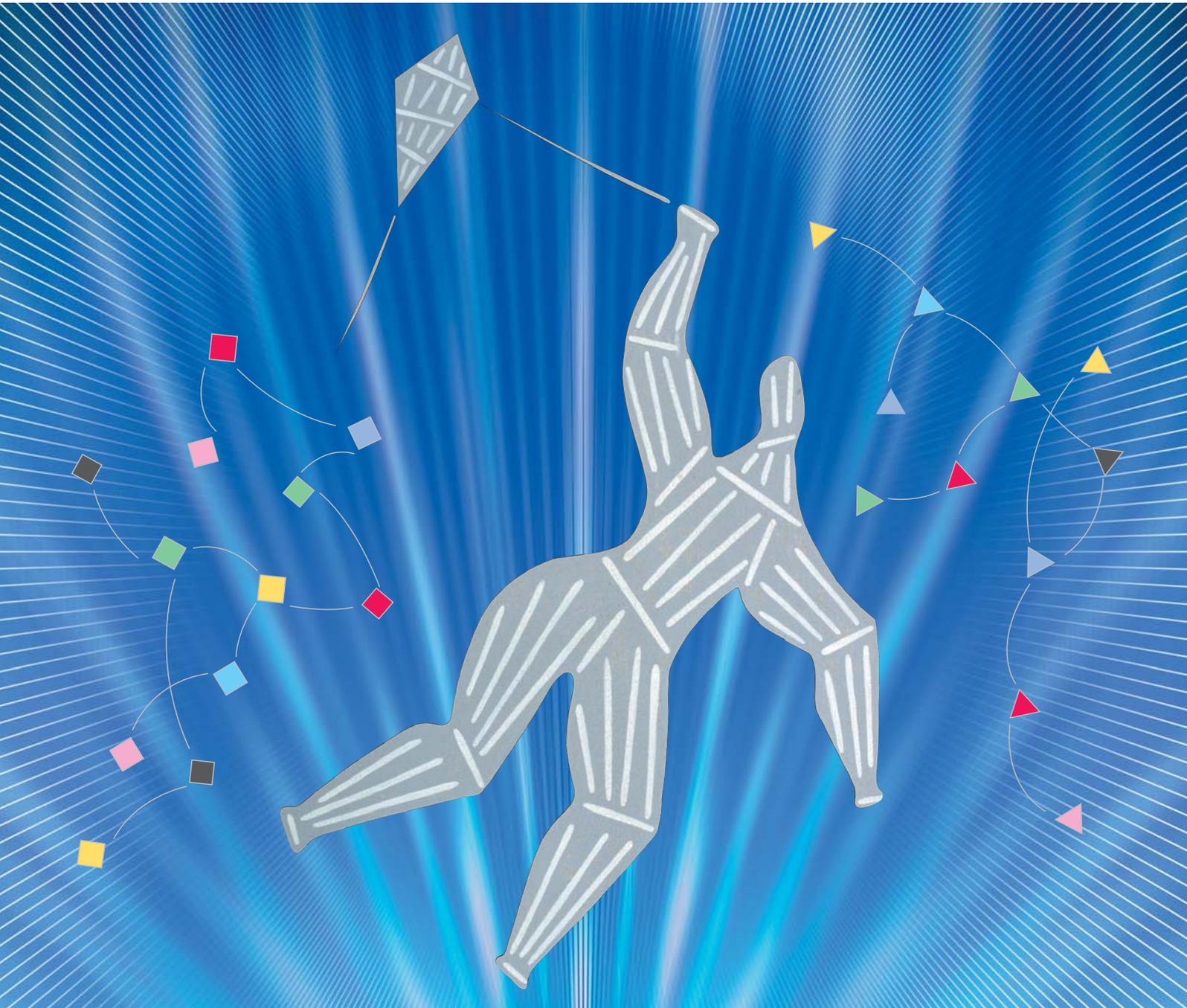


NICT NEWS

National Institute of Information and Communications Technology



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2005 New Year's Greeting

Makoto Nagao, President
National Institute of Information and Communications Technology



I would like to extend my sincere wishes to everyone for a Happy New Year.

Last April, we made a fresh start as the National Institute of Information and Communications Technology (NICT). Fiscal 2005, starting in this April, is the final year of the first medium-term plan since the establishment of NICT. We are determined to fulfill this plan successfully and to formulate an effective plan for the second term. I look forward to the continued efforts of our researchers in achieving these goals.

The NICT Vision

For the first three months of 2004, we were busy getting ready for the official establishment of this new organization. Thanks to the efforts of all staff members, we completed the preparatory work in time for its launch in April. At the inauguration ceremony, attended by several hundred people from various fields, we presented NICT's vision for the future and discussed the direction in which we intend to take the organization.

This vision mainly consists of four objectives:

- (1) New ICT: Building the "foundation" for a new ICT originating from Japan
- (2) Infrastructure for the ICT Society: Creating the desired "security and safety" for the ICT society
- (3) Challenge: Sowing the "seeds" for Japan in 10 to 20 years to come
- (4) Testbed and Promotion: Creating the "magic wand" that makes technology flourish

We will pursue these objectives to support the future development of Government's policy on information and communications, as we work to realize a vibrant and enriched society through technology transfer and collaboration with academia, industry, and foreign research institutes.

Our first task after the launch of NICT was to enhance the functions inherited from its predecessors (the Communications Research Laboratory, or CRL, and the Telecommunications Advancement Or-

ganization of Japan, the TAO) while increasing efficiency through consolidation and streamlining. We created a new system of cross-departmental research and development promotion units to increase effectiveness by organically combining the functions of both organizations. Although there are six units at present, we are continuing to explore the possibilities of establishing more.

Last June, the Ministry of Internal Affairs and Communications announced the u-Japan Strategy. As a successor to the e-Japan Project, which began in 2001, the u-Japan Strategy is aimed at achieving a so-called "ubiquitous society" within the period from 2006 to 2010. In this context NICT is developing technologies to support ubiquitous network infrastructures, in addition to making a range of efforts aimed at meeting the goals of the u-Japan Strategy.

Major Developments in the Past Year

Coincident with the launch of NICT in last April, we began operation of JGN II, an upgrade to the JGN system, an R&D gigabit network we had been operating for the previous five years.

JGN II is an ultrahigh-speed network with a 20-Gbps backbone. This project is designed to implement a variety of innovative practical measures by connecting universities and other institutes across the country through IPv6. This network extends to the United States with a maximum transmission speed of 10 Gbps and is used in Ja-



NICT Inauguration Ceremony

pan-US joint research activities. We are currently considering extending this line to China as well.

The NICT Asia Research Center, with labs located in Bangkok and Singapore, marked its first anniversary last June. Research activities at these sites are on track and beginning to yield results. Additionally, last November we concluded a comprehensive partnership agreement with Tsinghua University in Beijing and are currently planning specific collaborative activities.

The Information Security Center we set up last January has already completed the installation of various simulation systems, and corresponding research activities are underway. In the field of information security, NICT is developing techniques to ensure communications in disasters or other emergency conditions, in addition to security measures against cyber attacks and similar events. We consider it our urgent mandate to achieve concrete research results and to put these results to immediate practical use.

The EMC Center we set up last February deals comprehensively with matters related to electromagnetic waves, including studies of effects on communications systems, electric/electronic devices, and the human body; the Center is also involved in the development of related technologies.

The Applied Research and Standards Department has developed and begun normal operations of what it has termed the Earth Magnetosphere Real-Time Simulation System. This department also works on the standard time distribution technologies required for electronic time stamping.

In an effort to step up its activities in brain research, the Kansai Advanced Research Center has adopted a 3-tesla MRI (a device that generates a very strong magnetic field), and has begun to accept applications for joint research in its Brain Information Open Lab.

The various NICT departments and subordinate research groups have thus been very busy and productive in pursuit of their various projects; at the same time, NICT has successfully organized a number of international conferences.

As for the activities formerly carried out by the four departments of TAO (Research and Development Promotion, Collaborative Research Management, Key Technology Research Promotion, and Information and Communications Promotion), we conducted commissioned research by soliciting research subjects in basic technologies intended for commercialization, in addition to advanced topics from a wide range of fields such as ultrahigh-speed networks, mobile communications, and broadcasting. Also, we promoted subsidy programs for R&D into ICT relating to the elderly and physically handicapped, and provided support to venture businesses, for example with the IT Venture Intellectual Property Strategy Seminar 2004.

As we have inherited the responsibilities of these four departments, we have continually discussed the various challenges this transfer has posed, including discussion of possible consolidation with other departments.

Progress toward a Universal Communications Age

In terms of the evolution of ICT, in the 1980s “new media” was the prevailing topic, from CATV to satellite broadcasting. The Internet and mobile communications then became popular as so-called “multimedia technologies” in the 1990s. From 2000 to 2010, “ubiquitous” will be the mainstream catchword. With this transition it will become increasingly important to focus on information security, human interfaces, and barrier-free information, and on numerous additional required technologies.

Based on this history of development of ICT, I believe that a concept of “universal communications” is likely to emerge as the current decade comes to a close. This means that it will become possible to perform smooth communications anywhere in the world, whether between people, between people and machines, or between machines. In addition, these communications will probably be accompanied by creative real-time language translation, knowledge-sharing, and information transfer.

We will work hard to achieve all of our goals this year; in these efforts I am grateful for your ongoing understanding and support.



Opening Ceremony of JGN II Japan-US Line



First Anniversary of NICT Asia Research Center

Toward the Ultimate Communications Technology

— Significance of Quantum Information Technology and Development of Constituent Technologies —



Kenji Tsujino

Expert Researcher,
Quantum Information Technology Group
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Department

Graduated from Hokkaido University
Graduate School of Engineering in 2004.
Ph.D. in Engineering. Joined NICT as Expert
Researcher in 2004. Engaged in research on
quantum optics and quantum information
technology. Hobbies: Soccer and shopping

Introduction

We have seen that a decade can encompass an entire epoch. Ten years ago, most people did not expect the Internet to become as pervasive as it is today. Among its most beneficial features are electronic mail and access to required information using so-called “search engine” websites. You can also use the Internet to buy books, reserve air tickets, and even send gifts.

To achieve widespread adoption of the Internet, it was first necessary to prepare an environment in which services such as those mentioned above could be provided. A reduction in the cost of PCs, lower communications costs, and increased performance and transmission capacity together formed the basic factors most important to users. It was also important to provide security for user purchases online. Similar considerations will apply to the further proliferation of the Internet and continued improvement of services. Let’s take transmission capacity as an example. You will often see the prefix “Giga” in ads for ISPs or telecom carriers these days in Japan. This refers to a transmission capacity of one billion bits per second (1 Gbps). At such a high speed, it is in theory possible to watch things like sports programs and movies over the Internet. Moreover, it is said that current technologies will lead to increased transmission capacity over a single optical fiber to up to dozens of terabits (one terabit is equal to 1,000 gigabits) per second (Tbps). But what comes next?

The Demand for Quantum Information Technology

The pursuit of higher performance in communications inevitably leads to what are called “quantum limits.” In terms of transmission capacity, for example, “quantum fluctuation” must be taken into account when looking at energy at the level of the photon or electron. Quantum fluctuation is a type of noise inherent in elec-

tronic circuitry and laser light; this noise is impossible to eliminate. It is thus clear that in order to transmit information accurately, the strength of a given signal must exceed the strength of these fluctuations. At the same time, increasing transmission capacity necessitates an increase in the amount of information carried per signal. With this increase, the signal strength allocated to each item of information decreases. Therefore, the communications limit is defined by the minimum signal strength that can convey information accurately without being affected by quantum fluctuations.

With the aim of going beyond this limit, NICT’s Quantum Information Technology Group is actively applying the quantum mechanical principles collectively referred to as “quantum information technology” to information processing. It is particularly important to apply “quantum computation,” a method that is expected to increase information-processing capacity dramatically. Through analogy to amida-kuji (a Japanese network lottery), I’ll describe the difference between quantum computation and the computation technique used in existing computers (Figure 1). Existing computation can be compared to a game played by a single person: the player has to try again and again until he/she gets the prize. In the

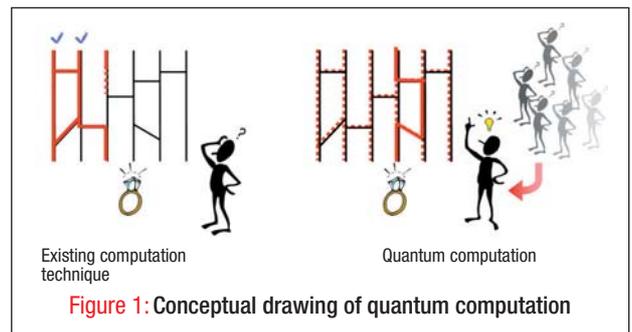


Figure 1: Conceptual drawing of quantum computation

case of quantum computation, on the other hand, the player makes a necessary number of “clones” to follow all possible paths simultaneously. The key feature of a mechanism for expediting computation in this way was already predicted, in the context of “quantum entanglement” described in the early stages of quantum mechanics. Using the quantum information processing just described, we have demonstrated the principles underlying basic communications procedures, such as quantum source coding and quantum channel coding (Figure 2). These research results are now highly valued in the field. To perform quantum information processing, we first select a component, such as an atom or electron, for which the attendant physical phenomena are described in quantum mechanical terms. In our case we have used the photon, the minimum

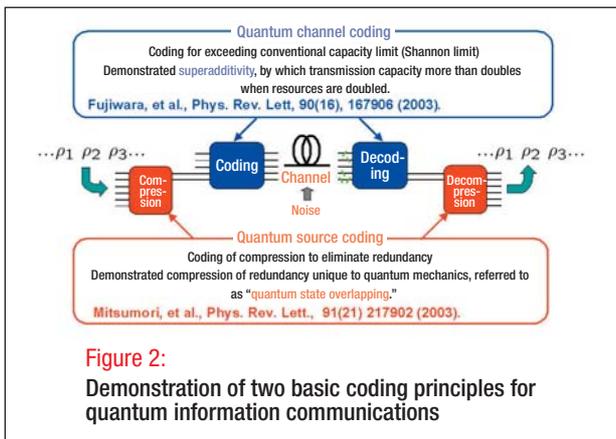
Q & A
I see.
Please explain in simpler terms.

Q What’s “quantum fluctuation”?

A Quantum fluctuation is a type of noise originating in quantum uncertainty. This noise cannot be eliminated at the time of measurement. If you repeatedly measure the energy (the number of photons) emitted from extremely weak laser light under the same conditions, you will not get the same result each time. Instead, you must determine an average amount of energy and a fluctuation range for the measurements. One of the goals of the Quantum Information Technology Group is to control these quantum fluctuations, enabling the communications limits caused by these fluctuations to be overcome.

Q What’s coherent light?

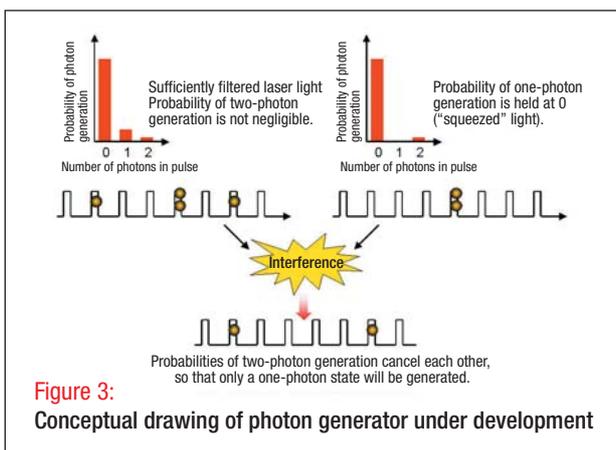
A In this context, “coherent” means interferential. Coherent light has a constant frequency and phase, just like radio waves, providing interference over a long distance. Coherent light communications is a method of optical communications that makes use of coherence. With this method reception sensitivity can be enhanced through detection on the receiving side in synchronization with the modulation of amplitude, frequency, or phase on the sending side.



unit of light, for this purpose. For the rest of this article, I will discuss our research activities relating to the constituent technologies required for photon-based quantum information processing.

Efforts to Establish Constituent Technologies

The first challenge lies in the development of a system to generate a "one-photon state." The technology involved in this effort will be indispensable in quantum cryptography, which enables determination of whether or not someone is "eavesdropping" on a communications line. To protect the secrecy of communications on the Internet, both the sender and receiver need to hold a random series of signals (comprised of zeros and ones) referred to as a "cryptographic key." It has been mathematically proven that once both sides hold such a key, it's impossible to crack the code. The point is to ensure that no unauthorized person can gain access to the key. Under existing communications methods, you cannot de-



termine when, where, or by whom communications may be compromised. However, the use of quantum cryptography (specifically, "quantum key distribution") allows detection of eavesdropping, enabling safe and secure key acquisition. To implement such a method, a system must be developed that allows for single-photon generation. This is because the photon occupies a physical state governed by quantum mechanical principles; these principles form the basis of security in quantum cryptography. To date various methods have been tested in the development of photon generators. Our method (Figure 3) has the advantages of high directivity, operability at room temperature, and support for high bit rates. We are now conducting joint research with other groups to move toward actual development of such a system.

The second challenge consists of the development of a system to determine the number of photons that arrive at a given destination. This is an extremely important constituent technology in photon-based quantum information processing. To apply quantum information processing to the laser beams currently in use in communications, increasing or decreasing the number of transmitted photons is a necessary part of the process. At present, however, such operations can only be achieved through an extremely inefficient physical process. A suggested solution to this problem is to simulate an increase or decrease in the number of photons by splitting a given beam or by adding another beam to the first, and then to extract the necessary information using a detector capable of measuring photon numbers. Such a detector must be able to detect photons with high efficiency and be able to detect extremely weak energy levels (such as the energy level associated with a single photon). In collaboration with NICT's Optoelectronics Group and various specialized companies, we are now developing a technique to prevent reductions in detection efficiency, as well as a mechanism for thoroughly removing noise from system components.

Perspects for the Future

One of our future goals is to perform quantum information processing on the types of coherent light currently used in optical communications. As I indicated above, we have already demonstrated the principles of quantum source coding and quantum channel coding. Although these technologies have not yet reached a practical level in terms of optical communications, I believe that we will be able to control the quantum states of such coherent light using the constituent technologies described in this article.

When it becomes possible to control the quantum state of all types of light, the communications environment will be markedly improved; such improvement in turn can lead to the advent of previously unimaginable services. We are carrying out research in the hopes of seeing such services developed in the coming "epoch."

Quantum cryptography offers the potential for commercialization in the near future.

The use of quantum information technology in communications was added to the Basic Research and Development Plan for Information Communications as a high-priority project in 2000. Since this is a fairly new field, it includes some technologies that are still in the basic research stages (e.g., research on transmission capacity, as described in the first half of this article), while others offer the potential for practical use in the near future (e.g., the quantum cryptography described in the second half of this article). Light plays a predominant role in the field of communications; however, in terms of the practical use of quantum computation, fierce competition is seen among researchers involved in nuclear magnetic resonance, ion traps, superconductivity, and quantum-dot technology.

Report on Symposium in Sophia Antipolis, France

Shinsuke Akasaka

Manager, Strategic Planning Division
Strategic Planning Department



Keynote speech by Mr. Omori, Senior Executive of NICT



Technical presentation by Mr. Fujise, Director of Singapore Wireless Communications Laboratory



Explanation of exhibits

On November 18, we sponsored a symposium held in the Sophia Antipolis Science Park in France with the aims of introducing NICT's activities to Europe and promoting industry-academia-government collaboration in R&D between Japan and Europe.

Sophia Antipolis, situated in Nice, is one of the largest science parks in Europe: approximately 1,200 companies, mainly in the field of ICT, have research sites here and over 26,000 people are engaged in research activities. The Yokosuka Research Park (YRP) in Japan and the Sophia Antipolis Science Park have signed a memorandum of understanding (MOU) to create a partnership.

This annual symposium is organized by Hitachi, Ltd. and L'Institut Eurécom (a French graduate university specializing in ICT). NICT attended this year, the symposium's eighth, for the first time, acting as a co-sponsor.

This year's theme was "Mobile Communications in Transportation." Participants included major car manufacturers and many other companies in non-ICT sectors. These companies and institutes presented overviews of their activities and engaged in lively discussions on the future use of ICT in transportation, addressing current topics such as intelligent transportation systems (ITS).

On behalf of NICT, Mr. Omori, Senior Executive, delivered a keynote speech. He briefly explained NICT's organization and R&D activities, and emphasized the need to reinforce future ICT collaboration between Japan and France. Mr. Fujise, Director of the Singapore Wireless Communications Laboratory, then gave a technical presentation, during which he talked about NICT's commitment to R&D in ITS communications systems using millimeter waves. In addition, we displayed a number of exhibits related to these presentations. As a result of these presentations, many participants became interested in NICT, which took part in this symposium for the first time.

This symposium consisted of presentations on the latest trends in R&D, question-and-answer sessions, and demonstrations. The event was unquestionably successful, with nearly 200 participants, including numerous representatives of ICT-related companies in France. Next year's theme will be information security.

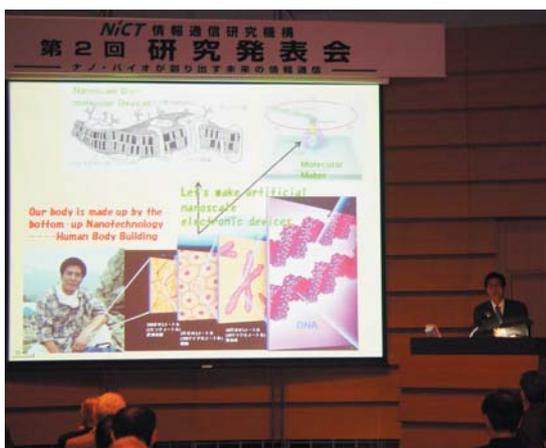
Through operations based in the NICT Paris Office, we will continue to publicize NICT's activities not only in France but throughout Europe. We also intend to reinforce our collaboration with research institutes in European countries, while working as a bridge between Japan and these countries to promote industry-academia-government collaboration in R&D.

We'd like to express our gratitude to the many people who offered their assistance in holding this symposium.

Report on 2nd Meeting for the Presentation of Research Results

Makoto Kusakai

Leader of Science and Technology Information Group
Research Support Division, General Affairs Department



Speech by Mr. Tomoji Kawai, Director of ISIR, Osaka University



Meeting hall



Poster session and exhibits

NICT held its second meeting for the presentation of research results at the Grand Cube Osaka (Osaka International Convention Center) on Thursday, December 2.

With the general theme “Future Nano- and Bio-Information and Communications,” the meeting consisted of three presentations and guest speeches, mainly dealing with basic research in nano- and bio-technologies. In addition, NICT’s Basic and Advanced Research Dept., Information and Network Systems Dept., and Collaborative Research Management Dept. presented overviews of their industry-academia-government collaborative activities through a poster session, exhibition, and demonstration.

Particularly noteworthy events included three guest speeches and three presentations by the Kansai Advanced Research Center. The first guest speaker was Mr. Kazuma Yamane, the non-fiction writer well known for his work “The Age of Metal Color.” In the course of his discussion, ranging from an account of his fascinating hobby of collecting insects to the mysterious behavior of flocks of birds and schools of fish, Mr. Yamane exhorted participants to attain unprecedented achievements—to be the “Marconis of the 21st century.” Next, Mr. Tomoji Kawai, Director of the Institute of Scientific and Industrial Research (ISIR), Osaka University, delivered an engaging speech about the future of nano- and bio-technologies. He cited actual instances in which human DNA and microcameras were directly used in diagnoses. Finally, Mr. Keiichi Torimitsu, Director of NTT Basic Research Laboratories, gave a presentation entitled “Information and Communications from a Biological Viewpoint.” He discussed current research into nano-devices designed for the creation of an interface between nerves and electronics, in part through the extensive use of video images.

In addition to these presentations and speeches, many people visited the venue during their lunch breaks to examine the range of posters and exhibits, which they did with great interest, and participated in question-and-answer session.

This year, we focused on basic and advanced research as well as on activities conducted in the Kansai Region. Thanks to the good weather, we received 246 visitors in total, mainly from companies, universities, and other related organizations located in this region.

We’d like to express our gratitude to all participants and visitors.

Signing of Comprehensive Research Partnership Memorandum of Agreement with Tsinghua University in Field of Information and Communications Technology

Kiyoshi Igarashi

Director, International Alliance Division
Strategic Planning Department

On Saturday, November 6, 2004, Mr. Nagao, President of NICT, visited Tsinghua University (President: Gu Binglin) in China and signed a memorandum of agreement for a comprehensive research partnership in the field of information and communications technology. These two organizations 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. In accordance with this memorandum, we are currently planning to carry out joint research in seven specific areas: (1) terrestrial wireless communications; (2) satellite communications; (3) stratospheric platform systems; (4) next-generation Internet; (5) nanotechnology; (6) natural language processing; and (7) multimedia computing and databases. Future consultations are planned to determine specific research subjects.

The signing ceremony took place in a modern building housing the Tsinghua National Laboratory for Information Science and Technology and the Tsinghua University's Research Institute of Information Technology. Speaking on behalf of the university, Vice President Kang Kejun stated, "by concluding this research partnership memorandum of agreement with NICT, a major state-level organization in Japan, we've opened a new page in the history of China-Japan relations. Since Tsinghua University has as one of its major goals the reinforcement of international cooperative activities, we are delighted to hold this signing ceremony today, particularly with the distinguished presence of President Nagao. I trust that both organizations will exercise the most assiduous efforts to achieve productive results and to contribute to the advancement of science and technology in both countries." President Nagao added, "it is exceptionally well-timed to conclude such an agreement with a leading university in R&D in information and communication technology in China. I look forward to our mutual cooperation and to contributions to progress in information and communication technology in both countries." After the memorandum was signed, we exchanged commemorative gifts and took a ceremonial photograph, and the event came to a close.



Signing ceremony between Tsinghua University and NICT



Mr. Kang Kejun, Vice President of Tsinghua University (left);
Mr. Nagao, President of NICT (right)