R&D Spirits

Development of Autonomous Ubiquitous Networks Based on the u-Japan Initiative

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Research and development espousing the "u-Japan" initiative continues to progress under the leadership of the Ministry of Internal Affairs and Communications (MIC) with the aim of making Japan a world leader in ubiquitous systems. As part of this huge project, a group headed by Senior Research Engineer Hiroshi Sunaga at NTT Network Service Systems Laboratories is researching and developing distributed service composition for autonomous and adaptive networks. We asked Dr. Sunaga to update us on the progress of this project, which is scheduled to be completed by fiscal year 2007, and to tell us about international standardization activities in this area.

Toward a ubiquitous lifestyle through development of service composition technology

—Dr. Sunaga, could you outline for us your current R&D efforts?

We are currently participating in an R&D project on ubiquitous network technology headed by the Ministry of Internal Affairs and Communications (MIC). This is a large-scale, 5-year project running from fiscal years 2002 to 2007 that aims to construct networks for a ubiquitous society and to establish Japan as a world leader in ubiquitous systems as a matter of national policy. This project also includes plans for even broader applications by linking up with projects associated with the Ministry of Economy, Trade and Industry (METI), Ministry of Land, Infrastructure and Transport (MLIT), and Ministry of Education, Culture, Sports, Science and Technology (MEXT). Within this project, NTT is working with Hitachi, the University of Tokyo, and Osaka University as the Ubiquitous Authentication and Agent (UAA) Group to research and develop new authentication and agent technologies that can accurately reflect individual lifestyles and behavior patterns. This group aims to contribute to the creation of personal ubiquitous lifestyles in the not-too-distant future. At NTT, we are working, in particular, on technology for distributed service composition in autonomous and adaptive networks as part of agent technology development.

—What can this research ultimately be used for?

The main goal of this research is to achieve ubiquitous lifestyles at the individual user level. Today, a wide variety of network domains are spreading through society such as those for business, education, retail sales, government, homes, hot spots, and intelligent transport systems (ITS). These domains can be used to form a ubiquitous world in which all kinds of devices including personal digital assistants (PDAs), home appliances, and sensors connect with each other (**Fig. 1**). Based on these networks and devices, the amount of information and programs that can be provided are sure to increase in an accelerated fashion in the years to come. In such a world, it would be extremely convenient if individuals on the service-receiving side could select and combine those functions that they deem necessary for their personal

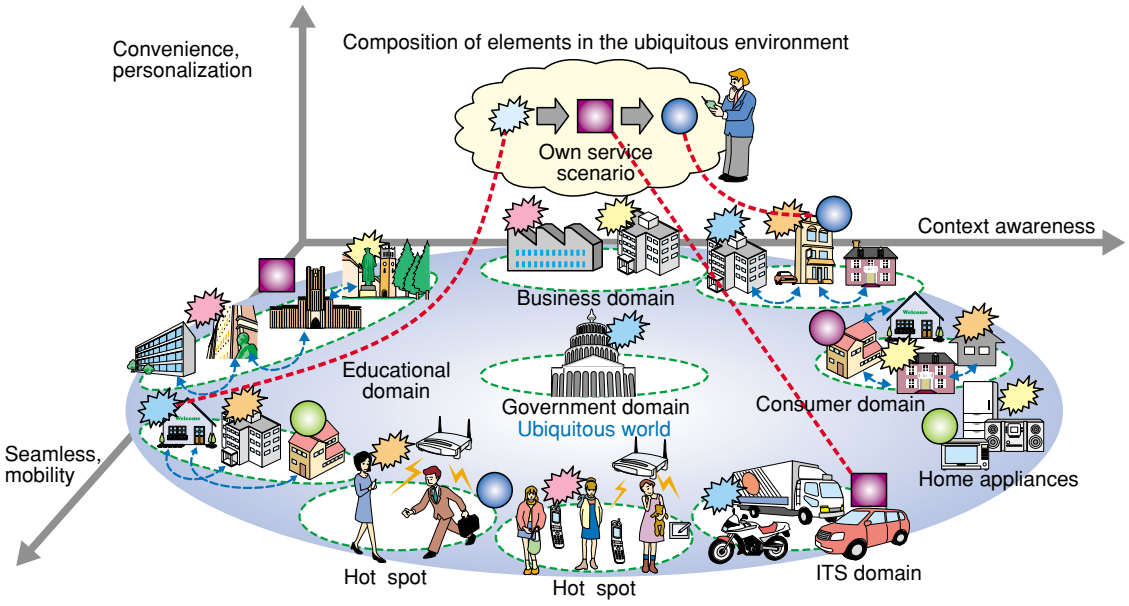

Fig. 1. Service creation in the ubiquitous environment.

needs. For example, a person who takes frequent business trips could choose to enter his schedule in a database so that an alarm would sound when it is time for him to depart. He could then be presented with useful information such as available transportation to the destination in question and relevant maps, current weather, and traffic reports. To make this possible, the system would search out his current whereabouts in order to provide that information via the most appropriate device for that location, such as a personal computer if he is in the office or a cellular phone if he is out of the office. Please note that, in this example, the user who wishes to receive certain information does not have to purposely specify "personal computer" or "cellular phone" to view that information. Instead, the system selects the most appropriate device for the location in question (**Fig. 2**). Furthermore, while I just stated that it would be convenient if individuals on the service-receiving side could select and combine those functions that fit their personal needs, I do not mean to say that a user would be expected to prepare a program every time a service is needed. The sheer diversity of user needs and circumstances would make this impractical. According-

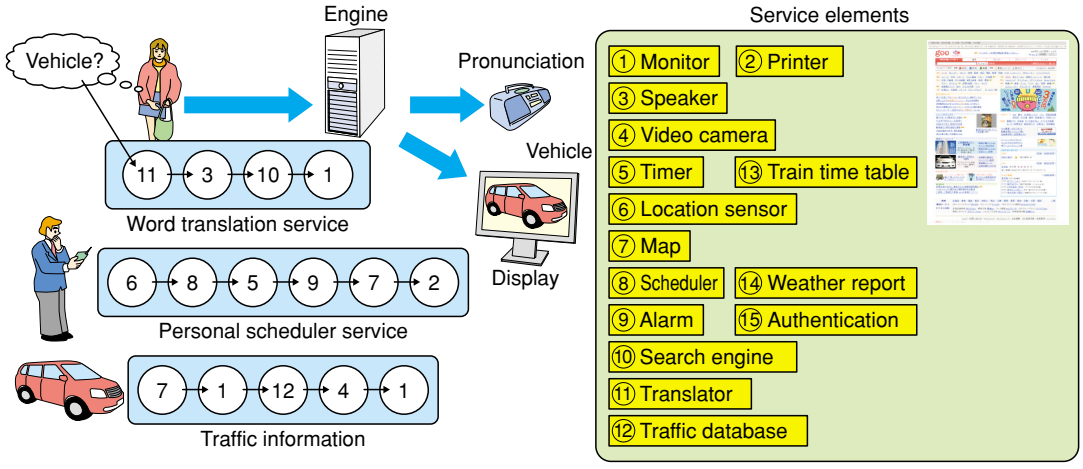

Fig. 2. Example of service composition.

ly, the combination of functions to create services according to personal needs and current circumstances must be based on the concept of distributed service composition in autonomous and adaptive networks. This assumes that sensor and device functions at the user's current location are accessible and that application programs on one person's personal computer are allowed to be used by other users. These functions and programs can then be combined to create new functions. To support this process, we need a service composition engine, which is what my group is currently working on.

—What are some key technical features here?

There are two key features here. The first is the combining of services and devices, each of which has a meaningful role on its own. This can best be understood by considering an orchestra as an analogy. An orchestra is made up of many musicians, each of whom is proficient to at least a certain level. Therefore, each musician can perform as a soloist, but if four come together, they can perform as a quartet. In a similar manner, our system combines individual services and devices in accordance with user needs and circumstances. However, the manner in which the functions of these services and devices are described must be standardized, otherwise it will be impossible for there to be any increase in the number of functions and the types of locations in which they can be used. For this reason, we use world-standard Web Services technology to describe these functions. This enables many and diverse types of information and services to be provided in a uniform way.

The second technical feature is the use of new technology for writing service scenarios instead of having to program a service each and every time. We use, in particular, the description scheme of the Semantic Web, which is becoming increasingly standardized. With this scheme, we create a semantic diagram for a scenario (consisting of a sequence of service elements) and input that diagram to a service composition engine for analysis. This engine discovers service elements required for the scenario on the network and executes it in the most appropriate form (**Fig. 3**). Though new technology is need to write scenarios, this is simpler than having to create new programs one at a time. It should also be easy to customize scenarios with a certain amount of knowledge, and for this reason, we think that providing a number of base scenarios at first will eventually result in a dramatic expansion of services.

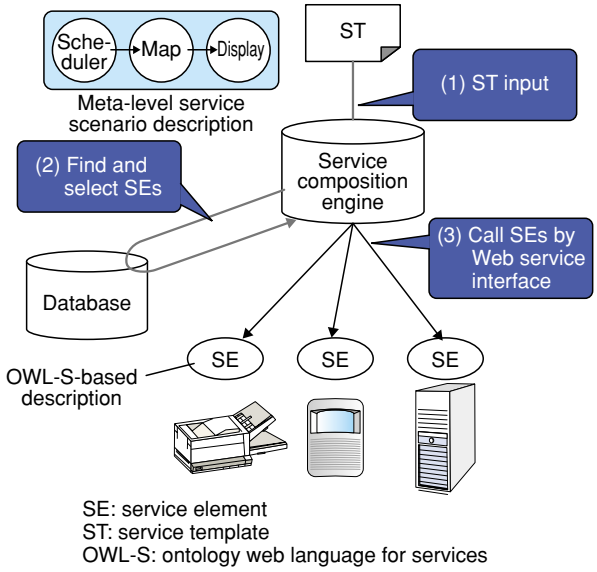

Fig. 3. Basic mechanism of service composition.

—How far have you progressed in service composition and what are your future plans for this technology?

Well, as we are already at the prototype stage, I would like to conduct field tests at the end of this fiscal year. Our target location for these tests will be a shopping mall, and our plan is to set up network-connected displays inside stores and give terminals that contain an IC chip and other functions to individual shoppers. We will also store individual shopper information such as hobbies, interests, and product preferences inside a database beforehand. Then, during actual shopping, the shopper's current location is detected by the IC chip and his or her personal information is retrieved from the database, so that personalized advertisements can be presented on the displays for that shopper. Although these will be short-term field tests, we plan to modify the system in accordance with customer needs and conduct technical verifications at the same time. Our goal is to bring the system to a practical level by 2007, the final year of the project.

Promoting international standardization of network management technology

—Dr. Sunaga, could you tell us about international and domestic trends in this research field?

Well, to begin with, Web Services and Semantic

Web technologies, which provide a basis for work in this field, are being actively standardized at organizations like the World Wide Web Consortium (W3C) and Global Grid Forum (GGF). And as a derivative of these efforts, technology for combining service components is also being researched at various places. Internationally, there is much activity surrounding a service-oriented architecture (SOA) for enterprise users. However, none of these technologies can select and switch available entities according to a user's current circumstances from one place to another as in our system. While it is true that some electrical equipment manufacturers and computer manufacturers in Japan are conducting research with objectives similar to our own, their approach is somewhat different as they mainly target the composition of devices within the home and the office. Our plan is to distinguish our research from the rest by treating the various network functions provided by NTT as service components.

—Are you involved in any international joint activities?

In the past, from 1995 to 2001, we periodically exchanged research findings on next-generation network software with Telecom Italia Laboratories. As for current research, we are working to get our results incorporated in GGF standards. Let me mention here that there has been much research effort of late to combine Web services with grid concepts. Although the word "grid" invokes an image of high-speed computing achieved by gathering together small units of computing power to create massive computational ability, it can also be applied to the grouping of various functions to create a new powerful function. In this sense, I think that our approach, which aims to combine a variety of services on the network and customize network services for each and every user, has many points in common with grid computing.

—Are you active in any international organizations or committees?

Yes. To mention past activities first, I served as a CCITT/ITU-T GS7 expert from 1987 to 2000. In this role, I presented a new direction in network management within the field of data communications and worked to have that standardized. I have also contributed to the preparation of six international standards as an editor of recommendations in the fields of open system interconnection (OSI) and telecommunications management network (TMN) and have served as a rapporteur promoting and overseeing meetings. Also, from 1999 to 2001, I participated in the TIPHON project of the European Telecommunications Standards Institute (ETSI) as a liaison rapporteur from Japan's Telecommunication Technology Committee (TTC). At that time, I worked to report on Japanese specific conditions and to incorporate requirements from Japan in the international framework for the initial VoIP (voice over Internet protocol) launch and contributed to the preparation of standards. Since 2001, I have been participating as an NTT representative first in the P2P (peer-to-peer) working group at ETSI and then in the GGF, which absorbed that working group.

In these standardization activities, I held discussions with many representatives from the leading carriers of France, the UK, Germany, the US, and other countries, but unfortunately there were more differences in opinions and individual circumstances than I had expected. To give you an example, NTT develops its switches in-house, but most European carriers are supplied with existing products from vendors. As a result, the upgrading of switches is something that we can do on our own as needed, while it presents a major hurdle to European carriers. In addition, all of the participating carriers came to the table as representatives of their respective countries and had to consider national policies. Standardization is not simply a matter of working out technical problems, so it can be quite vexing. In the end, however, our common interests won out and we were able to cooperate in solving new and challenging problems, which was a great experience.

—What has been the response to your research and activities to date?

In 1999, I was honored to receive the ITU Association of Japan Award for my standardization activities at ITU-T. And among the 50 or so papers that I have submitted to international conferences, a number of them have generated ongoing research exchanges with overseas researchers. With regard to more recent research, I exhibited a prototype system at INTEROP 2005 that generated various levels of interest in the mass media.

Researching and developing network software as a career

—What research themes have you been involved with including those as a university student?

I actually majored in a field totally unrelated to my present work—control engineering. And my master's thesis concerned research in measurement systems and spatial filters. But on entering NTT, I was put to work on developing packet switches. These switches came to be used in systems associated with the Meteorological Agency, Ministry of Labor, and elsewhere, and I have heard that they were also deployed in the product management system of a major convenience store chain. I then spent several years researching telephone switches that became the basis for NTT's new node system and promoting standardization of The Real Time Operating System Nucleus (TRON) devised by Professor Ken Sakamura of the University of Tokyo. Next, from 1993 to the beginning of 1997, I worked on the research and development of a common platform for the new node system. This platform was the basis of all the types of NTT's switching services and we eventually commercialized it but not without some setbacks. Just after the launch of this system, I moved to a section handling the next-generation network architecture. To be specific, node research became the study of algorithms as a part of VoIP technology, the forerunner of today's IP telephony. At that time, I served as a committee chairman at TTC, a Japanese standardization body, as I mentioned earlier. Then, in 2000, I returned once more to switch-related research and was placed in charge of extending the platform for use in a gateway system between ordinary telephones and IP phones. I also became involved with P2P research and development at that time, which is about when the current project started.

—What got you started in your present line of research?

When I returned to the department dealing with switches from the one dealing with network architecture in 2000, I felt that one of the most important concepts for forming an IT (information technology) society was ubiquitous services. Consequently, while researching and developing P2P technology, which was a very popular worldwide topic at that time, I also endeavored to develop the concept of service composition as a software technology that could aid in the construction of a ubiquitous society. It was in 2002 that I began hearing talk about UAA research to be consigned by MIC, and I went ahead and submitted an application. That is how I came to participate in the UAA project.

—What do you aim for as a researcher as a result of your past R&D activities?

I am always trying to improve my R&D skills. As a result, I hope that technology that I myself have developed will come to be recognized by the research community. I guess it would be true to say that I have spent most of my career in the research and development of network software. This is consistent with my aims as a researcher. Specifically, the work of software development is both physically and mentally trying, and when the deadline for program completion draws near, it is common for panic to set in. Here, the possibility of making my technology attractive to the world through standardization activities and other efforts plays a big role in helping me survive such grueling work.

Making the UAA project a success and spreading ubiquitous environments developed in Japan to the world

—Dr. Sunaga, where do you and your current research go from now?

As for the UAA project, I would like our service composition technology to be a core element of u-Japan and to be instrumental in producing ubiquitous lifestyles created by Japan. As you probably know, Japan had a late start in implementing IP networks, but this time, I want Japan to be a world leader in ubiquitous environments. As a nation, Japan is quite enthusiastic about this too, so we must succeed.

Individually, I have put a lot of energy into this project while here at NTT, and when it is finished, I wouldn't mind working at a university. While it is true that research suits me more than business, what I really enjoy is teaching. In fact, it would not have to be a university *per se*. At any rate, I would like to enter an organization involved with academic studies. Before that, however, I want to make sure that the people under me are on the path to becoming independent and productive researchers in their own right.

—What is your ultimate goal as a researcher and developer?

None in particular. The world of R&D is one in which something new is always appearing out of nowhere, so deciding on an ultimate goal at any point in time is meaningless. I enjoy taking on new and interesting research themes from time to time.

—Based on your personal experience, how do you think NTT is viewed by the outside world?

First of all, while NTT has traditionally been engaged in cutting-edge research, it cannot be denied that its overall direction in recent years has been toward business-oriented development. Even from a system-oriented perspective, the present arrangement of completely dividing research and development will affect not only flexibility in R&D activities, but also the motivation felt by the research staff. Not only does this situation make it hard to conduct technically meaningful research regardless of its business potential, it also makes it difficult to discover new research themes based on development experiences. Needless to say, this arrangement is not conducive to future expansion of NTT R&D. This June, at the "7th Symposium on Technology, Policy, and Industry for a Ubiquitous Information Society—Toward u-Japan," the current state of R&D in Japan was talked about. It was remarked that the corporate world is reducing its support of fundamental research and in this respect NTT Laboratories has not been fulfilling its original role since the privatization of NTT. I think this opinion warrants attention.

—What is it like to work at NTT Laboratories in your personal opinion?

Although research is now becoming more business-oriented as I mentioned, I think that NTT researchers are still blessed with a great environment compared with research laboratories of other private companies. I believe that a system that supports researchers in obtaining a doctor's degree is simply outstanding. NTT Laboratories also encourages its researchers to engage in standardization and academic activities and provides a relatively free environment in which to expand one's insight and deepen one's relationships with overseas researchers. This aspect deserves credit, and I myself appreciate it greatly. But as I mentioned earlier, NTT R&D will come to face some difficult obstacles in the future, and as a research manager, I worry about this.

—In closing, what advice would you give to young researchers and developers?

For one thing, give your undivided attention to the work that you are currently working on, even if it should be work given to you from above. In this way, your own research theme will one day come to light. I then want you to cultivate that theme and be active in writing papers on it. But, to be honest, academic papers are not strictly necessary. What is important is that you grab every chance you have to present your findings at international societies so that you can deepen your experiences of international forums and exchanges with overseas researchers and developers. And by all means, make an effort to improve your skills as a researcher at all times.

Interviewee profile

■ Career highlights

Hiroshi Sunaga received the B.E. and M.E. degrees in control engineering from Tokyo Institute of Technology, Tokyo in 1981 and 1983, respectively. He received the Ph.D. degree in information sciences from Tohoku University, Sendai, Miyagi in 2002. After joining NTT in 1983, he was engaged in R&D of telecommunication software for switching nodes (packet, telephone, PHS, and mobile), realtime operating systems, ATM, and VoIP. His current research interests include ubiquitous service creation, P2P, and grid technologies. Until 2000, he was a Rapporteur of ITU-T SG 7, where he contributed to the standardization of TMN, customer network management, and OSI communications. He received the ITU Association of Japan Award in 1999. He is a member of IEEE.