signing of Memorandum of Agreement on Research Partnership with Indian Institutions

Kiyoshi Igarashi
Director, International Alliance Division, Strategic Planning Department

NICT has signed a memorandum of agreement on a research partnership in the field of information and communications technology with the Centre for Development of Advanced Computing (C-DAC), the Centre for Development of Telematics (C-DOT), and the Indian Institute of Technology, Guwahati (IITG). The signing ceremony was held in the presence of Japanese Home Affairs and Communications Minister Taro Aso and Indian Communications and IT Minister Dayanidhi Maran on Wednesday, August 24, 2005 at Oberoi Hotel in New Delhi.

These four parties agreed to establish a system of research based on mutual cooperation and goodwill through exchanges of researchers and information, fellowship programs, symposiums, and joint research projects. With each of these Indian institutions, NICT shall form separate partnerships in research fields of mutual interest based on the principles of equal standing and reciprocity. The IITG, in particular, has been interacting closely with Yokosuka Radio Communications Research Center. The parties have already begun cooperative research in the terrestrial wireless communications, satellite communications, and ubiquitous technology.

After the signing ceremony, a Japan-India ICT Forum was held, with the attendance of some 100 members of the Japanese business community (led by Mr. Yoichi Morishita, Chairman of Matsushita Electric Industrial Co., Ltd.) and top managers from major private companies in India. This forum provided an opportunity for discussion of the latest ICT business and R&D as well as for personnel exchanges between the two countries.

Signing ceremony

Japan-India ICT Forum

Report on NICT Universal Communications Symposium

Hiroshi Emoto
Senior Researcher, Information and Network Systems Department

On Thursday, September 8, 2005, we held the “NICT Universal Communications Symposium: Toward the Start of the Book City Project” at the Tokyo International Forum.

To promote people-oriented communications in a future ubiquitous society, NICT has been conducting R&D based on the concept of “universal communications.” As part of these R&D activities, we are planning to carry out what has been designated the “Book City Project.” This symposium was held to solicit advice from outside experts and others about the future direction of our research efforts, as well as to increase public awareness of the project.

We received advice from Mr. Seigo Matsuoka, Director of the Editorial Engineering Laboratory (Mr. Matsuoka in fact created the concept behind the project) and other experts in various fields attending the symposium as speakers or panel members. There were approximately 200 visitors in all, including a range of people involved in the arts and culture, as well as attendees from the science and technology fields. This symposium turned out to be quite a significant one, as indicated by one attendee’s comment: “This is a novel and aggressive initiative that marks a new approach by NICT.”

We are planning to establish a consortium to promote the project to facilitate cooperation between internal and external researchers, enabling them to pursue a consistent stream of projects addressing the development of constituent and system technologies.

Speech by President Nagao

Panel discussion

Female Researchers at NICT vol.3

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.

Looking at the Stars and Making Time

Yuko Hanado, Senior Researcher, Time and Frequency Measurements Group, Applied Research and Standards Department

Ms. Yuko Hanado
Majored at university in solid state physics, mainly in the study of magnetism of rare-earth alloys. Joined the CRL (currently NICT) in 1989. Engaged in work related to VLBI at Kashima Space Research Center until 1995. Currently involved in work related to Japan Standard Time at Koganei HQ.

How I entered this profession

—You have said that you were first interested in astronomy.

Hanado: When I was in high school, I was interested in astronomy, especially radio astronomy. I majored in solid-state physics at the university, though, because opportunities to study radio astronomy were extremely limited. However, my enthusiasm for studies in this field continued. Then in my job search, I saw that CRL's Kashima Branch (currently NICT's Kashima Space Research Center) was performing the radio observation of stars. I took a civil service exam and was hired in 1989.

After joining the CRL, I was assigned to the Kashima Branch, since I wanted to work on projects related to VLBI (Very Long Baseline Interferometry). At the same time, I started to work on the radio observation of stars known as "pulsars." A signal from a pulsar flashes with extremely precise regularity. So we conducted basic research to explore the potential use of this signal as a space clock, as well as for use in combination with an atomic clock to arrive at a more stable clock. Although my main job changed with the transfer to Koganei Headquarters ten years ago, I have continued to observe pulsars in Kashima once a week.

—What kind of research are you working on now?

Hanado: I am working on R&D related to standard time, which is quite different from my previous research subject at the Kashima Branch. For the first few years at headquarters, I was working on the management of the atomic clocks and measurement systems at the Time and Frequency Standards Section (currently the Japan Standard Time Group). I also worked on the maintenance and upgrading of the Japan Standard Time system and of the JJY LF station measurement system. Currently my main task is the development of a new system of the Japan Standard Time. On my own, I have begun researching time scale algorithms, with the aim of making a more stable clock. I believe this research will eventually have a connection to the research into pulsars mentioned above.

Endless questions about time

—What do you find interesting or fascinating about research into time?

Hanado: Time is a kind of "yardstick" we generally use without questioning it. However, since I am involved in the task of actually making this yardstick, I always have to wonder, for example, if I have correctly marked the scale and how to verify whether it is correct. You can determine the amount of deviation by comparing the value with a standard, but what is a reliable standard? It's my job to rack my brain over these questions. I sometimes feel as if my life would be easier if I could just find a reliable answer; then I could stop thinking about these questions. Still, I take pleasure in the methodical search for a solution. I find it fun and challenging to pursue this sort of research, where I'm constantly working to answer my own questions.

To distribute standard time, we need to meet extremely rigorous system requirements, including the prevention of any stops and skips, easy and quick recovery from any problems, and high-quality signals. This is really hard work, but I feel a strong sense of achievement when we work together as a group to overcome these difficulties. I think that I have stayed with my research activities in this and other fields because I occasionally get the opportunity to be pleased with these kinds of achievements.

—What do you most hope to achieve through your research into time?

Hanado: I think there are some points in common between the research into algorithms for producing standard time using atomic clocks and the research into a pulsar time system. It is exciting for me to analyze the characteristics of individual clocks and to think about the best way to combine them. My dream is to develop a general principle that can be applied both to atomic clocks and to the pulsar time system. It will be also an exciting challenge to devise a system that will put this principle into practical use.

Fostering researchers to inherit research into time

—A great deal of attention is now being given to the time business, to radio-controlled clocks, and to a range of other issues related to the use of time. What do you feel are the needs with regard to the research environment?

Hanado: I feel a sense of crisis about the shortage of younger researchers. If there is no generation to take over a research project when it reaches a certain level after years of efforts, staff transfers carry the risk of stalling the project in its tracks. Even if others resume the task from zero after some time, they won't go any further forever; these new researchers will also be left behind by their counterparts in other organizations in the same field. I strongly hope the institute will hire young researchers at sufficient frequency to allow us to pass on our expertise and research results.

Ms. Hanado in front of the JST system in Building No.3 of Koganei HQ

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