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Developed the World's First Earth's Magnetosphere Real-Time Simulation System

Mitsue Den

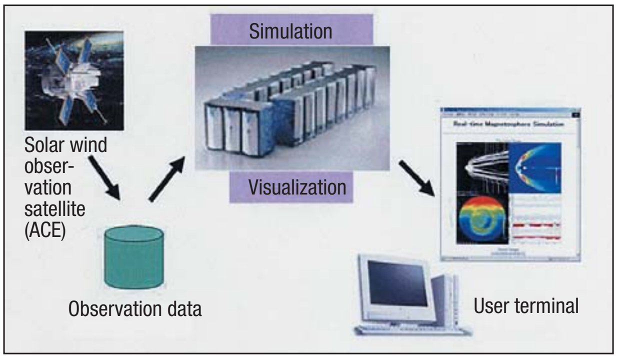
Chief Researcher, Simulator Group
Applied Research and Standards Department

Joined in 1991. "From graduate school on, I've worked with numerical models on varying scales simulating phenomena from cosmology and astronomy to interplanetary space. The ever-growing computing power at our disposal makes it possible to re-create in real-time phenomena that can't be observed directly, which is one of the long-sought goals of researchers who use computer simulations."

Artificial satellites such as meteorological, communications, and broadcasting satellites now constitute essential components of society and daily life. What's more, as symbolized by the Space Station Program, the actual sphere of life is extending into outer space. The conditions of outer space affect today's society. In fact, solar activity has profound effects on conditions around the Earth, including significant effects on satellite function.

In 1988, NICT launched the Space Weather Forecast Project to provide information on solar activity levels, the Earth's magnetic fields, and high-energy particles. Reliable forecasts mean clarifying the mechanisms that generate and propagate disturbances, as well as tracking conditions. In addition to ground-based observations, satellites have recently been used to observe the sun, solar winds, and the Earth's magnetosphere. Advances in network technologies allow collection of observational data in real-time for use in understanding the space environment. On the other hand, advances in space physics and in computing resources make it possible to model and re-create disturbances that cause variations in outer space, based on numerical simulations. It's important to enhance simulation speeds to be able to follow actual physical phenomena and visualize computation results in real-time, so that we can use up-to-the-minute observation data in simulations to provide reliable and valuable forecasts. The Simulator Group tries to clarify the mechanisms and effects of disturbances occurring in space between the Earth and the sun using the Supercomputer SX-6 (made by NEC). We forecast variations in outer space to reduce damage to satellites such as surface charging, orbital changes, and degradation of solar battery panels.

We developed an Earth Magnetosphere 3-Dimensional Real-Time Simulation System in collaboration with NEC and Professor Tanaka of Kyushu University (former NICT Senior Researcher). This system uses real-time data (density, velocity,



System Structure

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

Q First of all, what is the magnetosphere?

A The magnetosphere is an area around the Earth in which its magnetic field exerts effects. On the sunny side (the region of the world experiencing day), its radius is around ten times that of Earth (60,000 km). On the opposite side (the night region), it's more than 100 times as large (600,000 km). The conditions of this magnetosphere change in response to variations in solar winds (an ionized thin gas blowing from the sun), which in turn causes magnetic storms and variations in the radiation environment.

Q What's the L1 point?

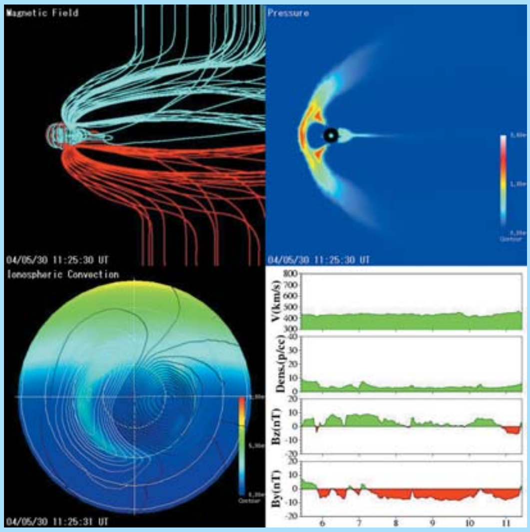
A The L1 point is a gravity equilibrium point between two astronomical objects (e.g., the Earth and sun) at which universal gravitation and centrifugal force are in equipoise, allowing artificial satellites to maintain their relative positions. There's an L1 point 1.5 million kilometers away from the Earth. "L" is named after Joseph-Louis Lagrange, who proposed the underlying theory.

and temperature of solar winds and the y and z direction components in the magnetic field of interplanetary space) observed about once per minute by ACE, a US solar wind observation satellite located 1.5 million kilometers toward the sun. The system incorporates constantly updated data in simulations around once a minute to perform computations in quasi-real-time. The system's simulation program uses spherical coordinates distorted to match the Earth's magnetosphere, as well as a TVD scheme (a differential scheme that reduces errors, such as those arising from vibrations with minimum numerical viscosity; suitable for simulating discontinuous structures such as shock waves) to provide an interaction model of solar winds and the magnetosphere with 3rd-order accuracy in space. This system can track physical phenomena in real-time for real-time simulations. To obtain the necessary speed, the simulation program is written in HPF (High Performance Fortran). The SX-6 system is configured with eight CPUs for parallel computations. We achieve real-time visualization by using RVSLIB (Real-time Visual Simulation LIBrary made by NEC) to process computation results in tandem with simulations on the supercomputer. Updating images about once a minute, the system provides a comprehensive picture of the Earth's magnetosphere about one hour in the future. Real-time simulation and visualization of variations in the magnetosphere caused by variations in solar winds now make it possible to constantly monitor variations in outer space where artificial satellites are located. It represents the first system of its kind anywhere in the world.

This system runs nonstop, 24 hours a day. Past data are archived as motion picture data (in avi format) on a daily basis. These files are freely available for downloading. Current real-time images and past simulation data are available at: http://www.nict.go.jp/dk/c232/realtime/

From this point, we plan to analyze this system's computations and improve the simulation program through comparisons to observation results of aurora activity. We also plan to establish quantitative and highly accurate forecasts of magnetospheric disturbances, which may be used as input data in models of the ionosphere and radiation belts where high-energy particles are distributed. We intend to develop simulation models for the region of interplanetary space located above the magnetosphere and to make space weather forecasts that cover interplanetary space and the Earth's magnetosphere and ionosphere.

Simulation Results



An example of 3-dimensional numerical simulation results for magnetic fluids present throughout the entire magnetosphere (upper left: magnetic field lines; upper right: plasma pressure; lower left: activity levels of the polar region; lower right: six hours of solar wind parameter data used in simulation)

Life & Technology

● Space weather is observed worldwide.

Observations of the space environment, including the Earth's magnetosphere, must be performed on a global scale. An international network called ISES (International Space Environment Service) has been established for this purpose. As a member of this organization, NICT plays an important role in exchanging observation data and forecast information. We provide a space environment information service through the Internet and by telephone. In Space Weather News, launched on the Web last October, we also predict the appearance of auroras. Solar activities have led to numerous incidents, such as the premature decommissioning of the ASCA scientific satellite, the breakdown of the Mars orbiter Nozomi, and temporary interruptions in satellite TV broadcasts. We shall strive to provide more accurate forecasts in order to reduce the frequency of such incidents in the future.

Information Communication Technology for Linking Family Members

Tatsuya Yamazaki

Chief Researcher, Distributed and Cooperative Media Group
Keihanna Human Info-Communications Research Center
Information and Network Systems Department

Joined the Communications Research Laboratory (currently NICT) in 1989. Worked on research in quality control of statistical image processing and multimedia communications. Currently engaged in R&D involving distributed collaborative networks and services. Holds a Ph.D. in engineering.

Introduction

The widespread use of broadband networks today throughout the country has created a ubiquitous information society in which every home appliance is connected to a network and vast volumes of information are available for every public space or household. One of the main information communication technology issues for the future will be how to make use of this wealth of information and the appliances connected to various networks. Places such as classrooms and offices have already come to rely on such information and these appliances. But it is in the home and on the street where we'll find diverse needs connected to the most basic aspects of our lives.

Especially at home, people of various ages have different living patterns. We need to provide services tailored to the detailed needs of individual users—in other words, highly flexible and adaptable technologies. To find out which IT services are in demand, we need to design services from the viewpoint of daily life and solicit feedback from users. It's also important to test the interconnectivity of various types of appliances and multiple vendors.

To address these challenges, Keihanna Human Info-Communication Research Center (hereinafter "Keihanna Center") built "The Ubiquitous Network Home," a test bed for demonstrations of real-life ubiquitous networks.

The Futuristic Ubiquitous Network Home

The Ubiquitous Network Home located on the premises of Keihanna Center looks like a model condominium. Figure 1 gives its floor plans. The right half of the home is the actual living space for a family, consisting of a living room, study, bedroom, dining room with kitchen, and bathroom. We installed cameras, microphones, displays, RF-ID tag systems, and floor pressure and human sensors everywhere in the home. These devices are all connected through a network. Figure 2 shows the locations of these devices and sensors.

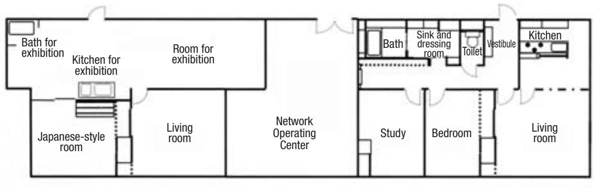


Figure 1: Floor Plans of "Ubiquitous Network Home"

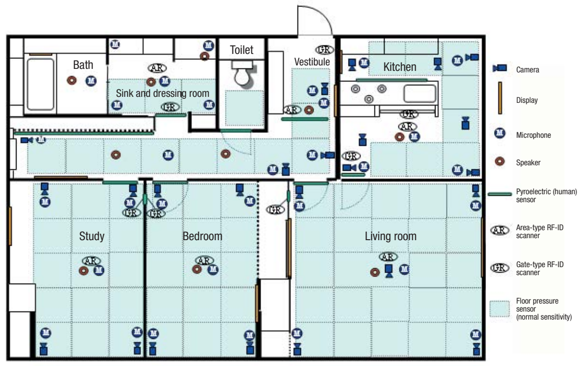
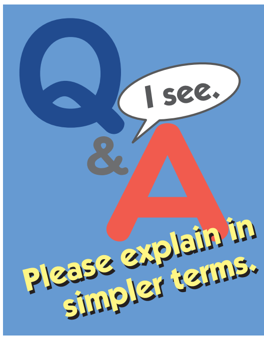


Figure 2: Locations of Devices and Sensors

Power-operated dome cameras are installed in the ceiling of each room, capturing video at 5f/s (frames per second). The database capacity is sufficient to store up to two months of video information. Microphones are also installed in the ceilings to gather voice and sound information. To provide rather than collect data information, we installed displays not only in the various rooms where family members spend time together, but in other rooms and in hallways. Each room's ceiling has built-in speakers.

Pressure sensors (with dimensions of 180 mm x 180 mm) are installed in the floor to determine where people are and to monitor where they've tread. Infrared human sensors are installed in the upper part of the doors as well as certain areas of the kitchen and hallways to detect the passage of people. The RF-ID tag system has



Q What's a ubiquitous network?

A Drawn from Latin, the word ubiquitous means "present everywhere". A ubiquitous network is a network where all types of information equipment are linked over a wide area network, allowing users to exchange information anywhere and at anytime.

Q What's an RF-ID tag system?

A RF-ID stands for Radio Frequency IDentification. This system reads/writes data from/to tag-shaped media via radio frequencies to identify objects and process information. Possible uses include freight sorting, distribution management, and entrance/exit control. An RF-ID tag is also referred to as a wireless, wireless IC, or electronic tag.

two types of scanners that can be used for respective purposes: an area-type scanner detects tags within a limited area, while a gate-type detects tags when they pass through a gate where a scanner is installed.

Our goal is to create a new framework in which a house can understand the status of its residents on its own and provide appropriate services by integrating the data obtained via precisely placed sensors.

Unconscious and Visible Robots

Keihanna Center's Distributed and Cooperative Media Group is currently undertaking a project called UKARI (Universal Knowledgeable Architecture for Real-LIfe Appliances) using the Ubiquitous Network Home in joint efforts that also include industry, academia, and government representatives. This project seeks to create a "universal usage environment" in which each individual can easily make use of support services for daily life in the most suitable manner. One of the project features is cooperation between "unconscious" and "visible" robots, as shown in Figure 3. In this model, we consider a Ubiquitous Network Home equipped with various sensors and devices as an unconscious robot that protects its residents without drawing attention. By combining this robot with a visible robot that interacts with the residents and serves as a user interface, we intend to provide sophisticated new services. To prevent the network and its connected devices from offering services the user doesn't want, this model combines carefully planned default protection levels and interactions with a visible partner (robot) that allow user adjustment.

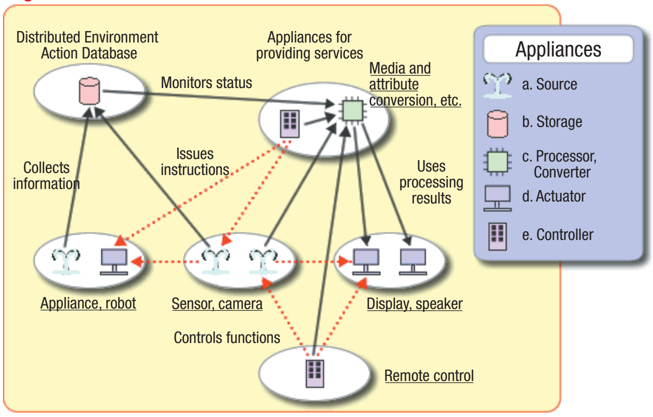
Figure 3: Conceptual Drawing of Unconscious and Visible Robots

The unconscious robot (the house collectively) works in the background unnoticed to protect the family (as the mother robot); the visible robot interacts with family members (as its child).

Distributed Collaborative Infrastructure Middleware

Another important subject of UKARI is R&D involving a mechanism for simplifying appliance functions and integrated appliance functionality over a network (Figure 4). Many of us don't bother using all the functions of various appliances, often discarding such appliances when a single function fails. This research is intended to eliminate such waste. A distributed collaborative infrastructure will make it possible to build virtual equipment that links only necessary functions, allowing for efficient sharing of various network-linked functions and optimizing the usage environment for individual users. We're currently developing "UKARI Core," built-in middleware that implements the distributed collaborative infrastructure. We've succeeded in identifying the functions of a washer, refrigerator, and television and gotten them to function collaboratively over a network. Users will be able to receive a new, superior type of integrated services rather than a mere aggregate of separate appliance functions, while eliminating the difficulty of controlling and operating multiple appliances. I think this research will create the basis for developing universal services for specific daily needs.

Figure 4: Distributed Collaborative Infrastructure Middleware



Divides information appliances into five categories and provides a mechanism for integrating control of the various functions provided by the multiple appliances.

Conclusion

In this article, I introduced the Ubiquitous Network Home, which uses information devices, sensors, and network-connected home appliances to create a ubiquitous networking environment and provide various services for daily life. By incorporating information communications technologies into homes, the UKARI Project seeks to realize easy-to-use services and a usage environment linking family members and promoting communication. By tailoring applications to individual needs, this project seeks to create universal designs for living environments based on information communications technology.

Life & Technology

● The Ubiquitous Network Already Around Us

A ubiquitous network may sound like science fiction—but in fact, we've already started to adopt such technologies in our daily lives. For example, mobile phones now support many functions, including providing navigation services and serving as electronic cash, while wireless IC cards enhance the convenience of using commuter passes. Such devices are also part of the ubiquitous network.

Report on Opening Ceremony for the JGNII Japan-US Line

Hiroyuki Aoyama
Director, Network Test Bed Management Division
Collaborative Research Management Department

Photo 1: Greetings from President Nagao (left) and Vice Minister Tabata (right)

Photo 2: Ribbon-cutting ceremony (from left: President Nagao, Mr. Kito, Councilor for General Technical Affairs of MIC, and Professor (by special appointment) Ikeda of Tokyo Institute of Technology)

Photo 3: Video messages from overseas on big screen [Professor DeFanti, University of Illinois (left) and Vice President McRobbie, Indiana University (right)]

Photo 4: Panel discussion

Since April 2004, NICT has operated JGNII, an open test bed network for R&D. To promote international collaborative research via JGNII, we developed an ultrahigh-speed test bed network (10 Gbps) linking Japan and the United States, which became operational on August 1, 2004. To commemorate this event, we hosted an Opening Ceremony for the JGNII Japan-US Line on August 2 at Tower Hall, on the 49th floor of the Roppongi Hills Mori Tower. Mr. Masahiro Tabata, Vice Minister of Internal Affairs and Communications, attended the ceremony as an honored guest, while over 200 individuals involved with JGNII from industry, academia, and government attended.

At the ceremony, President Nagao of NICT delivered an address thanking the individuals responsible for the endeavor and expressed his hopes for the project, noting that the JGNII "will allow researchers to obtain results that help to create the next-generation Internet." In his own address, Vice Minister Tabata advanced his own hopes for the initiative—that "performing advanced collaborative research will constitute a significant step toward the creation of a ubiquitous network society (Photo 1)."

A ribbon-cutting ceremony followed congratulatory speeches by other honored guests. The opening of the Japan-US line was formally announced as Mr. Kito (Councilor for General Technical Affairs, MIC), Professor (by special appointment) Ikeda (Tokyo Institute of Technology), and President Nagao cut the red and white ribbons with scissors (Photo 2).

Mr. Kito delivered a keynote speech entitled "Toward Realizing the Ubiquitous Network Society." He expressed high expectations, remarking as follows: "The construction of an ultrahigh-speed and highly functional R&D test bed across the Pacific will promote international collaborative research and proof-of-concept experiments on leading-edge technologies involving next generation high-speed networks, as well as technologies for applying the ultrahigh-speed Internet."

A panel discussion on the subject "Expectations for the JGNII Japan-US Line" followed an intermission, with Professor (by special appointment) Ikeda (Tokyo Institute of Technology) serving as moderator (Photo 4). The panelists included the following dignitaries: Professor Aoyama, University of Tokyo; Professor Goto, Waseda University; Mr. Fujiwara, President & CEO of Internet Research Institute; Mr. Matsubara, Associate Editor of Nikkei BP; and Mr. Kato, Vice President of NICT. The discussion was also attended remotely by Dr. Esaki, Associate Professor from the University of Tokyo, who is currently in San Diego. The lively discussion included an audience question-and-answer session.

Finally, we'd like to express our gratitude to the over 200 participants and to all those who provided their cooperation and assistance to make this ceremony possible.

Open House at NICT Facilities

Tetsuo Sato
Chief, Public Relations Division
General Affairs Department


Linking to the Showa Station in Antarctica (Koganei Headquarters)


Children doing an experiment on coherers (Kashima Space Research Center)


Exhibition hall (Keihanna Center)

Next-Generation Wireless Technology Showcase

NICT facilities were open to the public for the first time since its foundation: Koganei Headquarters on July 30 (Fri.) and 31 (Sat.); five research centers on July 31 and August 1.

The weather was unusually poor during this year's open house days. Typhoon No.10 in particular lashed the Kanto to Kinki regions.

Despite intermittent heavy rains, numerous guests visited the Koganei HQ. An annual event called the Kid's Handcrafting Class was very well attended. At the research group exhibition areas, visitors engaged the NICT staff in earnest discussions. In the main building lobby, we set up a booth to present the Shiba HQ's activities. We also established the first communications link via ISDN line to the Showa Station in Antarctica. The children attending posed question after question to station members. The Koganei HQ received more than 4,500 visitors over the course of two days.

In addition to describing their facilities and activities, the research center staff used various creative events such as the Kid's Handcrafting Classes to enrich the experience for visitors. The Kashima Space Research Center held a "Science Show Using Parabolic Antennas—Expanding the World of Telecommunications"—a special event to commemorate its 40 anniversary. Children found this event particularly enjoyable. Since it was the first time that the Keihanna Center was open to the public, extensive efforts were made to prepare the facility, and there were a large number of visitors. The number of visitors at the Okinawa Subtropical Environment Remote Sensing Center set a record high.

In place of open house days, the Yokosuka Radio Communications Research Center took part in EXPO COMM WIRELESS JAPAN 2004 and the 1st Next-Generation Wireless Technology Showcase, held concurrently at Tokyo Big Sight from July 21 to 23. The Yokosuka Center exhibited various next-generation mobile and millimeter wave ad hoc wireless access systems that will permit easier mobile access across a broad region. The exposition was remarkably successful, with more than 30,000 visitors.

Finally, we'd like to thank all our guests for visiting our facilities despite the bad weather, as well as those involved in preparing for and hosting these events.