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Biomedical EMC Feature

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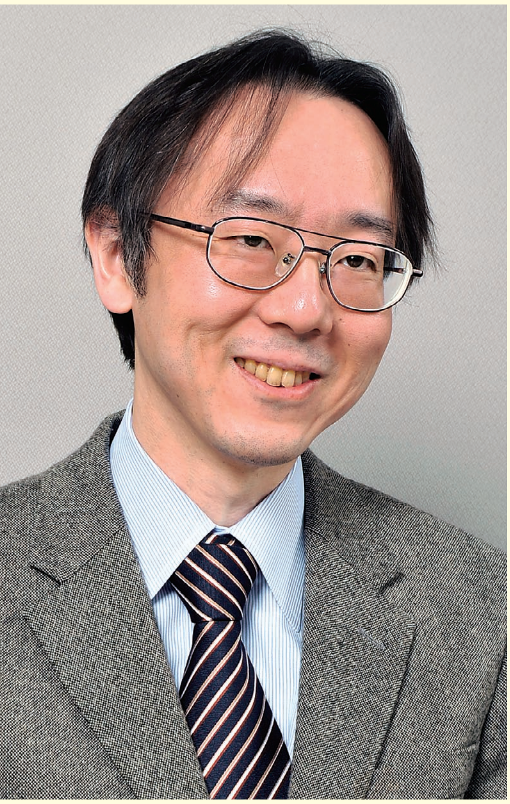

Biomedical EMC —Ensuring the safety of human body exposed by radio waves

Safety standards from Japan for one of modern life's essentials: radio-wave emitting devices

Soichi Watanabe

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After completing a doctorate at Tokyo Metropolitan University, joined CRL (currently NICT) in 1996. Engaged in research related to Biomedical EMC. Doctor of Engineering.

Radio waves are used in all kinds of situations in modern life, from mobile phones, wireless LANs for personal computers, and portable game machines. Under such conditions, one of the issues on which NICT is conducting research is the safety of exposure to these radio waves for the human body.

Technology to measure the effects of radio waves on the human body

— What research themes are you pursuing in the Biomedical Electromagnetic Compatibility Project?

Watanabe: We have set the objective of "Establishing a safe and comfortable environment for using radio waves based on radio frequency radiation protection guidelines." Towards this, we are advancing research in three main areas.

The largest of these is research on high-precision technology to evaluate exposure to radio waves. In order to study the safety of radio waves, we need to be able to accurately investigate where and how much of the energy of the radio waves has been absorbed when a body has been exposed--we need exposure evaluation, also called dosimetry. We are developing technology to do this.

An example of this is the high-precision numerical models of the human body we have developed. In our human body numerical models, aspects like the structure and shape of organs in the body are expressed as aggregates of tiny elements. We can not perform actual experiments exposing human bodies to radio waves ethically, so these models enabled us to perform computer simulations of what happens when the body absorbs radio waves.

When we first started this research, the only models available were of European-American males, which were quite different from the average Japanese body. So, in around 2000, we created models of adult male and female Japanese bodies based on MRI imaging. In particular, the female model we developed was the world's first whole-body numerical model with millimeter spatial resolution.

— So you created realistic models of Japanese persons.

Watanabe: Then, we developed child models and a model of a pregnant woman including a fetus, with a modeled embryo or fetus, and some of these models are now publically available, free-of-charge for non-profit use and for a fee for profit making purposes.

This study is the foundation for two other types of research. One is "Research related to compliance testing for radio frequency radiation protection guidelines", and the other is "Research related to development of an exposure system and exposure evaluation/Dosimetry for use in medical and biological studies."

— Could you first give an outline of research on compliance testing for radio frequency radiation protection guidelines?

Watanabe: Currently, there are various types of radio devices, such as mobile phones, and when manufacturers actually place the products they have developed on the market, they must confirm that the products satisfy the legally determined radio safety standards. For these tests, it is necessary that the evaluation methods provide the same results no matter where they are done, and by whom. To achieve this, the evaluation methods must be relatively easy to perform, and the results must be easy to reproduce and be the worst-case evaluation in practical situations. Our research is in creating evaluation methods that satisfy these types of conditions. It is also a problem if each country uses different evaluation methods. International standardization for these methods is extremely important. For these reasons, we also contribute to standardization activities at international standardization bodies such as the International Telecommunication Union (ITU) and the International Electrotechnical Commission (IEC).

— Specifically, what sorts of technology are you developing?

Watanabe: As an example, one index for safety standards of mobile phone terminals is amount of electromagnetic energy absorbed per unit mass in each part of the body, called the Specific Absorption Rate

(SAR). Methods for measuring the SAR were standardized internationally in 2005, but these have basically only been applied to cases when a device is used near the ear. Recently, however, devices are being left in a pocket while using a Bluetooth headset, so the mobile phone is in a breast or trouser pocket. In other cases, a PDA or laptop computer may be used on the lap. Personal computers now often have wireless LAN, so radio waves are being emitted in many positions, no longer just near the head.

We are calling these types of terminals "Body worn" terminals, and we are now in the final stages of standardizing measurement methods for radio terminals used next to any part of the body. We will have to deal with these works.

— How do you perform these measurements?

Watanabe: For SAR measurements, we attach an electric-field probe to the end of a robot arm. One of NICT's tasks is to calibrate these sensors (ensuring that the sensor output signal correctly corresponds to the electric field strength). NICT is the only organization in Japan performing this calibration. In other words, the safety of mobile phones sold in Japan is evaluated using sensors that are calibrated by NICT. Now, with the standardization of new measurement methods, the number of frequencies measured will increase. With the increase in frequencies, calibration systems for each of the frequencies must be developed and maintained.

— Next, could you tell us about research related to exposure systems and exposure evaluation for medical and biological studies?

Watanabe: The nature of this research is a little different from what we've talked about so far.

The radio wave safety standards currently in use were created based on results from past research. However, how radio waves are used has changed with the times, so for example, we are now using frequency bands not used before, or used in a way that was not anticipated when the safety standards were created. In order to confirm that the protection guidelines we have been using are still adequate with these new radio wave forms of use, animal and human studies and epidemiological studies are needed. We are also supporting development for this type of research from an engineering perspective, such as developing equipment to expose animals to radio waves.

As an example, in epidemiological studies, we examine patient histories for people that did and did not get cancer to see how much they used a mobile phone in the past, so we can find out how much difference there is in the actual amount of exposure to radio waves. Our group is participating in that sort of research.

— I've heard that NICT is also conducting experiments. Can you describe what sort of experiments?

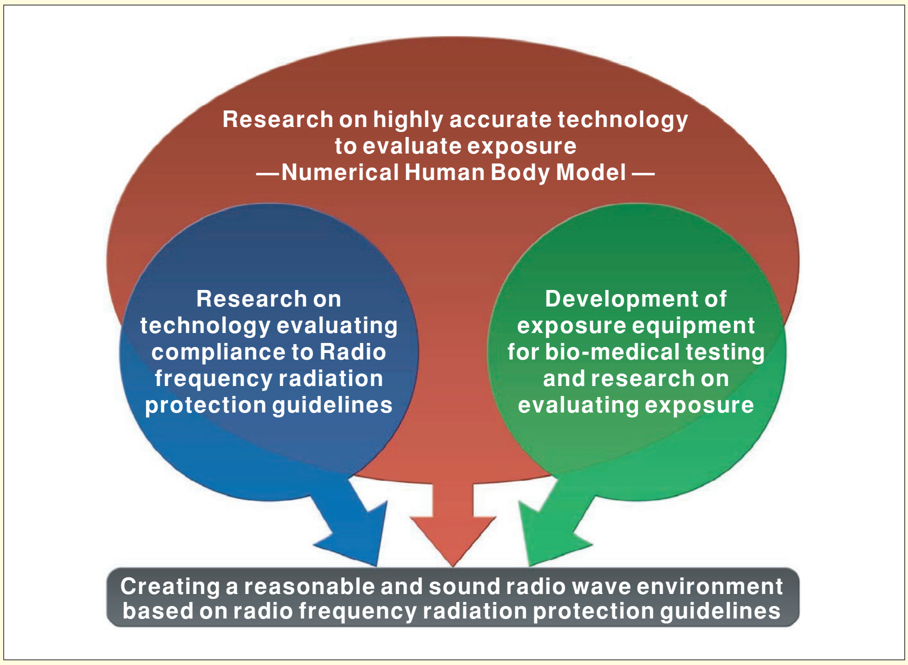
Watanabe: In the past we collaborated with the Medical faculty at Nagoya City University in an experiment called "Partial-body radio wave exposure experiments on the rat brain." These experiments were for studies about on carcinogenesis in brain tumors. Brain tumors are quite rare, so we used 500 rats and exposed them to radio waves over two years, equivalent to a whole life. We then compared the group exposed to radio waves with an unexposed group. The results showed no difference in occurrence of cancer whether exposed or not.

Currently we are conducting an experiment called "Whole-body radio wave exposure experiments using fetal and neonatal rats." In this experiment we expose young rats to radio waves inside their mother before and after they are born, and monitor their development and growth. Even in these experiments there was no difference between the exposed group and the unexposed group, but we are continuing further to see if exposure of their descendants has any effect.

— I have heard that you are also participating in international epidemiological studies.

Watanabe: We participated with Tokyo Women's Medical University and Keio University in a study of past use of mobile phones by brain tumor patients. Since brain tumor patients are rare, the study gathered data from patients from 13 countries around the world. There are also many types of mobile phones, so we divided them into categories by how radio waves would be absorbed by the head, providing data on whether there was any correlation between the location of brain tumors and the amount of radiation absorbed.

There was another issue, called electromagnetic-wave hypersensitivity, in which subjects complained of headaches when mobile phones are used next to them or when working next to a computer monitor, even though the devices were well within the levels of safety standards. In collaborative research with Fukushima Medical University, the University of Tokyo and the National Institute of Public Health, we conducted experiments with the cooperation of subjects having these



●Research objectives of the Biological EMC Project complaints. We studied changes in mood and other factors under conditions where they did not know whether radio waves were present or not.

Ongoing research to reduce risk to the absolute minimum

— I was surprised to hear that studies using rats have gone as far, but does research in biomedical EMC make the assumption that radio waves are not always safe?

Watanabe: We cannot prove that there is absolutely no risk. Even if we did, new technology would come out and there would be renewed concern whether it is safe. For that reason, we pursue safety to the point that we can say, "we have studied it thus far with no problems, so even if there is some effect, the risk is likely within a range that it can be safely ignored."

In 1996, the World Health Organization (WHO) initiated a project doing a comprehensive evaluation of health risks, recommending all countries to share in advancing the research.

This project is promoting countries to conduct many experiments to confirm the safety of radio waves, including experiments to determine how much exposure can cause risk to life. Safety standards are to be decided on the basis of this project's risk assessment, but there are still examples when results indicated there "may have been some effect," even below these safety standards. When such experiments were repeated, however, they were not able to confirm such effects, so it was concluded that there is no problem. It is still very important to accumulate such data carefully, however.

— Surely there is a need to study further if there is suspicion that there may still be some risk?

Watanabe: I believe that even now, we have reached the point where we can say there are probably no significant effects that could cause serious health effects. Many people around the world are now using mobile phones, and through their entire lives from childhood to senescence, so, even if the risk is small, it may present a societal risk that we cannot ignore. I have heard that this is the basis for why the WHO continues to stress research on the effects of radio waves, and even more thoroughly than for other risk factors. Accordingly, NICT is also conducting research on the assumption that there may be some risk.

— This means that study and research must continue, because there may be some effect on humans when they are exposed continuously to radio waves over long periods of time, even if they are weak.

Watanabe: There is one major milestone we are expecting in the near future.

In the WHO project we were discussing earlier, one of the studies we participated in was an international epidemiological study on brain tumors. The studies in each of the countries have ended, but pooling of all of the data and the results of evaluating it should become available within this year. When that comes out, the International Agency for Research on Cancer (IARC), which is a WHO research facility, will put out issue a judgment about whether radio waves are a potential cause of cancer. With this evaluation, the WHO will give a comprehensive evaluation of health risks, including health effects other than cancer.

This is expected in around the year 2012. I think that at that point, we will be able to say we have a conclusion to some extent, on the health risks related to mobile phones.

— What effect do you think that conclusion might have on activities at NICT?

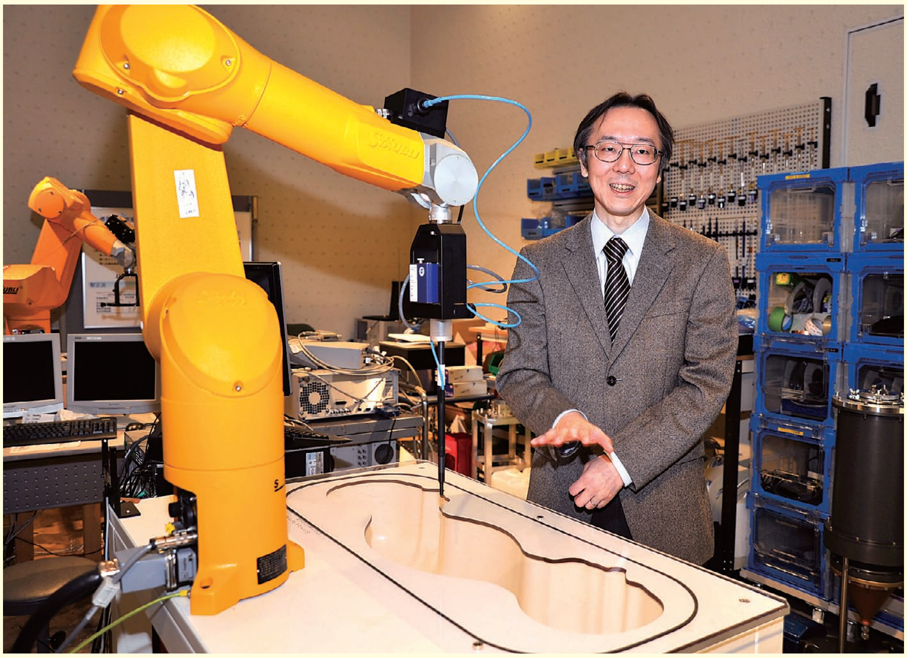
Watanabe: At that point we will have to reexamine our safety standards in light of the report, and if they are revised, we will need to change the evaluation procedures used to check compliance to the new safety standards. In the meantime, new technology like 4G mobile phones is coming out, and we will have to continue research on what effects the radio frequencies they are using could have. So, the cycle continues.

But even so, this state of not knowing will not continue forever. One-by-one, we examine uses of radio waves, and conclude the safe range, and this research will continue for new radio systems.

The state of international standardization regarding safety standards

— How is this research done in Japan positioned among research around the world? Also, we hear about the importance of international standardization for safety standards, but what is the current state in this area?

Watanabe: Safety standards for radio waves are being created in countries around the world, and most of the western countries, as well as Japan, have basically the same content. On the other hand, safety standards in places like Eastern Europe have become quite strict. Nonetheless, if the safety standards between countries are too different, it can cause problems, and one of the major themes addressed by the WHO is the coordination of these international safety standards. Recently, safety standards in all countries are



●System for measuring SAR for a mobile phone

gradually approaching conformity.

— This means they are still not completely aligned, doesn't it? Does that mean that even if I create a mobile phone that clears the standards in one country, I cannot necessarily sell it in all other countries?

Watanabe: For mobile phones, some countries have different safety standards. There are guidelines created by the International Commission on Non-Ionizing Radiation Protection (ICNIRP), which have been adopted in Japan and the EU. In the USA, safety standards are based on guidelines from the IEEE standards issued in 1991. These safety standards both consider the thermal effects on the health of the human body, but the indices used to express these thermal effects are different. The other day, the USA Food and Drug Administration (FDA) held a workshop to study this issue, and NICT, in cooperation with the Nagoya Institute of Technology, provided dosimetry data on the exposure to the body, contributing to promoting international safety standards.

There are also other issues with the safety standards of various countries. Some of the countries in Europe take a very strong position on the principle of precaution. When the mad cow disease became a problem, before the causes were clearly known, some countries stopped importing beef from any country where BSE had occurred. This was based on the principle of precaution, and some think it is necessary to apply this same type of policy in the case of electromagnetic radiation. Some research has reported results that there may be some effects even for radiation below the safety standard levels, and some people think we need to limit use of radio waves as much as possible until this possibility is eliminated.

— That seems to mean that if they conform to this principle of precaution, some countries think that the safety standards we have been using are actually inadequate.

Watanabe: That's right. In some places adopting this approach, it is not possible to build base stations near hospitals or schools where there are children. However, in some of these countries this is being applied rather haphazardly, not requiring existing facilities to be moved, but restricting construction of new facilities. This is being done under the guise of the principle of precaution. These actions have no basis in science, and just promote further confusion, so neither we nor the WHO recommend them. In particular, the strength of radio waves emitted from mobile phone base stations is much lower than levels set by safety standards (less than several thousand times below), so it is the opinion of the WHO that there could be no health effects from exposure to radio waves from a base station. On the other hand they have indicated the opinion that further research is needed on the effects of exposure to radiation from mobile phone terminals themselves. But, there are those who are still concerned, even though a mobile phone has actually cleared the required safety standards. We cannot scientifically say with certainty that it is absolutely safe, but in order to convincingly say "it is probably fine," we need more reliable research data, so we will continue our research.

Research contributing to global standards from NICT

— Is NICT the only place in Japan conducting this level of research and development?

Is it expected that the need for this sort of research result will increase in the future?

Watanabe: There is also quite a bit of theoretical research, mainly using simulation, being done at universities. There is also work being done proactively in private enterprise in areas like compliance evaluation testing and contributing to the IEC or ITU.

Recently, when new measurement methods are standardized, wireless LAN may also come under regulation in Japan, so manufacturers of products other than mobile phones are also playing some attention.

— Can you tell us about any future objectives you have with the EMC Group?

Watanabe: Till now at NICT, we have focused mainly on mobile phones in our work on compliance and biomedical studies. However, in addition to mobile phones, new devices used near the body with radio waves are now appearing, such as wireless LAN, RFID, and millimeter-wave devices. We need to continue research on these new types of device.

Basically, we are required to produce data enabling us to accurately evaluate whether the radio frequency radiation protection guidelines we are using now are able to handle these new uses of radio waves, either by animal testing or by simulation using human-body models.

— Ultimately, after reviewing the safety standards, what sort of compliance evaluation methods do we need to accurately evaluate our safety standards? I would like to expand that sort of research to also cover devices besides mobile phones.

NICT is the only public facility in the world that is conducting this sort of comprehensive research on this scale. Research is being conducted in other countries, but usually it is only within a particular field, so NICT has some global name value in that respect as well.

As I discussed the numerical human body model development earlier, but we have a firm grasp on technology able to perform inspections at a world-class level which is recognized globally. We want to send this technology into the world and build global recognition of the quality of NICT research and development. Our goal is for NICT to be leading the development of global standards.

— Thank you very much for speaking with us today.

Human-body Numerical Models for Estimating Absorption of Radio Waves Inside the Body

Detailed safety evaluation for using radio waves under various exposure situations

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Estimating the amount of electromagnetic energy absorbed from radio waves in the human body

Recently, the use of radio-frequency (RF) electromagnetic waves has spread rapidly, as represented by mobile phone, and devices emitting radio waves are being used close to our bodies more and more often. On the other hand, concern about the health effects of these radios waves on the human body has also increased dramatically. When considering the safety of radio waves for the human body, it is necessary to accurately estimate Specific Absorption Rate (SAR), which is the per-unit-mass amount of energy absorbed when exposed to radio waves , for each part of the body.

The SAR, which is used as an index to measure the thermal effects (thermal stress) of RF electromagnetic field exposed on an organism, is estimated using a numerical model of the human body and computer simulation. A human body numerical model expresses the forms of the human body (tissues, internal organs) using collections of very small blocks (elements), with each block assigned a number indicating tissue or organ name, such as muscle, fat, or heart. So far at NICT, we have created a detailed simulation of the anatomical structure of the human body using MRI data, and developed numerical models of adult male and female bodies, having average Japanese physique and in a standing position. These are called TARO (male) and HANAKO (female).

These models called TARO (male) and HANAKO (female) contain 51 types of tissues and organs, and TARO is composed of about 8 million, 2 mm-cube blocks, while HANAKO is composed of about 6.3 million such blocks. This enables highly accurate simulations for a Japanese adult. However, it is well known that the amount of energy absorbed by a human body depends heavily on body size (height, weight, body type), posture, internal structure (amount of body fat, etc.), so problems arise because, for example, a numerical model of an adult is not suitable for simulating a child,

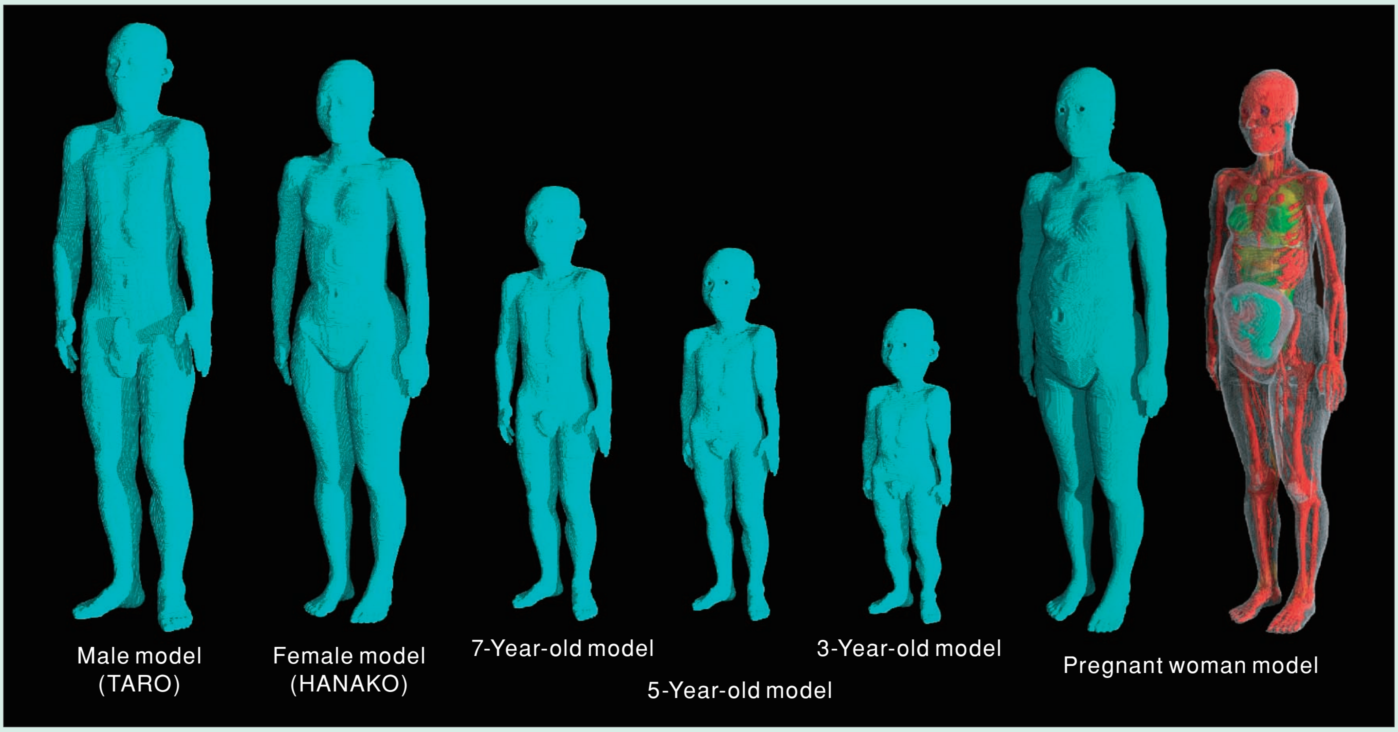

Figure 1 ●Human-body numerical models developed at NICT
An image of the surface of each model is shown. A volume rendering* image of the pregnant woman model is also shown, showing the shape of the fetus. The block size in these models is 2 mm. There are 51 different tissue types of structure in the adult male, female and child models, and a total of 56 different tissue types including gestational tissues (fetus, fetal brain, fetal eyes, amniotic fluid, and placenta).

* Volume rendering: A visualization method used for viewing objects such as the human body in 3D, including the internal structure of the objects.

which would be quite different in these respects. Thus, in order to handle this sort of issue, NICT is conducting research on the sophistication of these models to cover arbitrary body types and arbitrary postures.

Models of pregnant women and young children

Recently, SAR evaluation of pregnant women, and their fetuses, and small children has become one of the most important research issues related to radio-wave protection, and in 2006, the World Health Organization (WHO) raised SAR evaluation of fetuses and infants to one of its top issues. However, creating numerical models of a pregnant woman or children using the same method as was used to create TARO and HANAKO models, with MRI data of the whole body, presents ethical issues and would require much development time. To handle these problems, we are building models of a pregnant woman and small children by applying 3D transformations to the TARO and HANAKO models (Figure 1).

The pregnant woman model, developed in cooperation with Chiba University, was constructed by combining a newly developed model with structures particular to pregnant woman (fetus, placenta, etc.) based on MR images of the abdomen of a 26-week-pregnant woman, with a model expanded from HANAKO by FFD (Free-Form Deformation) method, matching its abdomen to that of pregnant woman. This numerical model is the first in the world that faithfully models the particular structures of a pregnant woman's body, including 56 type of tissues and organs, including the fetus and other structures of a pregnant woman, and is composed of 7.1 million, 2-mm-cube blocks. This pregnant-woman model database is currently published on the Web for use in a wide range of research fields in the same manner as TARO and HANAKO models (http://emc.nict.go.jp/bio/data/index_e.html).

The proportions of various body parts relative to height (e.g. head size relative to height) are quite different for adults and children, so it is not possible to construct small child models that resemble an actual child body by simply transforming the adult model to match the height and weight. Thus we measured the dimensions of over 60 parts of children, and used the data to transform the TARO model to match them. At NICT we are currently developing human-body numerical models of children ages 3, 5, and 7 years-old, composed of the same tissues and organs structure and block size as the TARO model, and for use in SAR evaluations. This method also enables us to construct models of arbitrary body types in a short time, allowing the evaluation and study of various age groups.

Expanding the range of application for human-body numerical models

As can be seen in Figure 1, all of the human-body numerical models discussed so far are in a standing posture. In order to perform SAR evaluations under more realistic conditions, and in positions that wireless telecommunication devices are actually used, we are studying ways to allow the numerical body models to be placed in arbitrary positions. By dividing the numerical models into several parts at the joints, and using FFD to move them in arbitrary directions, we are able to generate models in various positions (Figure 2). The numerical body models developed at NICT have very-high-resolution, 2-mm blocks, and can be used for SAR evaluations up to about 3 GHz, but wireless telecommunication devices will move into higher bands in the future, and we will need to have even higher resolution models for these higher frequencies.

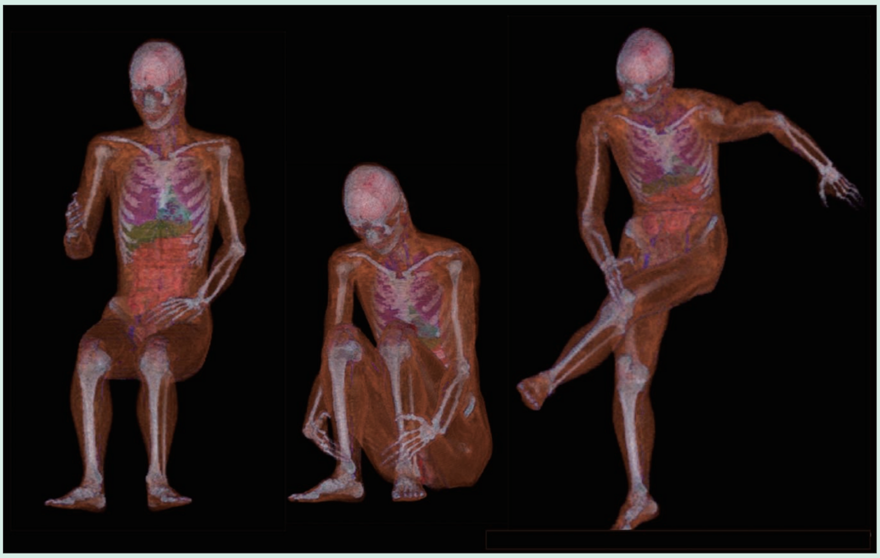

Figure 2 ●Examples of transformed poses of the adult male model (TARO) (displayed with volume rendering)

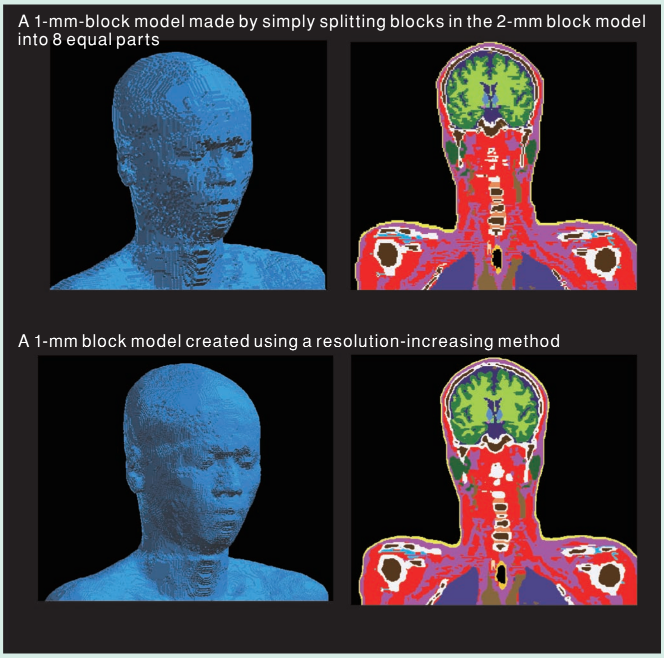

Figure 3 ●Increasing the resolution of numerical body models

We are smoothing roughness at the boundaries between structures in the numerical model that can be a factor which induces error, as shown in Figure 3, we are also studying methods for constructing models of arbitrarily high resolution.

Future initiatives

NICT has advanced research in creating more-sophisticated numerical models of the human-body by extending existing models to develop new ones and by adding new functionality such as the ability to change postures. This is being done to enable approximation of SAR inside the human body with high precision and under realistic conditions for a variety of types of people. In the future, we hope to make further improvements to methods for constructing models of arbitrary body type shape, taking anatomical features of the internal structures into consideration rather than just the shape, and allowing us to perform electromagnetic safety evaluations in fine detail for a variety of situations using RF electromagnetic waves. We believe we will be able to instantly construct models of the body type of any individual, being faithful to the internal structure of the body, and to use these models to accurately estimate the SAR amount of radio-wave absorption inside the body.

New Generation Network Targets "Sustainable Networks"

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What is "Sustainable Network?"

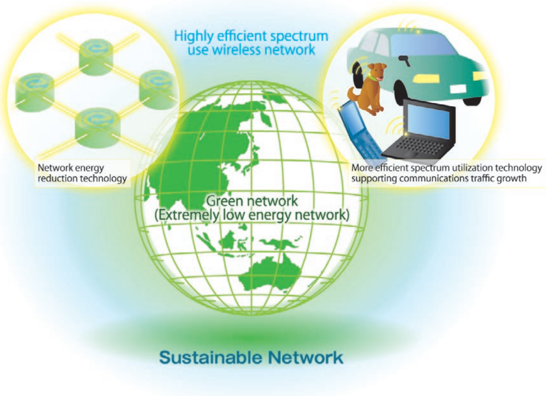
Through the next several decades, New Generation Networks are expected to be applicable continuously matching needs, costs and the environmental condition at the time.

"Sustainable Network", which is one of the targets in the New Generation Network Technology Strategy, is aimed to find solutions to various constraints imposed by the limited capacity of the earth, enabling sustainable development of networks and society.

The Energy Problem: Green Networks

The amount of traffic generated by the use of ICT has been increasing recent years, and it is estimated to reach from 1 to 100 thousand times its current level in 15 years time.

Already, the energy consumed by ICT is approximately 5.8% of the total in Japan, and if this trend continues, serious increases in energy consumption will be unavoidable in the near future. Considering recent international trends regarding energy issues (e.g. global warming by more emissions of greenhouse gases), finding a radical solution is an urgent task.



For this reason, our goal with New Generation Networks is to dramatically increase the energy efficiency of transporting information, by a factor of 1000 or more. The increasing traffic will be accommodated in New Generation Networks without increasing power consumption.

Some research results have been indicated that achieving this sort of drastic increase in energy efficiency will be extremely difficult by merely improving the efficiency of individual components of communications equipment, such as routes.

Thus, more radical fundamental counter measures covering networks or ICT overall, including redesign of the network architecture, may be required.

This could include energy-saving transmission methods such as photonic networks, equipment configuration methods, device technology and technologies like sleep modes for when an equipment is idle. It could also include communication technology that achieves ultra-low power communication by innovating on the major core protocols used on the current Internet, such as IP and TCP, that assume all nodes keep always-on.

Furthermore, Technologies to improve energy efficiency of network and servers, they cloud be appliances, the efficient information and contents distribution to reduce the amount of traffic flow are also thought to play a key role to achieve the reduction of power consumption.

Spectrum resource issues

Due to the rapid increase of wireless communications users and of communication data rate per user, we are rapidly approaching the limits of radio spectrum resources, and on the verge of them.

New wireless technologies, such as ubiquitous communications and sensor networks, will also be accommodated in New Generation Network. Research and development of technologies to handle the increase in wireless communication traffic is imperative.

For that purpose, the goal is to increase the wireless communication capacity for end users to 100-times the current level. To accomplish this, we are developing various wireless technologies. As examples, we are conducting research to realize the following: (1) Increasing the range of available frequencies, e.g. high-frequency bands that are not yet fully utilized, that can be used by new developing technologies; (2) Increasing the efficiency of spectrum use (information transmitted per Hz and per unit area: bit/Hz/km^2) through technologies like cognitive radio and Multiple Input/Multiple Output (MIMO) transmission; and (3) allocating spectrum resources dynamically according to type of users, by accommodating fast-moving users through macro-cell networks like the mobile phone networks, on the other hand by high-frequency wireless systems for nomadic users or (quasi-)static appliances. To Bring the nomadic users and (quasi-)static appliances into short-range wireless devices attaching to wired networks may be a solution without causing inconvenience to them.

New Generation Network Targets "New Generation Network Fundamentals"

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Fundamental areas that form a common infrastructure for the five network targets

The goal of "New Generation Network Fundamentals", one of the technological strategy items for New Generation Networks, is to enrich fundamental areas that are commonly important to all of the five network targets introduced in earlier articles. This "fundamental areas" will also address several important facts and trends that should be taken into account in the mid- and long-term vision for the New Generation Networks. For example, it has been evident that (1) solid novel foundations for New Generation Network are highly demanded, beyond what conventional theoretical basis can support, (2) with increasingly fierce global competition in innovation as well as the structural changes in the industry, the importance of strategically placing individual technological innovations, such as in devices and materials technologies, in the value chain of the whole system is increasing.

In order to deal with these situations, the New Generation Network Fundamentals are summarized into following three important technological agendas.

Three important technologies and creating innovation

The first is "Network Architecture Fundamentals". As mentioned earlier, the classical theoretical basis in communications is becoming obsolete to be applied in the New Generation Networks.

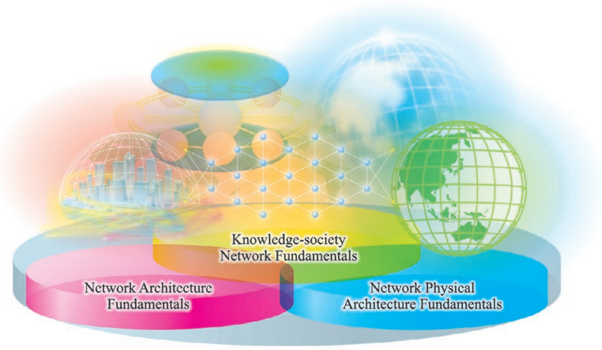
For example, queuing theory, which is based on the Markov characteristics of network, is inadequate for New Generation Network as the pattern of traffic gets more complex and diverse. Also, strong trends in cloud computing, commoditization of devices, and strict demands in green innovations are radically changing the assumptions of network design that have not been taken into account in conventional theoretical frameworks in ICT.

Therefore, the "Network Science", or theoretical foundations for New Generation Networks, is strongly demanded. It is also required in industry because the issues related to large-scale, complex network systems are commonly important in today's ICT infrastructure.

The second important area is "Knowledge-Society Network Fundamentals". As discussed in the "Value-Creation Network", New Generation Network should create value for people and society, not just serve as a transmission medium. Therefore the basic research in network is relevant to our fundamental understanding of human beings, including brain information. Also, careful consideration is required in the relationship between network and complex socio-economic impacts.

The third is "Network Physical Architecture Fundamentals". As raised in the "Sustainable Network", energy efficiency is one of the most important issues for New Generation Networks. It will be imperative to achieve the required coordination across all levels ranging from materials and devices to whole systems with respect to energy. There is a demand for creation of added values in coordination with physics and information, and new concepts should be built in network, such as Network Unification in the "Self-* Networks", Safe Networking in the "Trustable Networks".

Finally, the fundamental research itself can also be positioned as an important strategy for creating innovation. For example, Framework Programme 7 (FP7) in European Commission is now strongly pushing the "Future and Emerging Technologies (FET)" program in ICT. The individual projects in FET are, of course, seeking technological innovations in important research areas. At the same time, there is another important strategic reason behind FET; raising intellectual curiosity by pursuing fascinating fundamental research themes, attracting excellent researchers from around the world, and so forth. These are fundamentally important in surviving in the fiercely competitive global intellectual society. We should recognize the importance of strengthening fundamental research for mid- and long-terms.



New-generation Network Fundamentals

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Jian-Qin Liu

●Profile
After working as a professor at Central South University in China and as a Senior Researcher at Advanced Telecommunications Research Institute International (ATR), assumed his current position in 2006. Engaged in research on robust control of New Generation Network Architectures inspired by biological systems.
Ph.D, & Doctor of Informatics.

Towards Robust Network Control and Autonomous System Building

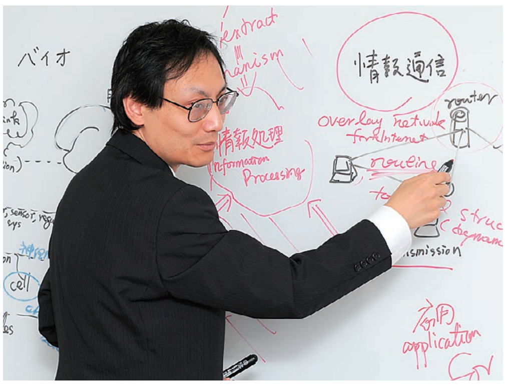
Designing New Generation Networks Inspired by Biological Systems

For information and communications networks several decades in the future

At NICT, we are advancing R&D on New Generation Networks, which will form the ICT infrastructure in the next several decades. Given the many technical problems and limitations that are difficult to overcome with only modifications to the Internet, we are working to find radical solutions by innovating new designs from a clean slate, unrestricted by existing technology. Research on one such entirely new concept, biologically-inspired dynamic networks, is being advanced at Kobe Research Laboratories. Expert Researcher Jian-Qin Liu of the Kobe Advanced ICT Research Center is undertaking this research.

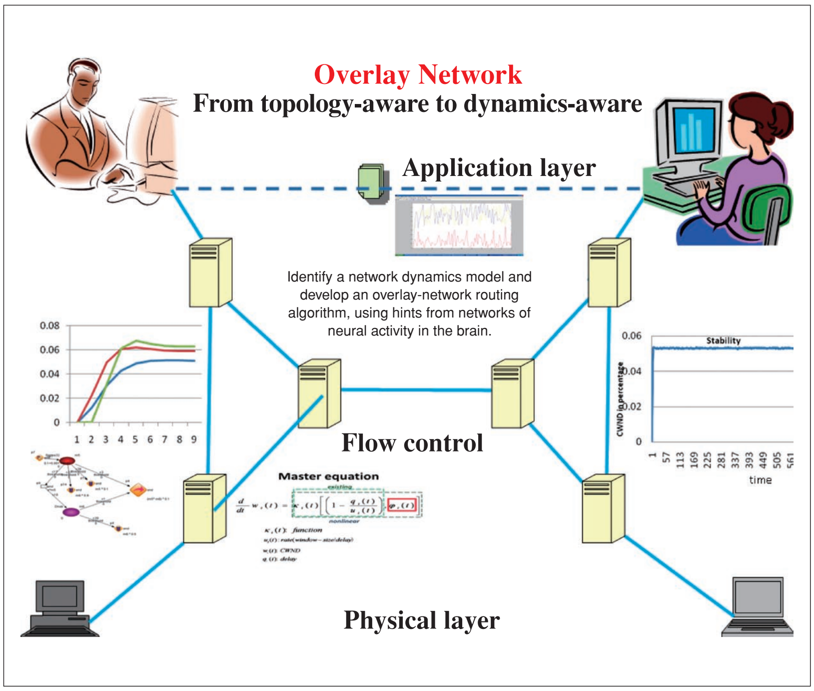
"We are focusing mainly on signal transduction in biology, and particularly the signaling pathway networks in the cell. Normally, chemical signals in biology, and the ones in data communications obey different rules and superficially look too different to be related each other. At first glance, these seem like different phenomena, but from the viewpoint of using a signaling pathway to exchange information, the corresponding informatics mechanisms extracted from them are identical. We are pursuing this research into biological mechanisms of signal transduction in the hope of discovering new principles that will be effective in data communications, as we create networks for the future.

There are several weak points in the current Internet, which was built on basic principles from the middle of the previous century. For example, we have all experienced the inability to access the Internet when many people try to access it at the same time, and transmission speeds drop suddenly due to traffic-jam-like congestion. We also need to secure communication methods and remedies when Internet infrastructure is destroyed by disasters such as large earthquakes. New Generation Networks must guarantee a minimum level of basic data communications, even in cases of natural disaster. For this, we turn our attention to networks at the cell level in biology.



Superior information transduction functions of organisms and a computational model

"The networks at the cell level in living organisms are able to process information dynamically, with flexibility and adaptability, even when assaulted with large amounts of information and in response to changes in their environment.



●Dynamics analysis and autonomous control of overlay networks

For example, when transferring information from protein A to protein B, if protein X is not available as a medium to transfer the information, protein Y can be used instead, so there is an ability to use alternate routes if one route is not working.

Neurons, which are nerve cells in the brain, are also a good example. Usually, neurons are autonomous, but they are known to be able to link together and behave collectively according to need. And yet, these autonomous neurons are able to communicate information effectively by synchronization within the brain.

I have been thinking about how to use these neuron properties in the architecture of New Generation Networks. If neuron-like sensors can be placed on the network, they would normally be turned off to save energy, but they could turn on autonomously and of their own volition. I am trying to learn from biology about the dynamics of these types of networks."

Dr. Liu is attempting to apply the excellent information transduction functions of living organisms to the theoretical design of New Generation Networks and to achieve "Robust Network Control” and "Autonomous System Building." Robustness refers to the mechanisms, characteristics and qualities of a system that enable it to preserve and recover its functionality in response to changes in its environment. Autonomy refers to the ability to produce solutions through local interactions, without having a centralized controller.

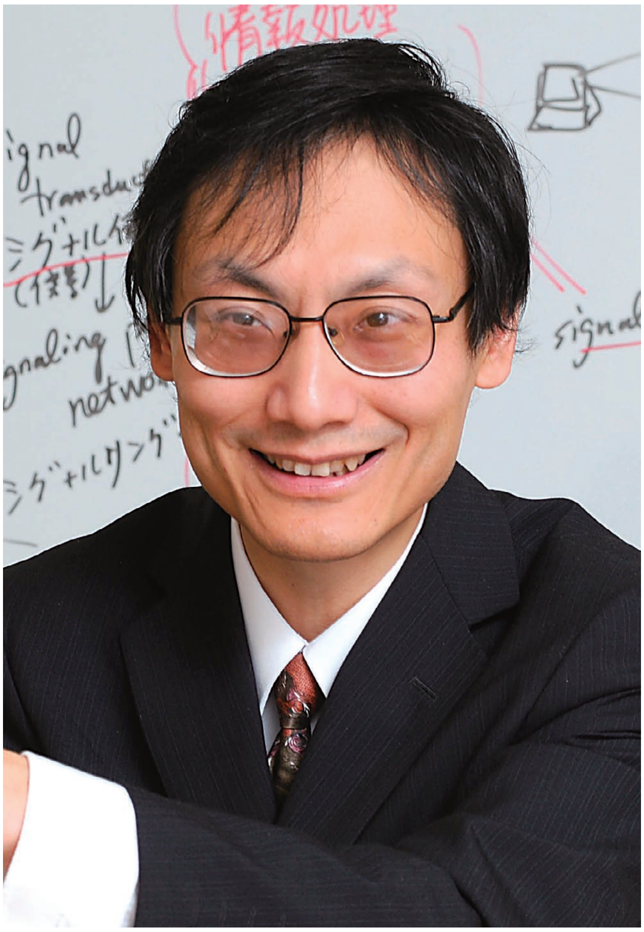
As one example of robust networks in biology that we can learn from, Dr. Liu describes the cell signalling network used by E. coli for Heat Shock Response (HSR). The folding mechanism of proteins in E. coli that is robust to heat shock is a series of biochemical reactions, but in order to design a new kind of network architecture for communications, Dr. Liu proposed a bioinformatics model of the HSR cell-signaling network and simulated the corresponding biochemical reaction processes based on biological faithfulness and evidences from molecular biology. Through this research methodology, he is developing a new, robust network control technology for providing high-reliability networks, applicable to the Transmission Control Protocol (TCP).

Kyoto and Nara, like the streets of his home town

Dr. Liu comes from Xi'an, formerly Chang'an in China. This city is also familiar in Japan as the destination for Japanese envoys to T'ang China, and is said to have had a close relationships with Kyoto and Nara.

"The 1300th anniversary of the transfer of the capital to Nara is in the news this year, but I noticed the similarities to back home when I first came to Kyoto and Nara. I was surprised to see the buildings preserved just as they were at the time."

Dr. Liu says he is interested in history and reading, and he learns a lot by reading history and then visiting the places where the events took place. On days off he likes to go out with his wife and daughter.



"I am a fan of Ryotaro Shiba and enjoy reading his books. I have also visited the Shiba Ryotaro Memorial Museum in Osaka."

Incidentally, he says that when he first came to Japan, he was reading the novels in English, but now that he has learned Japanese, he's reading the Japanese originals.

Bridge building between Japan and China

When asked about his image of Japanese people, Dr. Liu says:

"Japanese people take their work very seriously, follow the rules and proceed very carefully. I think that is their most prominent characteristic. In terms of human nature, they have a unique Eastern philosphy that Chinese people can also understand. I think that if this traditional oriental culture can be integrated with western methodologies represented by Galileo and Newton, it will be even more complete."

Regarding prospects for the future, "I wish to make a contribution to bridges building between China and Japan. If I return to China, I hope that I will be able to participate in planning a collaborative laboratory like NICT, with an environment that allows researchers to move back-and-forth between Japan and China."

Expert researcher Liu is examining phenomena at the cell level with a micro-perspective, while conducting research with a macro-perspective crossing national borders.

"2nd US-Japan Future Network Collaboration Workshop"
—Strengthening cooperation between Japan and the USA for implementation of the New Generation Network—

Tetsuo Aoki, Director, Strategic Promotion Office for New-Generation Network R&D, Strategic Planning Department

NICT and the National Science Foundation (NSF) collaborated in holding the second "US-Japan Future Network Collaboration Workshop."

Dates: December 4-6, 2009 (Fri-Sun)
Location: Honolulu, Hawaii, USA.
Attendees: 24 Americans, 32 Japanese
(including 13 from NICT)

The attendants who promoted alliance toward the realization of New Generation Network.

The first workshop was held in Palo Alto, USA, in October 2008, promoting exchange among researchers working on New Generation Networks in Japan and the USA. Following up on this first meeting, the second meeting had the goal of narrowing down the research themes and quickly initiating practical collaborative research projects between Japan and the USA. On the first day, NICT President Hideo Miyahara and Dr. Ty Znati from the NSF gave keynote addresses, followed by discussion from NICT Program Coordinator Tomonori Aoyama and Dr. Freeman from the NSF on the significance of the meetings from the Japanese and USA perspectives. Then the participants introduced themselves before engaging in a frank exchange of views on common areas of research.

On the second day, the New Generation Networks research environments in Japan and the USA (JGN2plus, GENI, etc.) as well as future research topics were introduced, followed by a description of the research systems at the NSF and NICT. This was followed by brainstorming and discussion on four themes, with a goal of creating a draft establishing themes and a system for collaborative research.

1) Testbeds for New Generation Networks and Services
2) Networking science and modeling
3) Network infrastructure technology
4) Reliability and security

The common challenges, approaches to solutions, and related issues were discussed. Based on the discussion, the coming challenges in research and possibilities for US-Japan collaboration will be summarized within the next one or two months, and will be published on the Web in the same manner as for the first Workshop (at http://nwgn.nict.go.jp/index_e.html).

The next workshop will be held in March 2011 in Japan.

Information for Readers

The next issue will include a variety of content, from practical research in the medical field to a report on leading-edge developments in nanotech.

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