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National Institute of Information and Communications Technology

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NiCT

2009

New Year's Greeting

Hideo Miyahara, Ph.D.
President

National Institute of Information and Communications Technology (NICT)

A Happy New Year!

We started the New Year of 2009 amid unprecedented global financial crisis beginning in the last autumn. Despite growing a concern about decline both in corporate motivation to invest and consumer confidence caused by the impact on the real economy, I believe such situation will lend weight to information and communication technologies. I believe that leveraging this technology which enables us to further expand the scope of activities in a wide range of areas, from industrial activities including manufacturing, distribution, retail, as well as entertainment and education, to intellectual activities and human relations and the like, will be essential to restore social stability and vitality in the future.

With a goal of developing the information and communication technologies which will be able to fully meet these requirements, NICT established the "New Generation Network R&D Strategy Headquarters" and announced the "New Generation Network Vision" as one of its activities in the last autumn. This vision aims to encourage research of networks designed from a clean slate without being constrained by conventional network technologies. For the future, we plan to identify various technologies required to achieve this vision, and formulate a roadmap for the research and development of these technologies. As a leader of national R&D, we are committed to strategically promoting this initiative in a bigger picture to gain and maintain the competitive advantage of Japan in the framework of international cooperation.

Furthermore, NICT launched the MASTAR Project last year to comprehensively research and develop voice and language processing including multilingual speech translation, machine translation and voice interaction, as well as to promote deployment of the outcome achieved in this R&D. As part of this project, taking the opportunity of the Beijing Olympic Games held in last year, we were able to appeal to the tourists for the distinguished technological strength of NICT in the demonstrative experiments for our speech translation system. We also provided technical assistance to multilingual information services operated by the Beijing Olympic Organizing Committee. Therefore, it presented us a letter of appreciation for our contribution.

Recently, with global awareness of environmental protection having been increasingly growing, NICT has also been responding to these trends by promoting activities to contribute to global environmental protection while utilizing information and communication technologies. Leveraging all of our accumulated technologies for electromagnetic wave measurement, we developed a technology to measure how CO_2 is distributed in the air and actually measured CO_2 which was distributed over Koganei-city. We believe that administrative actions will become available by controlling the quantitative information including reduction of CO_2 emissions and CO_2 absorption by the tree-planting.

This year is the fourth year of the Second Medium-Term Plan of NICT. It is the year when we should accelerate the progress of our activities to achieve the goal of this plan, while launching fully into preparations toward the initiation of the next medium term plan to attain further progress of NICT.

On the other hand, as one of our major long term initiatives which promote collaboration among the industry, government and academia, we will enhance the "study of brain information and communications" as research and development in which we analyze human brain functions to apply the findings to future information and communications. In around next three years, we aim to establish the world's most advanced encephalometer technology that will be the fundamental technology in the research and development of brain information and communications.

Through these studies, our utmost efforts are committed to promoting our contribution to that information and communication technologies could resolve negative aspects including social and environmental problems, while encouraging positive aspects including an affluent knowledge-based society provided by creating diversity in the culture and life.

I would like to conclude my New Year Greeting by hoping that 2009 will be a wonderful year for all of you.

Kobe Research Laboratories, Kobe Advanced ICT Research Center

Aiming at Fusion of Bio, Nano and Information Technologies

Kazuhiro Oiwa

**Director General
Kobe Research Laboratories, Kobe Advanced ICT Research Center**

After completing a doctoral course in the graduate school, served as Research Associate and subsequently Assistant Professor in School of Medicine, Teikyo University. Since joining Communications Research Laboratory (currently NICT) in 1993, has been engaged in single-molecule measurement of protein motors and research of molecule communications. Professor, Joint Appointment with the University of Hyogo. Ph.D. of Science.

A center for basic researches of NICT

What research are you pursuing in Kobe Research Laboratories?

Oiwa: Kobe Research Laboratories will mark their 20th anniversary next fiscal year. The laboratories have been consistently served as a center for basic researches of NICT. The first decade was a ramp-up period, during which we established the primary foundation, and in the latter decade, we have built up basic strength. In the next one decade and two decades, we wish we could play a more important role in many fields than we have done so far. While having started in three departments of information, bio and nano technologies, our research is now mainly focusing on bio and nano technologies, where bio and nano technologies are fused on the foundation of information science.

Which research are your laboratories particularly putting emphasis on?

Oiwa: One of our prioritized topics is the study on brain functions. Based on the estimation that the study will play an important role in the field of future information and communications, we created the concept of “brain information and communications” and have promoted the research for it. We have also been developing technology for “molecular communications,” which we have been trying to enhance to functional elements applicable in the field of information and communications by the fusion of protein or cells with nano technology.

Another topic which we are focusing on is the development of superconductive devices. This is precisely the study we have built up and nurtured over twenty years from the basic research. We have developed all the technologies for these devises, and this research globally comes to the front today.

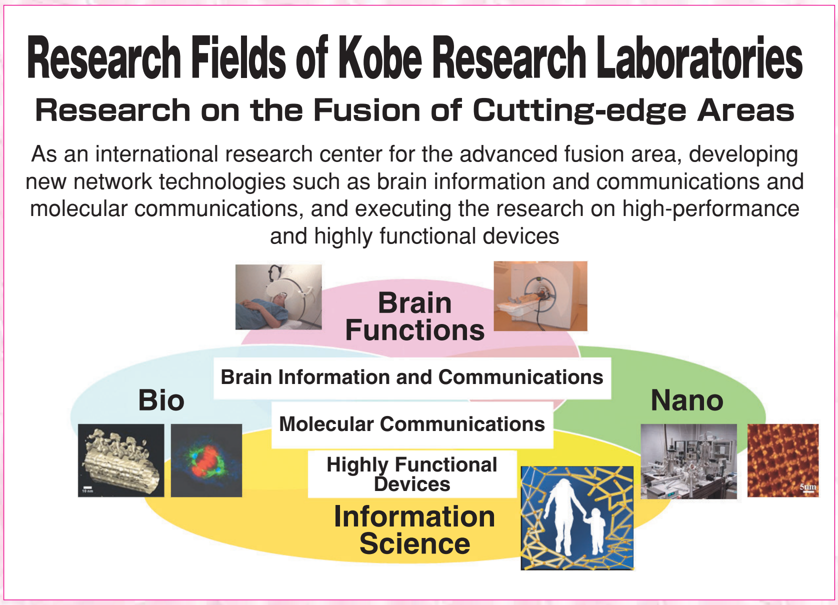
How do you pursue the brain research?

Oiwa: Information and communication technologies have been expanding at an explosive pace. On the other hand, since it is undeniable fact that brain plays the central role for receiving and sending information, we can understand that the brain research should be promoted in the field of these technologies. The most important is to identify how brain processes information for more accurate information transmission and comfortable communications between human beings. As the method for this research, we chose both fMRI (functional Magnetic Resonance Imaging) and MEG (Magneto Encephalo Graphy), which are able to measure human brain functions without hurting it. Although many institutions worldwide are using fMRI and MEG, we pride ourselves on uniquely presiding as we have introduced these methods to the research of information and communication technologies.

Researches to foresee the information and communication beyond the brain research are few, don’t they?

Oiwa: Probably. In addition, there is a technology called BMI(Brain-Machine Interface) or BCI(Brain-Computer Interface) which interfaces between brain and computer. The technology allows us to turn on a light or type a keyboard by just thinking it in the brain, the research of which has been increasingly expanding these days. Our

External view of Kobe Research Laboratories



Research Fields of Kobe Research Laboratories

laboratories are also engaged in this research. While R&D of brain takes a significantly long time, I believe that NICT should lead such research of information and communication technologies which provide the foundation of human communications.

Brain study is now attracting worldwide attention, isn't it?

Oiwa: I think so. The brain research truly seems to me as a comprehensive science. The research includes data of physiology and psychological experiments, as well as mathematically theoretical models and engineering study, in which all knowledge and insights are integrated for the understanding of brain. If seeing a single aspect of brain functions, we would not be able to precisely answer the question "What are brain functions?" The methods to validate models emerged from a computer or information sciences by contiming in experiments will be encouraged. If the model is fully effective, it can be used in the silicon-based realm, which may also be applicable to network technologies and other relevant fields.

Pioneering research nurtured by us has become a global boom

What is the research using protein and cells?

Oiwa: When communicating via the Internet, we are transmitting information on electromagnetic waves. On the other hand, in creatures like us, information is conveyed on chemical substances. While nerve cells send information by using electrical pulse, communications between nerve cells are operated by neurotransmitter, a chemical substance released from synapse. Also, interactions of information via chemical substances such as hormone or growth factor are performed among cells. Creatures are able to cleverly live out through using this information transmission by chemical substances for adaptation to environment. We are leveraging the mechanism. Specifically, we are pursuing research to create information and communication systems by using cells or protein. For example, cells have many ultra-compact sensors which are highly-sensitive to chemical substances, heat, light, and other substances. If we are able to develop a system using cells to amplify or translate signals detected with these sensors, and finally convert these signals into electrical signals by silicon-based technology, we will create a new hybrid sensor integrating cells and silicon.

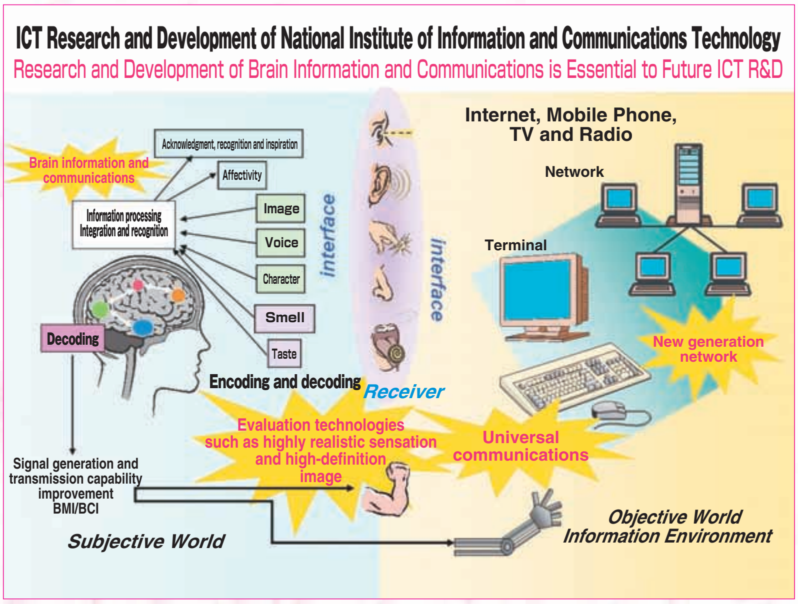
Is there any other method to utilize protein?

Oiwa: My major is protein motors, a kind of proteins which bears movements. I have developed a technology in which we attach this protein on a silicon substrate and reproduce its functions as it is in a living organism. Directional movements are not extracted by just attaching the protein on a substrate, however, we can control movement directions by adding special board or cut a gash on the substrate. We expect that we will be able to successfully create biochips by this control of movement directions. We have promoted this research as a pioneer since around 2000, which becomes a global boom just now.

Great potential of systems using biological specimens

Systems using biological specimens seem to be very different from systems made of silicon, don't they?

Oiwa: I think so. Biological systems have characteristics typically found in biological organisms. One of major reasons for using biological specimens is what is called self-organization. It is a feature that an organism can build up its own structure without an overall design plan. The application to use this characteristic as a template for nano technology is also being examined. In addition, ambiguity and flexibility of biological specimens is another important characteristic. Although behaviors of each element may be rather



ICT Research and Development

ambiguous, behaviors of elements as a group is stabilized. On the other hand, thanks to the ambiguity, these elements are able to quite flexibly accommodate themselves to environmental changes. If using them as sensors, there is a potential to create elements with features including flexible response to a wide variety of substances, greatly enhanced sensitivity, and usability even in a lot of noise.

Are your laboratories executing researches at a basic level?

Oiwa: Certainly, we are mainly executing researches at a basic level. However, we also keep in mind of the image of final application. It is an application to sensors or ultra-compact functional elements for protein or cells, and an explicit application to communications between human beings for brain study.

Don't you expect that these researches may be applied to business and lead to launch of ventures?

Oiwa: I hope so. If clear targets with a full prospect of future commercialization emerge, the idea you mentioned is substantially likely to be realized. We are very grateful if researches which we are executing mature to that point.

The most important is how we make people understand the researches which we are executing

As the strategy of Kobe Research Laboratories, will you further enhance the fusion of bio and nano technologies to actively develop them from a basic stage to an application stage?

Oiwa: We expect that we are able to develop each basic research for bio and nano technologies to fusion and application stages. We really hope this progression. I think that is an ideal state of Kobe Research Laboratories. Currently, the most successful research reaching application and deployment is the Superconductivity Project, in which we started from the basic study to build up the world's most advanced, top-level system. We have developed the whole system by ourselves including a lot of microfabrication technologies. The system has a path to commercialization. I believe this is one of the most successful models in this regard.

For application of researches, it is also important to externally disclose what researches Kobe Research Laboratories are executing, isn't it?

Oiwa: That's right. Taking as many opportunities as possible, I have actively visited, and will go anywhere to talk about how interesting the outcomes of our laboratories are. During the period of November 6 to 8 last year, I and our staff participated in the open house event in Keihanna Research Laboratories and introduced our activities. We also provide highly professional presentations for business organizations, as well as giving speeches at lecture meetings. I believe that the most important is how we make people understand the researches which we are providing.

Thank you very much.

High-Speed Superconducting Single Photon Detectors for Communication Wavelength Range

To deliver an ultimate photon detection technology and application to quantum information and communications

Zhen Wang
Group Leader
Nano ICT Group
Kobe Research Laboratories, Kobe Advanced ICT Research Center

Joined Communications Research Laboratory (current NICT) in 1991 and has been engaged in researches on superconducting electronics. Guest Professor of Nanjing University in China and Osaka Prefecture University. Visiting Fellow of Nanjing Purple Mountain Observatory, Chinese Academy of Sciences. Ph.D. of Engineering.

Quantum information and communication technology which is currently attracting attention

Quantum information and communication technologies such as quantum cryptography which will never be defeated are currently attracting attention as next generation cryptography or information and communication technologies.

In the quantum information and communication technologies which is different from conventional optical communication using "sufficiently strong light," establishing new infrastructure technologies including generation, transmission and detection of single photons is essential since quantum information and communication technologies use "single photons" as carrier of information. Among these technologies, the research and development of high-speed and high-efficiency single photon detectors is particularly critical research subject. Against this background, NICT has promoted the research and development of high-speed single photon detectors using superconducting materials, with the collaboration between Kobe Advanced ICT Research Center and New Generation Network Research Center.

Why superconductivity?

As photon detectors, avalanche photodiode (APD) using semi-conducting materials such as Si or InGaAs/InP was already developed. When used for quantum information and communications, however, APD has a number of problems, including low operation speed, insufficient detection rate or a lot of noise. Superconducting single photon detector (SSPD) using macroscopic quantum phenomenon in a superconductor was recently proposed as a key device to resolve these problems, with which research and development from materials, devices to a system has vigorously been pursued mainly in Europe, the United States and Japan. Since SSPD operates with high-speed electron-phonon interactions at extremely low temperatures brought by superconducting phenomenon, the detector is expected to achieve capabilities including high-speed performance over double digits faster than APD and ultimately low noise. Furthermore, the detecting wavelength range of SSPD is extremely wide, and only a single device is able to cover the entire detection ranges of Si-APD and InGaAs/InP-APD. Another great advantage of SSPD is easier building up of its system in practical application, because SSPD doesn't require any gate synchronous operation as required for APD.

Operating principle

With SSPD, photon is detected using the radical resistance change occurring when transferring from superconducting state of superconductor to normal conducting state in a superconducting nanowire. In order to detect photon fast and efficiently, the superconducting processed nanowire is from an ultra-thin film into an ultra-narrow meander line. Fig.1(a) shows the schematics of the SSPD. The operating principle is that firstly, bias current slightly lower than the maximum superconducting current (critical superconducting current) available without any resistance is applied to the superconducting nano-wire. When a single photon is irradiated to the superconducting nanowire here, the superconducting electron pairs in the nanowire are broken and a part in normal conducting state (hot spot) is generated (Fig.1(b) ①).

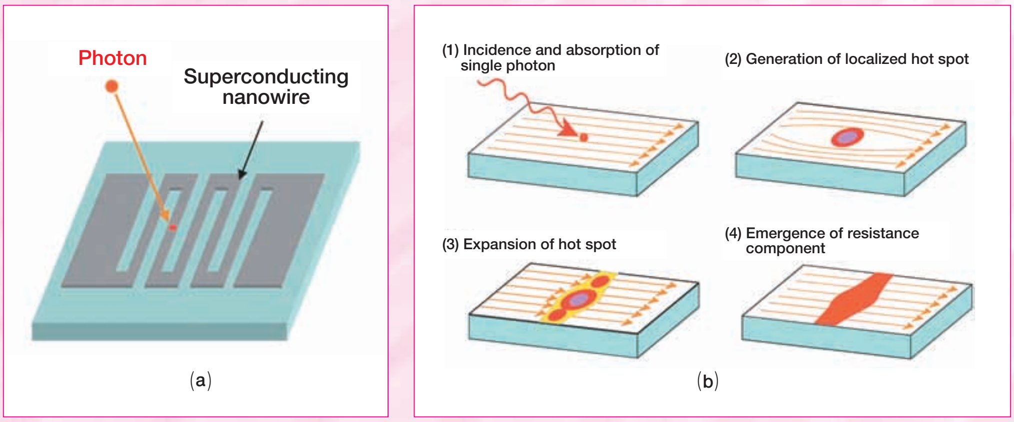


Fig.1: (a) Schematics of Superconducting Nanowire Single Photon Detector (b) Hot Spot Formation Mechanism

At this time, while the bias current flows to the superconducting part excluding the hot spot, the current density of the part increases to transfer the superconducting state to the normal state, the hot spot expands (Fig.1(b)② and ③), and finally the hot spot covers over the part extending to the both ends of the nanowire (Fig.1(b)④). At this stage, the superconducting current is completely interrupted, a localized hot spot emerges in the superconducting nanowire, as well as output voltage is generated. After that, as the excitation energy in the hot spot is diffused to the substrate, the superconducting state is restored and the output voltage returns to zero. Consequently, the signal of incident single photon is measured as a voltage pulse output.

SSPD devices and system performance

Key technologies which decide the performance of SSPD include deposition of high-quality ultra-thin superconducting film, fabrication of nanowire, highly efficient integration of incident photon and device, high-speed measurement, and so on. Systemization for practical application has seemed to be impossible so far, because of the difficulties in depositing ultra-thin superconducting film and fabricating the nanowire, in addition to operation at extremely low temperatures. Also a lot of unexplored technical issues remain. NICT succeeded in fabricating niobium nitride (NbN) nanowire single photon detectors with 5nm thickness or less, and 80-100nm line width, leveraging its unique high-quality superconducting thin film deposition technology, electron-beam and photolithographic technique, and other relevant technologies. Fig.2 shows a micrograph of SSPD device we developed. The active area of the device (nanowire meander area) is 20×20 μm^2, the thickness and line width of the nanowire are 5nm and 100nm respectively, and we successfully developed a single nanowire with total length of 2000μm in homogeneous line width and thickness.

In order to efficiently input single photon into the detector, we developed a technology to implement optic fiber and SSPD device, successfully combining optic fiber and the device to an accuracy of micron order. Fig. 3 shows a photo of SSPD package implementing optic fiber. Aiming at practical application, we also developed an SSPD system using compact transportable Gifford MacMahon (GM) cryocooler which can operate with 100V power and without refrigerant. Fig.4 shows a photo of SSPD system integrating GM cryocooler, its peripheral bias circuit, photon counter, and other relevant items, and the list of the system performance. In the developed system, six SSPD packages shown in Fig.3 are implemented, which can concurrently detect photons in six channels. Currently, the quantum detection rate is about 3%, the operation speed is 50MHz, the dark counting rate is 100counts/second, and the total performance already exceeds that of APD. For the future, further performance improvement is expected by the optimization of film thickness, line width, structure and other properties.

Future prospects

The research and development of single photon detection technology with SSPD has just begun for practical application as a core technology which supports future quantum information and communication technologies. In the years ahead, this technology is expected to become an ultimate photon detector which exceeds APD as its performance including detection rate and operation speed is improved, and practical application may also be realized not only in the quantum information and communication field, but also a wide variety of other fields including quantum optics, astrophysics, biological mass analysis, new medicine development, and low-energy particle detection.

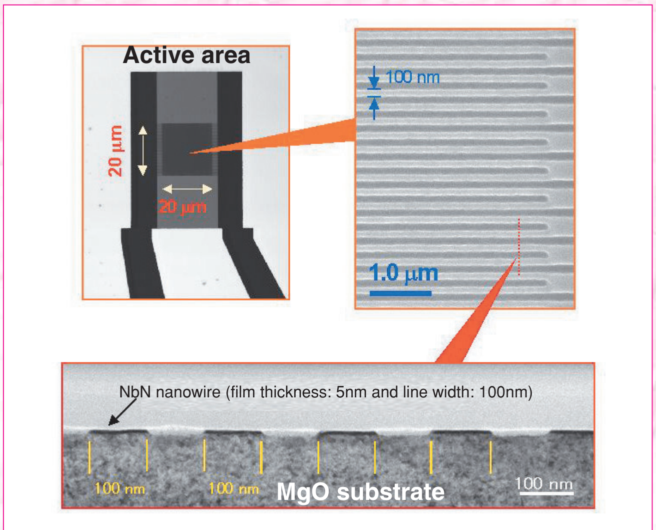


Fig.2: Superconducting Nanowire Single Photon Detector

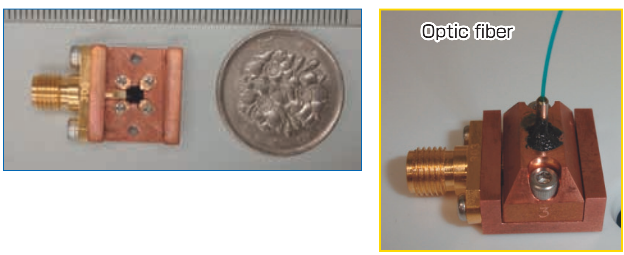


Fig.3: SSPD Package Integrated with Optic Fiber

Specification and performance of SSPD system

Channel number	6 channels
System detection efficiency	1～3%
Dark counting rate	<100 counts/second
Response speed	50MHz
Jitter	50ps
Bias current	10-50μA
Power	AC100V,15A
Operation temperature	2.9K
Size	H1750×W570×D650 (mm)

Wavelength: 1550nm

Fig.4: Photo and Performance List of SSPD System

Reproducing Space Weather in Real Time

Research and development of real-time space weather integration simulator

Profile

Hiroyuki Shinagawa

Senior Researcher
Space Environment Group
Applied Electromagnetic Research Center

After completing a graduate school course, served as Research Fellow in US NRC (National Research Council). Joined Communications Research Laboratory (current NICT) in 1990. Associate Professor in Solar-Terrestrial Environment Laboratory of Nagoya University from 1994 to 2005. Has been engaged in research and development of space weather simulation model at NICT since 2005. Visiting Professor in Space Environment Research Center, Kyushu University. Ph.D.

Space utilization and space weather

A half century has passed since space exploration began. Toward real utilization of space, construction of a space station and a laboratory is now vigorously being promoted today. A lot of experiments and observations are scheduled after the completion of these facilities, along with long-term stay in the space, machine operation and extra vehicle activities. The outer space, however, is never a safe place, where high-energy particles, X-ray and other hazardous elements generated from solar activities impose negative impact on satellite devices and human bodies. In addition, when a magnetosphere storm occurs, the ionosphere is disturbed, which may lead to interruptions of wireless communications with boats, ships and airplanes as well as overseas broadcasting, errors of GPS positioning, and other negative effects. It may also cause failure of the equipment because currents in the ionosphere pass abnormal inductive current flow into electric power transmission lines or submarine cables. Furthermore, the upper atmosphere may be swollen to make friction with artificial satellites at altitude of 100km or lower, causing orbital changes or postural disorder of these satellites (Fig.1). Safe use of space requires accurate forecast of space environmental disturbances, for which research of space weather has been promoted in space research institutes worldwide.

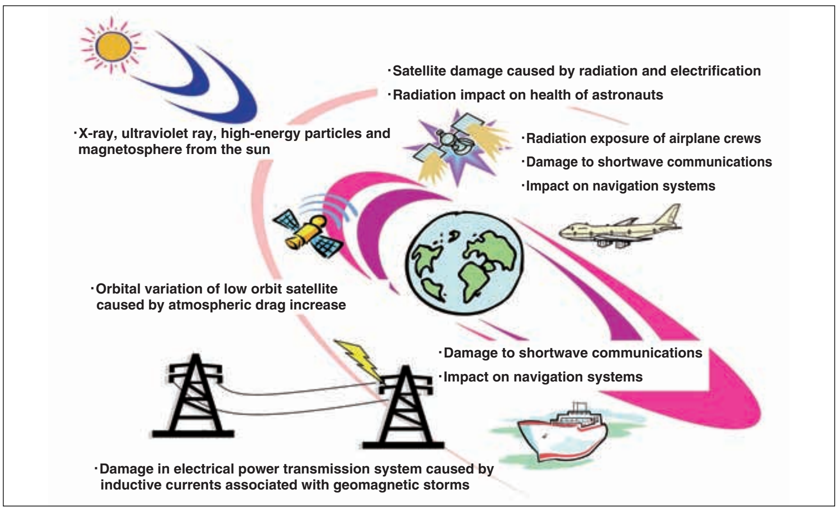


Fig.1: Various Impacts by Space Environment Disturbance on Social Life

Space weather forecast which enters a new stage

Radio Research Laboratories of Ministry of Posts and Telecommunications (current NICT) has been engaged in research on radio wave propagation in the ionosphere and provided forecasts and alarms since 1957. Later, the laboratory evolved into Communications Research Laboratory (current NICT). Leveraging the technologies of this laboratory, the "Space Weather Forecast" Project started in 1988, in which optical and radio wave observations of the solar surface, geomagnetic observation, ionosphere observation, data collection and distribution systems, and other related components are implemented. Along with the later applied data collection from artificial satellites, available data of the space environment has dramatically increased.

With conventional space weather forecasting, similar to early weather forecasting on the ground, forecasters predict space weather disturbances based their own knowledge and experience, using various observation data. Recently, however, with enhanced space utilization and demand for quantitative space weather forecasting, the need for numerical forecasting using computer technologies has been growing.

Research and development of space weather simulation

While the cosmic space is made mainly of ions, electrons and other relevant substances, there is the neutral atmosphere in circumterrestrial space. Ions and electrons move by electric or magnetic forces, however, the neutral atmosphere is not affected by these forces, and behaves meteorologically. In the ionospheric region, where ions, electrons and neutral particles are mixed, these substances hit each other to show extremely intricate behaviors. Reproducing such a system requires us to numerically solve differential equations called magnetohydrodynamic or hydro-dynamic equations using computers. Since development of program to describe the cosmic space needs a great deal of time and labor as well as enormous amounts of calculation, however, numerical models to reproduce the cosmic space were not able to be developed easily.

It was around 1980 when capabilities of computers significantly enhanced that enabled the application to practical simulations of the space environment. Communications Research Laboratory also introduced supercomputers in 1990s to launch research and development of simulation models which solved three-dimensional magnetohydrodynamic equations to reproduce the magnetosphere structure and dynamics. In late 1990s, a high-resolution magnetosphere simulation model was completed, which enabled us to reproduce a realistic magnetosphere. In 2003, our institute successfully developed the “Real-Time Magnetosphere Simulator”, which produces the magnetosphere by using real-time solar wind data collected by the satellite ACE.

Reproducing space environment by the computer

Recently, in addition to this real-time magnetosphere simulator, we have developed another two real-time simulators for sun/solar wind and ionosphere/thermosphere, and we have also built up the “Real-Time Space Weather Integrated Simulator”, which reproduces the state of the solar surface to the altitude of around 100km near-earth space (Fig.2). This is the first system in the world that is able to comprehensively calculate the space from the solar surface to near-earth space in real time.

The sun/solar wind simulator calculates and displays the solar wind from the solar surface to the earth orbit by solving three-dimensional magnetohydrodynamic equations using magnetic field observation data of the solar surface collected by the solar observation satellite. Using this simulator, we are able to know when a fast solar wind causing a geomagnetic storm reaches the earth.

The ionosphere/thermosphere simulator solves hydrodynamic equations for ionized gas and neutral atmosphere with input data into the model including electric potential and conductivity in the ionosphere collected by the magnetosphere simulator. This simulator enables us to display the results in images calculated from observation data including the current ionosphere/thermosphere states and auroral occurrence in the polar ionosphere. In this calculation, we use solar wind data collected by the solar wind observation satellite ACE as input for the magnetosphere model to calculate the magnetosphere, and immediately send the results to the ionosphere model to calculate the ionosphere.

These real-time simulations have been achieved on the supercomputer NEC SX-8R (Fig.3) introduced in 2007, the results of which have been publicly disclosed on the web site of NICT “Space Weather Forecast” since August 2008.

Towards numerical forecasting of space weather

While the real-time space weather integrated simulator, which we developed recently enables us to capture the current state of the space environment from the sun to near-earth space, we found that some observed changes or disturbances were not able to be reproduced. Currently, we are comparing the results calculated in this simulator with the data collected by satellites and ground observations, and review them to enhance the model and improve the quantitative reproduction of disturbance phenomenon. Space weather forecast requires prediction in the next several hours to a few days, for which numerical forecasting of solar wind is essential. Since it takes a few days for solar wind to reach the earth’s orbit from the the solar face, we will be able to forecast space weather of the next few days with an appropriate accuracy by increasing the precision of the sun/solar wind simulator. The solar activity is currently still in the minimum state, however, we are committed to pursuing research and development of the numerical forecasting technology towards the solar activity maximum period expected about three years from now, to build up the “Space Weather Numerical Forecasting System.”

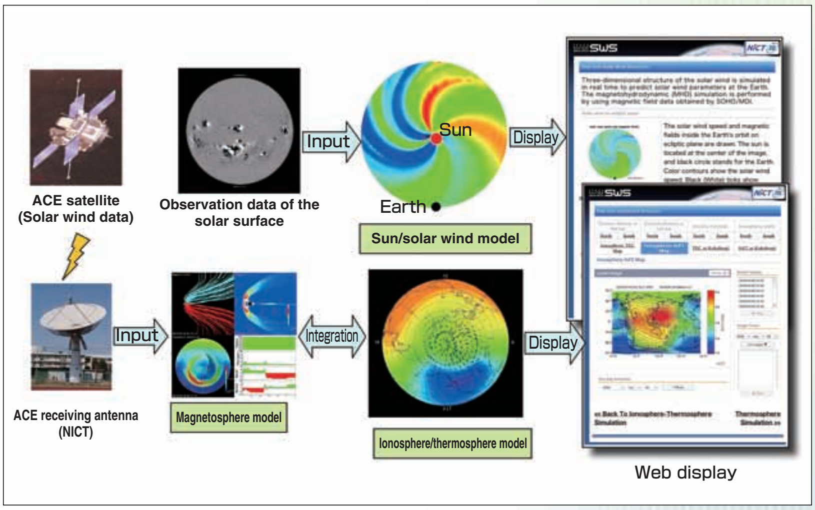


Fig.2: Data Flow of Integrated Simulator in the Real-time Space Weather

Fig.3: Supercomputer NEC SX-8R, Performing Real-time Simulation in NICT

Establishing Space-Time Standards

Profile

Yasuhiro Koyama

Group Leader
Space-Time Standards Group
New Generation Network Research Center

After completing a master's course in graduate school, joined Radio Research Laboratory of Ministry of Posts and Telecommunications (current NICT). Since then, has been engaged in a wide ranging of researches including mainly geodesy using VLB in Kashima Space Research Center, as well as radio science, radio astronomy and geophysics. Has been assigned to the current position since July, 2008. Ph.D. of Science.

Activities of Space-Time Standards Group

Positions in time and space are fundamental information required for everything from social life and advanced research. While accuracy and reliance needed there vary depending on the purpose, these two properties are almost treated independently. In measurement requiring extreme precision, time and space are inseparable, and we must take them as a unit in a concept of four dimensional time-space. The Space-Time Standards Group has been comprehensively striving for ultimate measurement of reference frames which serve as basic data of time, frequency, and position, as well as research and development of technologies to use this information.

What are space-time standards?

First of all, currently the most basic definitions in time-space are velocity of light and quantum transition frequency of specific cesium atom. The length of one second is defined by this frequency. Based on this background, our group developed atomic fountain type primary frequency standards to create frequency standard signals with which we seek for ultimate accuracy using cesium atom, and regularly operate these standards. We also operate multiple atomic clocks always running in the primary standard room under the specific temperature control, to provide the Japan Standard Time created there to a wide range of users via standard long wave radio signals and high-performance Network Time Protocol (NTP) servers. The Coordinated

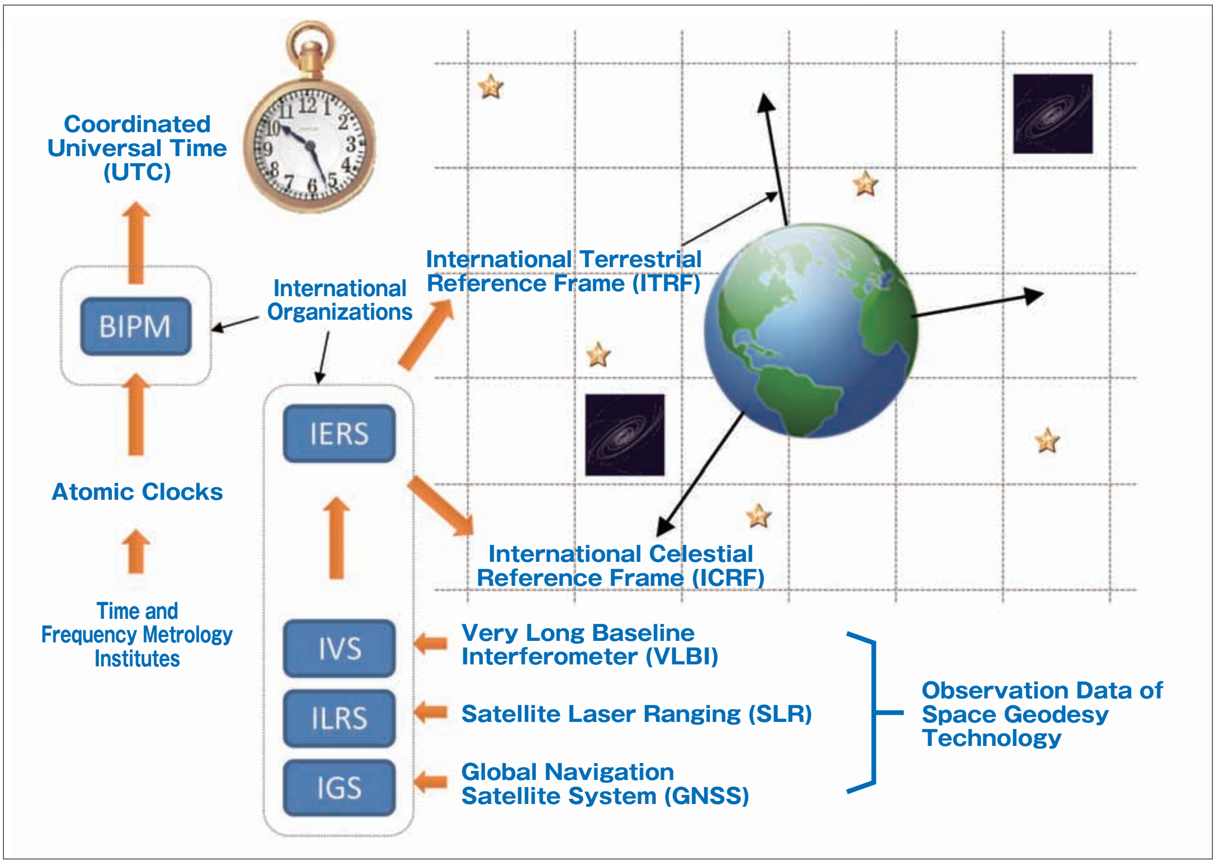


Fig.1: Mechanism to Establish Coordinated Universal Time and International Reference Frames

Universal Time (UTC), broadly used as the global standard time, is created by using a number of atomic clocks reported from time-frequency standards research institutes worldwide to Bureau International des Poids et Mesures (BIPM). Among them, the atomic clocks in NICT are rated at the second highest contribution in the world, greatly contributing to definition of the Coordinated Universal Time.

On the other hand, the standard for position measurement in the space is Reference Frames. Regarding the gravity center of the earth as coordinate origin, the International Terrestrial Reference Frame (ITRF) which rotates on its axis together with the earth, and the International Celestial Reference Frame (ICRF) which is fixed to the celestial sphere and doesn't move are internationally adopted. In the geographic coordinate system which decides longitude and latitudes in Japan, the global geographic coordinate system based on ITRF was introduced by the Revised Survey Law enacted in 2002. These Reference Frames are established, based on observation data collected by space geodesy technologies including Very Long Baseline Interferometer (VLBI), Satellite Laser Ranging (SLR) and Global Navigation Satellite System (GNSS) (Fig.1). NICT not only executes key research and development as a technology development center for the International VLBI Project, an international organization coordinating the observation of VLBI, but also operates international observation facilities for SLR and GNSS. Our institute is only one research organization in Japan which has all of three major space geodesy technology observation facilities.

Particularly, observation data of VLBI fully supports the establishment of ICRF, as well as being used as the basic data to decide the overall scale of ITRF. This means that since with observation methods using artificial satellites such as SLR or GNSS, the accuracy of GM (multiplication of gravitational constant and the mass of the earth) value is not sufficient, VLBI data is used as the length standard in such a large scale like the dimensions of the earth.

For each of these activities to measure positions and develop reference frameworks, or establish the Coordinated Universal Time, specific frameworks are created respectively with the international collaboration. NICT is actively positioned in these frameworks to contribute to these activities. As I mentioned at the beginning, basically these activities are closely related, and actually, international organizations are closely aligned with each other to promote these initiatives. Our group is one of the limited numbers of research institutes in the world that participate in both of these frameworks to contribute to playing an important role to create more integrated space-time standards as a unit.

Space-time standards for next generations

It was in 1967 that second was defined based on the microwave transition frequency of cesium atom. With forty years having passed since then, many research institutes are competing in research and development of next-generation optical frequency standards which lead to redefinition for more precise unit of second. Our group is pursuing research and development of optical frequency standard system using calcium ion (Fig. 2) and optical lattice clock system using strontium atoms. Technologies to precisely compare each frequency are also required for evaluation of these ultimate optical frequency standard systems. However, since the gravity changes depending on the altitude of the place where the standard system is installed, the location must be correctly measured. In addition, it is essential to accurately determine orbit of the satellites used for comparisons and rotational variation of the earth during the measurements. Like this, precise time and frequency measurement is inextricably linked to the location measurement. In the conventional comparison between frequency and time, the satellite interactive time comparison method mainly using communication satellites, and a method using GNSS observation data, a space geodetic technology, have been applied. It is also our important research subject, however, to seek for a more accurate time comparison method introducing the next-generation VLBI observation technology (Fig. 3). As mentioned above, integrated promotion of research and development for both time & frequency and location measurement technologies is one of our strengths. We believe we will play a critical role during the time when such integrated focus is truly required.

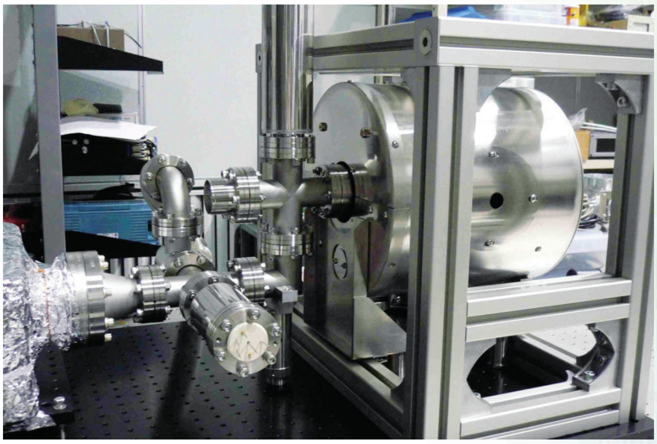


Fig.2: Laser Cooling System for Calcium Ion Optical Frequency Standard System

Fig.3: Radio Telescope Used for VLBI Observation (Kashima Space Research Center)

Wideband InterNetworking Engineering Test and Demonstration Satellite "Kizuna" (WINDS)

Profile

Takashi Takahashi

Research Manager
Space Communications Group
New Generation Wireless Communications Research Center

After completing a master's course in graduate school, joined Communications Research Laboratory (CRL, one of former bodies of NICT) in 1991. Has been engaged in researches including high-speed satellite communications using ETS-VI, COMETS and WINDS.

"Kizuna" connects us across the world

Technology demonstration for configuring high-speed satellite communications system

The Wideband InterNetworking engineering test and Demonstration Satellite "Kizuna" (WINDS) serves to provide technological test and demonstration of high-speed satellite communications system, as part of research and development for the formulation of advanced information and communications network based on the "e-Japan Priority Policy Program" promoted by the Japanese Government's IT Strategy Headquarters.

WINDS was jointly developed by National Institute of Information and Communications Technology (NICT) and Japan Aerospace Exploration Agency (JAXA) and launched by H-IIA Rocket on February 23, 2008.

This article introduces the outline of WINDS satellite communications system as well as the experiment plan.

WINDS

A regenerative switching device is mounted on WINDS with which high-speed switching is available on the satellite. The regenerative device demodulates signals transmitted from the earth station, switch and modulate them again on the satellite to transmit to the earth station. The switching device enables us to multiplex downlink signals transmitted from the satellite to the earth, while switching between beams allows us to efficiently use resources on the satellite.

The WINDS satellite communications network achieves the transmission rate of 155Mbps per one beam by using regenerative switching repeater links and satellite communications link performance of up to 1.2Gbps by the bent pipe relay bypassing the regenerative switching device.

By using WINDS, verifications of potential services are expected, as shown in the application scheme diagram of Fig. 1, including provision of emergency backup links, multi-media multi-cast services, high-speed long-haul and thin-route satellite communications linking to islands and mountain areas, and provisional installment of tentative linking.

For WINDS, in addition to the onboard regenerative switching equipment, devices such as Multi-Beam Antenna (MBA), Multi-Port Amplifier (MPA), and

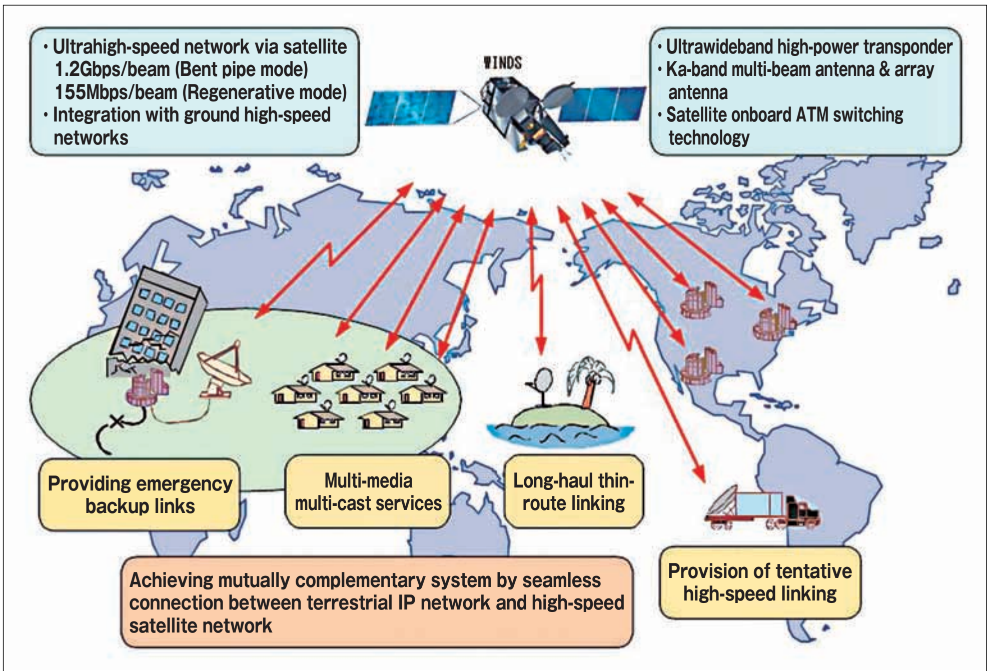
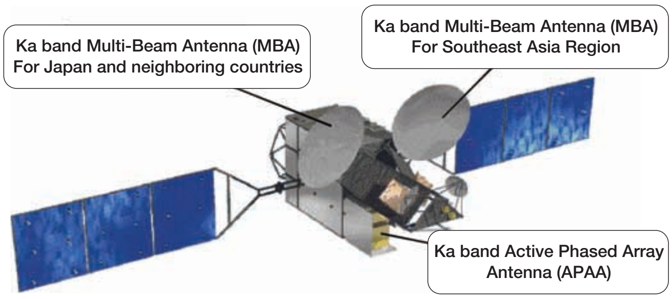
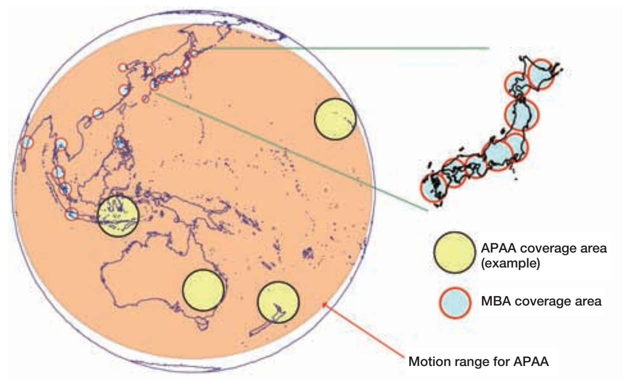


Fig.1: Schematic Diagram of WINDS Applications



Orbit : Geostationary orbit (143 degrees of east longitude)
Weight : About 4,850kg (as of the launch)
Dimensions : 2m×3m×8m
(Total width including solar cell paddles: 21.5m)
Mission life : About 5 years after the launch (target length)
Power generation : 5,200W or more
Frequency : USB (CMD/TLM) Ka band (communication mission)
Launch : February 23, 2008/H-IIA rocket

Fig.2: External View and Specification of WINDS



MBA for domestic and neighboring countries: Covering Japan with nine beams, and Seoul, Beijing and Shanghai
MBA for Southeast Asia Region: Hong Kong, Manila, Bangkok, Kuala Lumpur, Singapore, Jakarta and Bangalore

Fig.3: WINDS Coverage Area

Active Phased Array Antenna (APAA), which is regional electronic scanning antenna, are developed and mounted on this satellite to verify high-speed satellite communications technologies.

Fig.2 shows the external view and specification of WINDS. On WINDS, two types of antennas (MBA and APAA) are mounted. For communications, it applies Ka band (28GHz/18GHz bands) which ensure broad frequency bandwidth to achieve narrow beams and easy building up of multi-beam systems.

Fig.3 shows the service area. MBA covers Japan including Okinawa with nine beams, and other beams cover ten cities in Asia. On the other hand, APAA can broadly scan over Asia Pacific Region, within which two beams respective for transmitting and receiving (four beams in total) can be used.

WINDS experiment plan

For WINDS, two types of experiments are planned: basic experiments carried out by the satellite development organizations (NICT and JAXA) and application experiment selected from the publicly invited applications by the Ministry of Internal Affairs and Communications.

After the launch in February, 2008, we carried out the initial functional check for WINDS until June, confirming that major functional performances of WINDS were maintained on the orbit launched. The basic experiments started in July, and by September, verified that the WINDS satellite communication network was ready for the application experiments. From October, the application experiments began in parallel with the basic experiments.

NICT schedules the following experiments: the basic transmission experiments including performance check of the equipment mounted on the satellite, etc. and rain attenuation compensation experiment; the high-speed satellite network experiments including protocol evaluation experiment, etc. and the network application experiments including connection experiment with ground networks, etc. In order to perform these experiments, NICT has developed a Large Earth Terminal (LET) with the antenna diameter of 4.8m and an Super high Data Rate Very Small Aperture Terminal (SDR-VSAT) with the antenna diameter of 2.4m (Fig.4).

Along with these stations, JAXA has developed a High Data Rate Very Small Aperture Terminal (HDR-VSAT) with the antenna diameter of 1.2m and an Ultra Small Aperture Terminal (USAT) with the antenna diameter of 0.45m.

As for the applied experiments, 53 items from Japan, Thailand, the Philippines and other countries are adopted, including 30 international joint experiments. In the fields for the applied experiment, experiments for radio wave propagation, disaster prevention, telemedical services, and distance education, etc. have been proposed. The earth stations developed by NICT and JAXA can be utilized in these applied experiments and contributed towards promoting them.

Expecting to establish communication satellite technologies

WINDS jointly developed by NICT and JAXA was launched in February 2008, and currently various basic and applied experiments using this satellite WINDS are under way. We are aiming at establishing next-generation communication technologies by promoting to verify satellite communication technologies and creating new applications through international joint experiments.

Fig.4: Large Earth Terminal and Super-High Data-Rate Very Small Aperture Terminal

Enthusiastic reactions at Cellular Automaton Conference

Applying Biological Mechanisms to Information Processing and Communications

Profile

Ferdinand Peper

Senior Researcher
Nano ICT Group
Kobe Research Laboratories,
Kobe Advanced ICT Research Center

Degree in Theoretical Computer Science at Delft University of Technology in the Netherlands, followed by STA Research Fellowship at the Communications Research Laboratory (current NICT), at which he became a permanent member in 1993. Engaged in research including information and communication architectures on nano meterscales. Ph.D. of Engineering.

Applying biological principles to information processing and communications

"We can learn many things from living organisms," says Dr. Peper, Senior Researcher, who is engaged in research to establish architectures for computers and communications based on new technologies like nano- and bio-technologies.

After studying computer science at Delft University in the Netherlands, Dr. Peper came to Japan to become a Research Fellow of the Science and Technology Agency (STA) in 1990, and joined NICT as a permanent researcher in 1993. Having a background in distributed processing on parallel computers and pattern recognition, he has pursued research on ICT systems involving biological and nanometer-scale features since 1990. Dr. Peper aims to construct advanced architectures that utilize interactions between molecules, with biological systems providing a leading inspiration towards that goal. "Since molecular mechanisms in biological organisms have characteristics also found in nano-technologies, I focus on the reasons why activities of biological organisms are so highly efficient." Among the findings is that Brownian motion of molecules in living organisms resembles a search process that dramatically increases the probability of compatible molecules binding to each other.

Receiving a great response to the idea of exploiting Brownian motion

Brownian motion involves the random fluctuation of particles in a fluid due to collisions with the fluid's molecules. Modeling the random search processes caused by these fluctuations in the framework of mathematical abstract devices and circuits, Dr. Peper succeeded to significantly reduce the complexity of circuits. These ideas were applied to a cellular automaton, which is a mathematical model of a computer algorithm in which extremely simple cells behaving like finite automata change their states over time. When presented at an international conference, Automata-2008 Workshop, this result received the Best Paper Award.

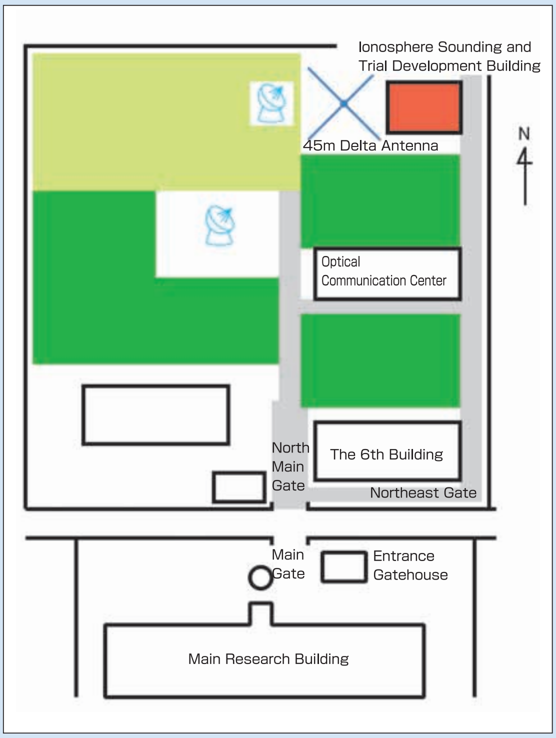
Dr. Peper said: "I intend to enhance this idea to more generally apply it to the field of information processing and communications. My particular focus is on researching whether useful integrated behavior can be achieved through the mutual interactions in distributed networks inspired by biological systems."

Report of Inauguration Ceremony for Ionosphere Sounding and Trial Development Building

A new building was constructed on the north site of NICT Headquarters, and renewal of the 1st Building (former Ionosphere Sounding Building) and transfer of Machine Workshop Room from the former 3rd Building was completed.

The new building was constructed as integrated facilities for ionosphere sounding and trial development on the site previously used for the former Ionosphere Sounding Building, which was demolished due to its aging structure after a long use for a half century. On December 17, NICT held an inauguration ceremony for the new building, where a number of employees including President Miyahara participated. In the excursion around the building after the ceremony, participants were divided into two groups to alternately visit the trial development facilities on the first floor and the ionosphere sounding facilities on the 2nd floor. During the facility tour, questions and answers were actively exchanged including about the functions of these new facilities, and the research and development provided there.

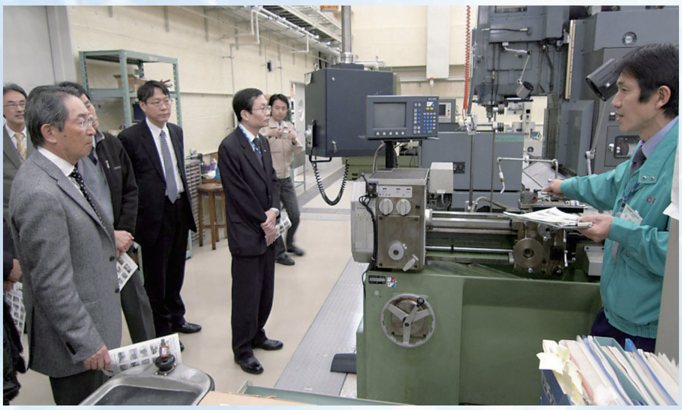
The former Ionosphere Sounding Building has provided ionosphere sounding for about 53 years since its establishment in 1955. Data collected there are immediately distributed on the Internet, and broadly utilized among currently operating organizations in the field of communications, broadcasting, positioning, etc. and amateur radio operators. The former 3rd Building formerly used for the Machine Workshop Room, where hundreds of trial items were developed every year, has served as facilities for trial development for about 34 years since its establishment in 1974. Prototypes created in this building have been applied to a great number of research results including research papers, patents and technology transfers.



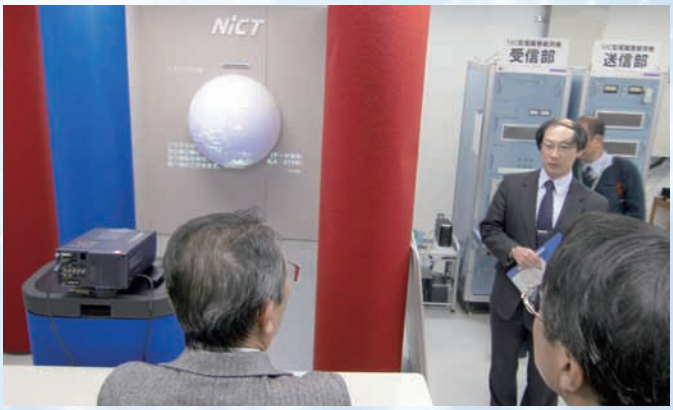
Layout of Ionosphere Sounding and Trial Development Building

External View of Ionosphere Sounding and Trial Development Building

Inauguration Ceremony Held with More than 60 Participants Gathering on the 1st Floor of the Building



A Scene of Explanation and Q&A about Various Engineering Machines and Measurement Equipment in the Trail Development Facilities (1st Floor)

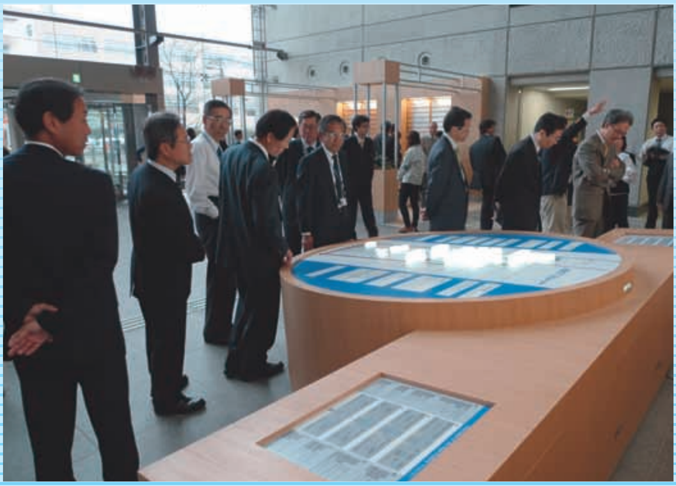


Explanations Provided about the Ionosphere Sounding Equipment, International Evolution of Observation Network and Data Utilization in the Ionosphere Sounding Facilities (2nd Floor)

Renewal Opening of Main Research Building Entrance

The entrance of Main Research Building was renewed in December, 2008.

With four keywords of "Welcome," "Understanding," "Interaction" and "Contribution," in the entrance hall, NICT introduced the new displays: "Welcome Zone" displaying the hall map and welcome messages; "Café Corner" providing an interaction place for internal and external researchers as well as a place to introduce NICT activities to visitors and other relevant parties; and "Individual Achievement Awarding Corner" appealing NICT's contribution to the society and awarding achievements of the NICT personnel. We hope this entrance hall becomes a space loved by visitors and the NICT personnel.



Information for Readers:

In the next issue, we will feature the Universal Media Research Center which is promoting the research and development to realize three-dimensional imaging system, and the ultra-realistic communication environment, which is sensuous with five senses.

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