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NICT NEWS

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National Institute of Information and Communications Technology

Commencement of the Second Middle-term Plan Toward the creation of a universal communication society

Hiromitsu Wakana Director, Strategic Planning Office, Strategic Planning Department

Long-awaited launch of the Second Middle-term Plan

The National Institute of Information and Communications Technology (NICT) began its five-year Second Middle-term Plan on April 1, 2006. The Middle-term Plan is a set of operational plans that NICT put together to achieve the Medium-term goals proposed by the Minister of Internal Affairs and Communications. These include operational plans for improving efficiency in management and the structuring of finances. To contribute to national policy in the field of information and communications, the Middle-term Plan specifically describes research plans to strengthen Japan's international competitiveness and economic strength, to expand the frontiers of human knowledge, and to promote safe and prosperous lifestyles throughout the nation.

Universal communications and new research problems

NICT has set "universal communications" as one of its goals for the next 10 to 15 years in the field of ICT. Universal communications will allow people of different languages, cultural backgrounds, values, and knowledge to transfer information and share knowledge while at the same time remaining aware of these differences. These technologies will assist in mutual understanding, collaborative activities, resolution of problems, and the creation of new knowledge. The aim is to achieve unrestricted communication between people, between people and machines, and between machines. For example, the less computer-literate, such as the elderly and children, will be able to acquire the information they are looking for without the need to learn the complicated operations of the devices involved; enjoying, for example, unimpeded communication with people in different countries.

Activities focused in three research fields

The Second Middle-term Plan also falls into step with the Ubiquitous Network Society (UNS) Strategic Program (*) of the Ministry of Internal Affairs and Communications, and NICT plans to conduct its activities in this area with a focus on three research fields. These include "new-generation network technology," taking the lead in the international community with its ultra-high-speed flexible network technology; "universal communication technology," which promotes the creation of knowledge; and "information and communications technology for safety and security," which is aimed at achieving a safe, secure, prosperous society. To realize these goals, NICT has decided to concentrate its research resources by integrating four former research departments (the Information and Network Systems Department, Wireless Communications Department, Applied Research and Standards Department, and Basic and Advanced Research Department) into three new research departments.

New research organization

Under these three research departments, NICT has selected seven research problems as targets for departmental goals and has established seven research centers corresponding to these seven challenges.

Research Department 1 is in charge of new-generation network technologies. Among its purposes is to maintain and strengthen the technological advantages of Japan, which has constructed the world's leading broadband environment. Another is to conduct research and development of new network architectures, protocols, and access technologies for future networks that will integrate wired and wireless technologies, alongside research and development of cutting-edge fundamental technologies that will support these networks. Under Research Department 1, NICT has placed three research centers: the New Generation Network Research Center (Koganei), the New Generation Wireless Communications Research Center (Yokosuka), and the Kobe Advanced ICT Research Center (Kobe).

Research Department 2 aims at making universal communications a reality. It consists of two research centers: the Knowledge Creating Communication Research Center (Keihanna), which conducts research and development of multilingual translation and knowledge processing, and the Universal Media Research Center (Koganei), which conducts research and development of "super-presence" communications, with three-dimensional images and sound.

Research Department 3 is in charge of the information and communications technologies that will ensure future safety and security. This department conducts research and development of technologies required to enable robust future use through the application of information and communications technologies to minimize public apprehension of issues such as cyber terrorism, natural disasters, and environmental problems. The Third Research Department consists of two research centers: the Information Security Research Center (Koganei) and the Applied Electromagnetic Research Center (Koganei).

Innovation through research collaboration with industry and academia

To strengthen research collaboration with industry and academia, NICT has appointed new program directors consisting of experts with advanced knowledge and insight in various research fields. The program directors give guidance and advice from research planning through implementation, allowing NICT's own and outsourced research to be conducted more effectively as a whole, yielding maximum achievements with finite resources. NICT has established the Collaborative Research Department to support the activities of these program directors and generally to strengthen research collaboration with industry and academia.

Outcome-oriented research and development

We should always bear in mind how research achievements are and will be used in society. To strengthen outcome-oriented research and development in accordance with societal and economic needs, NICT has established its Research Promotion Department. Through this department NICT will promulgate its research results proactively and strategically, for example by strengthening the acquisition and use of intellectual property rights and by supporting standardization activities. Further, the work of the Key Technology Research Promotion Department will continue, supporting research and development for the commercialization of cutting-edge technologies offering a potentially significant impact on society, as will the work of the

ICT Proactive Outreach Department, which supports the creation of venture businesses, infrastructural progress in information and communications, and elimination of the digital divide. NICT will thus conduct research and development, from basic work to final applications, under a unified point of view. At the same time, NICT will continue in its characteristic support of businesses in the field of information and communications.

Spurring research and cultivating human resources

To spur research and development further, NICT has established various competitive research grant programs to motivate researchers. These programs include a strategic research grant for the discovery of innovative, challenging research problems; a program for promising explorative research; a program to support the development of research results; and a program to secure external funds.

NICT also faces the important tasks of recruiting outstanding researchers and cultivating human resources, particularly young researchers. To this end, NICT intends to take advantage of its unique personnel-exchange programs, including the international dispatch of temporary researchers, an internship program (invited researchers from universities and research institutions overseas), dispatch of researchers to external organizations, personnel exchanges with the private sector, graduate schools open to collaboration, and the admittance of graduate students and doctors continuing to work for businesses.

Summary

The information and communications industry is an important source of national strength and is regarded as a strategic industry in Korea and China as well as in Europe and the US. Severe competition is also underway among all those aiming to capture future markets. Japan must also devote considerable efforts, through collaboration among government, industry, and academia, to maintain and strengthen its international competitiveness in this field. NICT intends to fulfill its expected role through research collaboration with industry and academia, accelerated technology transfer, promotion and support of standardization activities, cultivation of human resources, and innovative research and development.

We thank you for your past support and ask for your further guidance and support in the future.

* UNS Strategic Programs (Consultation No. 9) "ICT R&D Programs for the Ubiquitous Network Society" (Universal Communications, New Generation Networks, Security and Safety for the Ubiquitous Network Society). This is a strategic program initially presented in a report by the Telecommunications Council of the Ministry of Internal Affairs and Communications in July 2005. An overview of the report is available at http:// www.soumu.go.jp/joho_tsusin/eng/features/r_d_progrums.pdf.

New organization and program director

Organizational chart of the National Institute of Information and Communications Technology, Incorporated Administrative Agency

Key device for the use of terahertz-band electromagnetic waves — Research and development of quantum cascade laser —

The generation of terahertz-band electromagnetic waves used to require large devices; these devices were inefficient and difficult to control. Consequently, such devices found only limited use, such as in academic research.
However, in recent years, advanced laser and semiconductor technologies have spurred research and development involving the active use of terahertz-band electromagnetic waves.

The enormous potential of terahertz-band electromagnetic waves

Terahertz-band electromagnetic waves have many distinctive characteristics, including ultra-wideband properties; large absorption by water vapor and liquid water; high transmittance through plastic, paper, cloth, and oil; and the so-called "fingerprint spectrum" displayed by many substances in the terahertz-band. Thus, it is hoped that terahertz-band electromagnetic waves will be applied both to ultra-high-speed wireless communications (essential to the establishment of a future ubiquitous society) and to safe and secure personal identification based on biometrics. Breakthroughs in analysis and sensing technologies are also eagerly anticipated, with potential applications to health and medicine, pharmaceuticals, agricultural and marine products, the environment, industrial materials, and hazardous operations in forensic science.

Generally, communications technologies (wireless communications, broadcast, and fiber-optic communications) make advanced use of the characteristics of specific electromagnetic waves. Thus, in a frequency band for which advanced communications technologies have been developed, there are always compact high-performance "wave sources." For example, in the frequency bands below sixty of gigahertz (with applications including cell phones [up to 2 GHz], satellite broadcasting [several tens of gigahertz], and collision avoidance radar [60 GHz]) various oscillator circuits are available, developed based on semiconductor transistors. On the other hand, in the 1.5-micrometer band, which is used for fiber-optic communications, we have semiconductor lasers. Conversely, a compact high-performance "wave source" is required for any advanced use of electromagnetic waves.

Figure 1 shows the relationship between output-power and frequency in a semiconductor oscillator. The figure shows that radio-wave output-power and light output-power both decrease in the area near 2 THz. This behavior is sometimes referred to as the "terahertz gap." The Quantum Cascade Laser (QCL), operating in the terahertz band, is a promising candidate for a compact, high-performance device to overcome this terahertz gap.

What is the terahertz-band Quantum Cascade Laser?

A Quantum Cascade Laser is a new type of semiconductor laser that makes use of the intersubband transition. The term borrows from the sense of "cascade" as a series of stepped waterfalls. A Quantum Cascade Laser uses the photons (Figure 2) generated by the intersubband transitions that occur every time an electron goes down one of the quantum steps (within the semiconductor multilayer film structure) constructed by molecular beam epitaxy (MBE) or other techniques. The energy (frequency) of the photon generated is determined by the difference between the subband levels formed in the semiconductor multilayer film structure. Thus, lasers for different wavelength bands can be constructed using commonly found combinations of materials used in compound semiconductors—such as gallium arsenide and aluminum gallium arsenide, or indium gallium arsenide and indium aluminum arsenide—without the need to develop new materials. The maximum value of the photon energy that can be generated is limited by the amount of band discontinuity in the conduction band of the material structure. However, in principle there is no minimum-value restriction for photon energy. Further, electrons that have already contributed to emission may be used again by increasing the number of steps in the emission layer, leading to high external quantum efficiency and high power. Thus, output-power is ideally proportional to the number of steps.

Practical application of terahertz laser

NICT has been addressing the problem of applying the terahertz-band Quantum Cascade Laser and has been conducting research and development of the relevant devices and equipment. Recently, NICT was the first group in Japan to succeed in generating terahertz-band Quantum Cascade Laser

Life and Technology

Normally, when we look at the world with our own eyes (i.e., with visible light), we see colored, transparent, and opaque objects. This is because objects present different degrees of reflectivity and transmittance, depending on the wavelength of visible light. In a similar manner, objects may be colored, transparent, or opaque when viewed with terahertz waves, according to differences in reflectivity and transmittance, although things of course "look" different under terahertz waves relative to their appearance in visible light. For example, paper and silicon wafers are opaque when viewed with visible light, but transparent when viewed with terahertz waves. Using these differences in the appearance of objects in different wavelengths, researchers are developing various sensors (such as those to detect images, gases, or other materials) to construct networks that will ensure greater safety and security throughout society. Research is also being promoted for the application of terahertz waves in various fields—medicine, food, agriculture, engineering, and science, etc. Also in the field of information and communications technology that can take advantage of the large capacity of the terahertz band are much anticipated. One example of such anticipated applications may be seen in next-generation ultra-high-speed short-distance wireless technology. This technology can be seamlessly linked to optical-fiber communications technology in terms of data transmission speeds, as will be required in any connection between next-generation high-capacity mobile equipment and optical fiber networks. Another example use will be in mutual, highly secure data links between the ground and satellites, aircraft, and stratospheric platforms.

oscillation. The laser uses a gallium arsenide/aluminum gallium arsenide structure. We precisely controlled the thickness of the semiconductor layers and created a laser device with 3 mm long and 200 micrometers wide. The device has an active layer consisting of several hundreds of modules each formed of four quantum wells. (Each module corresponds to a single quantum step.) A device with 480 active modules was oscillated at approximately 3.1 THz. The device demonstrated high output peak power of approximately 30 mW at -234°C in pulse-mode operation. The maximum operating temperature was -150°C. These values are among the world's best. Figure 3 shows a micrograph of the device.

Future application in wider fields

This success has demonstrated that compact low-priced laser light sources (approximately 1/100 to 1/1,000 the cost of conventional terahertz light sources) can be mass-produced with semiconductor technologies even in the terahertz band. In the future, we intend to improve the laser's characteristics by modifying the laser structure, refining crystal quality, and optimizing the device-fabrication process. Our aim is to achieve practical operation within five years in a range of fields in which terahertz laser applications are eagerly awaited.

The results we have discussed here were obtained through collaborative research and development conducted with Professor Kazuhiko Hirakawa of the Institute of Industrial Science, University of Tokyo. Those involved in NICT's Photonic Device Technology Center also provided a range of support in this research and development, and we sincerely thank all such individuals for their cooperation.

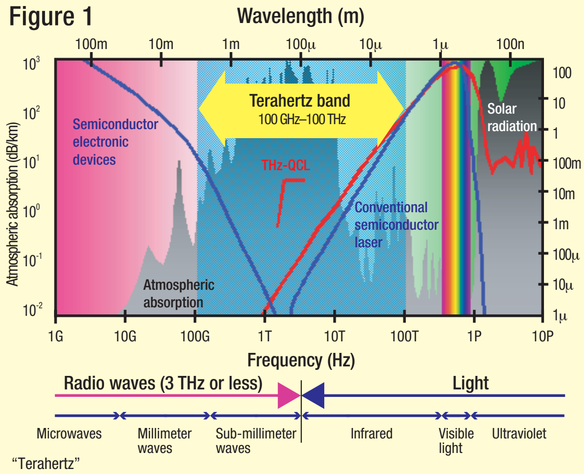
Researcher

Iwao Hosako

Research Manager
THz ICT Project
Advanced Communications Technology Group
New Generation Network Research Center
Research Department 1

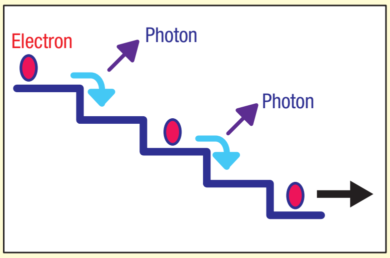
After completing his graduate course, Iwao Hosako worked on LSI fabrication, and then joined the CRL (presently NICT) in 1997. He has been working at NICT ever since. He is currently working on terahertz-band detectors, optical thin films, and lasers. He used to play soccer and badminton often but now he mainly watches the games. Ph.D.

Figure 1



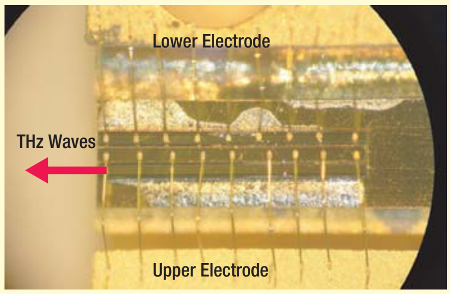
"Terahertz"
The terahertz band is located between the bands for radio waves and light. Use of this band has been limited due to its extensive absorption by the atmosphere and the lack of a suitable semiconductor oscillator.

Figure 2



Schematic diagram of Quantum Cascade Laser
Each time the electron goes down a quantum step, it emits a photon. Increasing the number of steps can generate higher power.

Figure 3

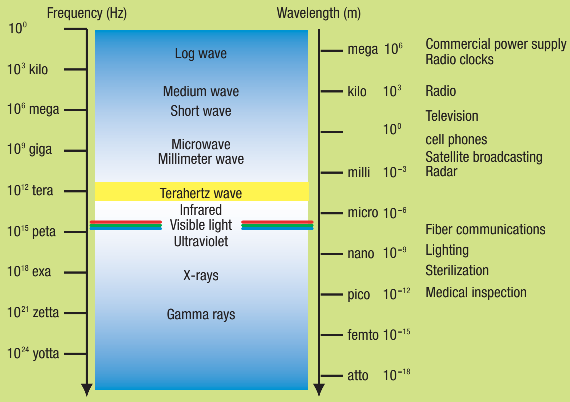


Terahertz-band Quantum Cascade Laser mounted on a heat sink
The wave guide (200 micrometers wide and 3 mm long) of the main body laser is in the center. Nine gold wires 25 micrometers in diameter are connected to each of the upper and lower electrodes. The terahertz wave is emitted from the edge face of the waveguide.

This month's key concept

[Terahertz Waves and Frequencies]

The advanced development of electromagnetic waves has led to various applications such as information transfer, energy transmission, sensing, and processing. These applications have brought significant benefits to our daily lives. Electromagnetic waves are transverse waves that propagate via oscillation of the electromagnetic field. They are roughly classified according to frequency, including radio waves (*) with frequencies at 3 THz (terahertz) or less, light (infrared, visible, and ultraviolet), X-rays, and gamma rays. Among these classifications, electromagnetic waves in the range between radio waves and light are referred to as terahertz waves. (See figure at right.)
(*) "Radio waves" are electromagnetic waves with frequencies at 3 million megahertz (3 THz) or less. (Radio Law, Chapter 1, Article 2-1)



Significant contributions to small, multifunctional cell phones
Multiband antenna for cell phones

As part of its dissemination of research results among the industrial sector, NICT has transferred to Nisshin Parts, Co., Ltd. the technology for a small multiband antenna, the end result of NICT's research on high-frequency circuit components. This device has been adopted in the latest multifunctional cell phone. The antenna is a multiband antenna that supports multiple frequency bands with a single antenna featuring the same structure as a single-band antenna. The antenna for a cell phone needs to be installed in a small space. The single-band antenna now used can be replaced with this multiband antenna within the same space. In other words, while the size of the cell phone remains the same, it will offer more reliable connections for phone calls and will allow for a greater number of functions.

Recent cell phones offer a range of diverse functions. Some use two or more frequencies to provide more reliable communications. Others provide positional information based on GPS satellite technology (1.6-GHz band). Others can connect to a network via wireless LAN (2.4-GHz band). We interviewed Dr. Li, Senior Researcher of NICT, who has developed a multiband antenna that meets these multifunctional requirements.

Q: What multifunctional features will this technological development provide in future cell phones?

This technology can support multiple frequencies, or multiband functions using a single antenna. For example, the three-band antenna now commercially available makes it possible to receive services provided in the ranges of 800–900 MHz, GPS, and 2-GHz with a single antenna. A cell phone is of limited size, so a small built-in multiband antenna is an important device in the development of multifunctional cell phones. Future cell phones will support multiple functions based on two or more bands of radio waves, such as network connection and bluetooth (2.4-GHz band) communication between electronic devices, reception of One-Segment digital television, and antenna diversity, to increase receiver sensitivity to radio waves.

Q: You say the multiband antenna has the same structure as a single-band antenna. What is the mechanism of the multiband antenna?

There are several problems in converting a single-band antenna to a multiband antenna. One example is operating two or more bands simultaneously with an integrated structure, while at the same time ensuring impedance matching in each band and preventing significant loss in radiation efficiency. Another problem is suppressing mutual influence between bands. We have come up with an innovative structure in response, which incorporates high-impedance matching.

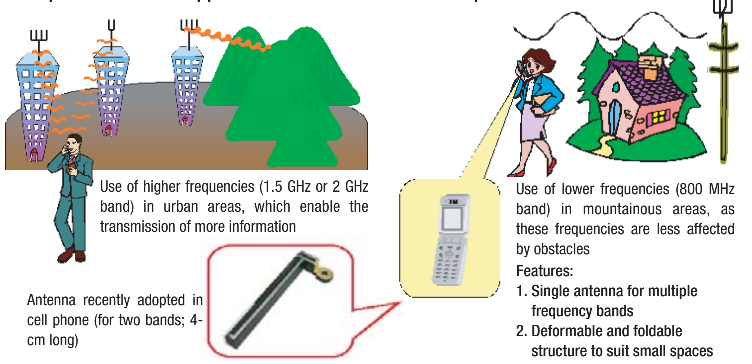
Q: Can you relay any interesting anecdotes about your struggles in this development?

As is often the case with small antennas, operation of the antenna depends not only on the antenna itself but also on the surrounding environment, which changes the radiation characteristics of the antenna. Thus, the development of an antenna does not end with the development of the antenna structure itself. In the case of a cell phone, we needed to install the antenna in the body of the phone to evaluate the radiation characteristics and adjust the frequency and matching properties. We had the most difficult time in this part of the development process.

Q: You say this is one result of research on high-frequency circuit components. Do you have a specific background or goal for this research?

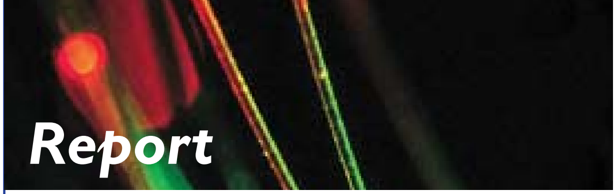
Many high-frequency circuits and components, including antennas, are now used with wireless devices throughout society, the result of considerable progress in wireless technology. Advances in the functions of wireless devices and their use of higher frequencies continually increase the demands placed on antennas and circuits. As high frequencies are involved, research and development entails the application of advanced electromagnetic field theory and also expensive equipment—from design to measurement to evaluation. NICT has long specialized in radio waves. Our group has access to the required measurement environment and also the necessary experience in research and development of antennas and high-frequency circuits. In the future, we would like to address problems in the field of ultra-wide band wireless technologies and millimeter-wave technologies, which require higher frequencies.

Example of multiband applications of multifunctional cell phones



Overview of technology:
A built-in multiband antenna for installation in mobile communication terminals (mainly mobile phones), which maintains ideal monopole antenna characteristics, allows for miniaturization, and supports easy adjustment of multiple frequency bands.

Inventors: Li Keren and Mikio Kashiwazaki
Patent application No. 2005-191945



"NICT Science and Technology Experience Day" held

On April 22 (Saturday), 2006, NICT held the first NICT Science and Technology Experience Day.

The NICT Science and Technology Experience Day is an event that has succeeded the "Science and Technology Lecture," which NICT used to hold around this time every year, during Science and Technology Week. The new event was a renewed version of the former, with a focus on a target audience of young people, under the main theme of the "Science and Technology Experience."

On this day, two sessions were held, one in the morning and another in the afternoon. The main participants consisted of elementary school children in the neighborhood community; 40 children took part in the morning and 38 in the afternoon (with two canceling participation just before the session.)

First, Mr. Kurihara, Director of the Public Relations Office, gave a lecture entitled "The Story of Japan Standard Time." The lecture presented the purpose of the event and introduced NICT to the audience. Then Mr. Kurihara continued onto the main theme, Japan Standard Time. When he said, "We have been making Japan Standard Time here at Koganei," many children were visibly surprised. In the subsequent question-and answer-session, some children asked high-level questions for elementary school children, showing their keen interest in the subject. The recent spread of wave clocks and the insertion of the leap second on January 1 of this year also increased the topicality of this lecture, and we realized that Japan Standard Time is now an important infrastructural element in our daily lives.

Following the lecture, the children took part in a workshop in which they drew and manipulated pictures using the "Squeak" software program. First, they learned the principles in fax, using paper and tops. They then made equivalents of a fax transmitter and a receiver on personal computers, experiencing a technology involved in converting pictures of their own to sound data, and transmitting the data to another participant. The children, although supposedly familiar with using computers, seemed to feel such programming was a bit of a challenge.

At the end of the event, the Director of the Public Relations Office handed out a "Certificate of Participation" to each of the participants. The children appeared very happy with their experience, generally agreeing that it was difficult, but fun.

NICT planned this event with a fresh concept and new aims, and many hitches that we came across will lead to future improvements. NICT considers these outreach activities an important one of its missions, and will hold such seminars regularly, with the aim of helping to keep young people interested in science.

Finally, we would like to thank those who visited us, and to express our gratitude to the educational boards of Koganei City, Kokubunji City, and Kodaira City for their warm support.

Awarding of the "Certificate of Participation"

Scene of the lecture

Scene of the workshop

NICT Science and Technology Experience Day
Date of event: April 22, 2006
Event site: NICT Koganei Headquarters
Report: Daisuke Tanioka
Public Relations Office
Strategic Planning Department

"NICT's New Challenge" Symposium
— Creation of a universal communication society —

At the start of the Second Middle-Term Plan, NICT will hold a symposium entitled "NICT's New Challenge" to inform a wide range of relevant external parties of the research projects etc that NICT will address under its new organization. In the symposium, we will present the directions that NICT will take, with an overview of our priority research and development toward the realization of our goals. We are also planning a discussion by invited panelists as experts in diverse fields.
We look forward to seeing many of you at the symposium.

[Date of event]
June 13 (Tuesday), 2006

[Event site]
Keidanren Hall
Keidanren Kaikan 14th Floor
(Otemachi, Chiyoda-ku, Tokyo)

Program

First Session 1:30 pm

(1) Opening
(2) Organizer's Greetings: Makoto Nagao (NICT President)
(3) Guest Speech: Masao Matsumoto (Director-General for Technology Policy Coordination, Minister's Secretariat, Ministry of Internal Affairs and Communications)
(4) Objectives of NICT: Masataka Kawauchi (NICT Vice President)
(5) Introduction to NICT's Research Strategies
Fumito Kubota (Director of New Generation Network Research Center)
Takashi Matsuyama (Director of Knowledge Creating Communication Research Center)
Yoichi Shinohara (Director of Information Security Research Center)
Takahiro Ueno (Director of Collaborative Research Department)

Coffee Break

Second Session 3:10 pm

(6) Panel discussion: "Expectations for the new NICT"
Panelists:
Tomoe Kiyosada (SRI International, Senior Analyst)
Masaru Kitsuregawa (Institute of Industrial Science, University of Tokyo, Professor)
Mario Tokoro (Sony Computer Science Laboratories, Inc., President)
Makoto Nagao
* Coordinator: Fumihiko Tomita (NICT, Executive Director of Strategic Planning Department)

(7) Closing 4:30 pm

* Honorific titles are omitted above

Please contact the address below for further information on the symposium:
Public Relations Office, Strategic Planning Department
Incorporated Administrative Agency, National Institute of Information and Communications Technology
4-2-1 Nukui-Kitamachi, Koganei, Tokyo 184-8795 Japan
Tel: +81-42-327-5392 E-mail: publicity@nict.go.jp
Please visit http://www.nict2006-symposium.jp for detailed information (including registration).

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