

## Report on “Ambient Intelligence Symposium 2006—The Future: A Tapestry Woven from Threads of Intelligence”

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### Abstract

This article provides a summary of the symposium held on September 22, 2006, in which the possibilities, future visions, and problems of information and communications technology (ICT) were discussed with a focus on “ambient intelligence” (*kankyo chinou* in Japanese) and the importance of NTT’s basic research related to ICT was asserted.

### 1. Overview of the symposium

In recent years, information and communications technology (ICT) has penetrated deeply into the world around us, and the Internet established by ICT has been forming a social infrastructure that has been affecting our lives by providing a great mass of knowledge. In these circumstances, we need to address the role of new knowledge in new environments. NTT Communication Science Laboratories (NTT CS Labs.) therefore decided to hold a symposium aimed broadly at asking people about the possibilities, future visions, and problems of ICT and at stating the importance of NTT’s basic research on ICT while presenting proposals for the future of “ambient intelligence” (*kankyo chinou* in Japanese) and the tasks that we face.

Yoshinobu Tonomura, the Director of NTT CS Labs., gave the keynote address and raised issues related to the possibilities, future visions, and problems of ICT within the framework of ambient intelligence. This was followed by a panel session that consisted of position talks by the panel members and free discussions between the panel members and the audience. In the position talks, Ikuo Takeuchi, Professor of the Graduate School of the University of Tokyo, Hiroki Azuma, a philosopher and critic, Hiroshi Ishiguro, Professor of the Graduate School of Osaka

University, and Eisaku Maeda, Senior Research Scientist, Supervisor in NTT CS Labs. gave talks related to ambient intelligence. Shinsuke Shimojo, Professor of Biology at the California Institute of Technology was unable to attend the symposium, but provided a pre-recorded video. After the position talks, there were vigorous and informative free discussions on various topics related to ambient intelligence between the panel members and the audience, which numbered about 230. Below, we present a summary of the issues raised by Dr. Tonomura, the position talks given by the panel members, and the subsequent discussions.

### 2. Keynote address

Dr. Tonomura raised issues to be discussed in the symposium (**Photo 1**). He said that although our lives



Photo 1. Dr. Tonomura raised issues for the symposium.

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have become more comfortable and convenient with the development of ICT, it is also true that we feel somewhat uncomfortable or uneasy about the effects of ICT. He then described experiences that were familiar to everybody. For example, many people like the convenience of Japanese kana-kanji conversion systems that convert a kana character string representing the phonetic readings of kanji into a kanji string. However, there is a downside to this. The lack of practice at writing kanji means that these days we often cannot remember how to write many kanji by hand despite being able to read them. Another example is email. Although it conveniently enables us to send messages at any time, it has led to a blurring of the boundary between our working time and our private lives.

He claimed that one of the factors contributing to these uncomfortable aspects of ICT was that ICT research and development has been carried out with a focus on achieving a “convenient, easy, fast, and secure” environment. When we return to the fundamental principle of what is really good for people, then we find that spending time and effort to achieve something or being unable to obtain an answer easily can in fact be beneficial. Something that one invests a lot of time and effort on is not easily forgotten, and a hard question with no easy answer gives one a chance to think deeply.

He then claimed that a broad environmental perspective will be required to enable us to tackle these complicated issues. He continued by saying that we must approach the issues from the viewpoint of our new environments including nature, artifacts, ICT, and people and that we must also consider the relationships between various events over a broad time frame. He pointed out that, in our complicated modern society, we need various types of knowledge from

fields including science, technology, and philosophy to allow us to consider various topics. He then said that he expected the symposium to help clarify problems across a wide range of topics including philosophy, society, ICT, robots, and people through the discussions among the panel members (**Photo 2**), who were drawn from a broad range of disciplines.

### 3. Panel sessions

#### 3.1 Session 1: position talks

##### (1) Ikuo Takeuchi

Professor Takeuchi argued that it is important to consider the balance between the environment, tools, and communities. Here, he described the environment as something given passively, in which we felt a sense of security and relaxation, tools as things we use with a sense of controlling them, and communities as things that have evolved through communication between intelligent agents and human beings.

He pointed out that, in terms of technological development, while some researchers aim at developing types of tools that always remain in the background and do not mediate between humans, the research on ambient intelligence at NTT CS Labs. seems to focus on communities and emphasize the role of a form of intelligence that mediates between people and systems. He then claimed that, in research on ambient intelligence, it will be necessary to consider whether or not ambient intelligence should become an equal partner with human beings. For example, it will be important to study the effect of a system’s speech on human beings when systems can speak like a real person.

In addition, he claimed that, in the information explosion era, people will not be able to make complete use of such an enormous amount of information, and that the importance of editing should be considered. He also pointed out that we must investigate technologies for undertaking this editing and a corresponding support social system.

##### (2) Hiroki Azuma

Dr. Azuma talked about the notion of the control imposed by our environment, where the aim is to maintain the social order without trusting human beings to do this by themselves. He began by mentioning the relationship between the notion of environment-imposed control and ambient intelligence. As an example of this control, he described the development of an automobile that would not start if the driver had been drinking. Such automobiles could



Photo 2. The panel members.

eliminate drunk driving without the need to educate and persuade drivers to obey rules.

According to Dr. Azuma, the concepts of multiculturalism, globalization, and libertarianism have spread over the past few decades, and these ideas respect individual choice. As a result, the system for maintaining the social order has been changing from a discipline-based system, which places high value on compliance with rules, to a system based on control imposed by our environment. This change is being accelerated by ubiquitous and Internet technologies. One example of this kind of control is the recommendation function common in online shopping that displays candidates for selection based on the user's preference and induces the users to buy additional items. He claimed that, in an environment-controlled society, one important issue will be free will.

Furthermore, he pointed out that the current social system determines where blame lies at the time of an accident based on the assumption that people act according to free will. However, he continued by saying that, in a society where the environment imposes control, the distinction between humans and systems would be vague, and the gap between technology and social systems would be exposed.

### (3) Hiroshi Ishiguro

Professor Ishiguro has used the term "ambient intelligence" with reference to the development of robots that can interact with humans, and he has argued the importance of the intelligence that is emerging from the interaction between robots and environments. In this symposium, he began by stating that if we are to develop robots that interact with humans, then these robots must use information in their environments flexibly and have perceptual abilities. He also stated that robots that worked closely with sensor networks would become the standard model for robots of the future. He said that robots of this kind could become a medium that actively affects humans and that a robot infrastructure supporting human activities would be achieved through the integration of robotics and the Internet.

Next, he pointed out that, when we are developing robots to interact with humans, it is important to have a design principle related to how "human" the robots should be. To enable extensive research on ambient intelligence to be performed, we must deal with complex interactions between humans and environments while considering the design principle.

Moreover, he claimed that, if we wish to develop

robots that are more like humans, we require both engineering approaches and brain and cognitive science approaches to provide us with a better understanding of human beings. He then advocated "android science", which combines cognitive and brain science, and robotics.

### (4) Eisaku Maeda

In his speech entitled "The role of new knowledge in a new environment", Dr. Maeda dealt with the issues of "ambient intelligence" in terms of a potential new type of knowledge in the evolving ICT environments. He pointed out that the basic ideas of symbiosis, ubiquity, and ambience, all of which are widely known today, are very similar to the issues that must be raised with regard to ambient intelligence. He continued by saying that the changes in the ICT environments over the last decade have been perceived as large environmental changes that affect human beings, and he wanted to get to grips with the issues of ambient intelligence in relation to these changes. Furthermore, he mentioned that he wanted to find the problems that had been left unaddressed by stereotyped thinking. Dr. Maeda claimed that agents that support our lives in some small way have been required throughout the ages and that the creation of such agents is one of the challenges that must be tackled by ICT.

He then explained about the relative positions of basic research and advanced research using the metaphor "small world and big world". He suggested that broadly speaking the world that we recognize is the small world, and the world that includes unknown areas that extend over unknown distances is the big world. Human intellectual activities, especially research and development in advanced fields, are equivalent to expanding the small world towards the big one. The boundary between the small and big worlds is very wide and forms frontier. This also constitutes a field of basic and advanced research. In the past, people thought of fairies and goblins as agents linking their small world to the big world. Such creatures can live in the modern world and may give us the opportunity to retrieve something that is already almost forgotten. He expressed this as the resurgence of fairies and goblins.

Finally, he gave the name "mushroom" to a type of agent corresponding to fairies and goblins that would appear in the future society. He showed three animations entitled "Being watched over", "Unselfconsciousness", and "Being connected", which expressed prospective scenes 50 years from now. He then point-

ed out the need to undertake research and development that will lead to the society he had mentioned, and he stated that NTT had already started research into some aspects of it. In addition, he raised three issues to be covered in the symposium: time and memory, environment-imposed control, and necessary approaches for the future.

#### (5) Shinsuke Shimojo

Although Professor Shimojo could not attend the symposium in person, he recorded an interview-style talk on video. He mentioned a large number of topics, and he revealed that he shared a common awareness of issues with the other panel members.

In response to a question related to how he saw the changes in information environments and their impact on human beings from the perspective of cognitive neuroscience, he first stated that the human brain, body, and environments were not isolated but interacted with each other and formed an intellect. He suggested that two ideas, namely “brainism”, where the environment itself is the brain, and the “brain machine interface”, where the brain becomes a controllable system, may be essentially the same. Second, he pointed out the importance of our bodies, which serve as links between brains and environments. He stated that he expected research to be undertaken on intelligence based on the existence of bodies such as “embodied intelligence” in robotics. He also indicated that he expected to see an approach to intelligence from phylogenetic and cognitive viewpoints represented by the new term “comparative ecological neuroscience”. Third, he mentioned the role of cognitive neuroscience in engineering and indicated that we must deeply consider engineering that is optimal for human beings.

Next, when asked how he considered the future of ICT and human beings from the viewpoint of implicit brain function research, he answered that he was interested in what would happen when implicitly recognized sounds were actually recognized and that this was closely related to issues about environment-imposed control and free will. According to Professor Shimojo, the mutual relationship between the implicit cognitive process and the actualized cognitive process will become a key topic.

Finally he raised two issues. The first was related to human comfort and discomfort. When considering the environment-imposed control, which affects implicit cognitive functions, as indicated by Dr. Azuma, the comfort/discomfort issue should be investigated in more detail from various standpoints.

The second issue was related to free will. Taking as an example the fact that a flea kept in a bottle for a long time gives up hopping, he expressed his concern that today's many consumers might be in the same situation.

### 3.2 Session II: free discussion

During the free discussion, Dr. Tonomura served as a moderator, and the four panel members, Professor Takeuchi, Dr. Azuma, Professor Ishiguro, and Dr. Maeda, had a lively debate about ambient intelligence with the audience. The purpose of the discussion was not to draw a conclusion about the issues of ambient intelligence, but to clarify various problems and stimulate discussion on ambient intelligence. Below are some of the issues raised in the discussion.

First, from the viewpoint of environment-imposed control, it was argued that the boundaries between human beings and their environment, and between human beings and machines are becoming ambiguous with the advance of ICT, and that it makes the locus of responsibility less clear. As regards associated issues, there was discussion of how the social system should be developed to clarify the locus of responsibility and how the sense of humanness and the notion of free will could be affected by the fuzziness of the boundary between humans and machines resulting from technological development.

Second, there was an opinion that as ubiquitous technology and other technologies supporting ambient intelligence become prevalent in our daily lives, the issue of privacy needs to be reconsidered. Some argued that systems that watch over us too closely might make us feel uncomfortable as if we were being monitored. There was a related opinion that the difference between being watched over closely and being monitored depended upon the sense of trust one has in the systems and that mutual interaction between systems and human beings played a significant role in increasing the sense of trust. Another participant mentioned that, even if people felt as though they were being monitored by systems, a more important matter was whether or not these systems could provide people with safety, convenience, and comfort.

Third, as an issue relevant to the information explosion era, there was discussion of the potential problem related to the feasibility of collecting a large amount of data including statistical information about human behavior, and the importance of developing a method for handling it was addressed. If statistics about human behavior are obtained, then various

kinds of systems interacting with humans could be arbitrarily controlled. On the other hand, some people indicated that such statistical information could be shared by many people as well as specific organizations, thus avoiding the privileged use of information. Another opinion was that once this technology has actually spread, the social system itself might change in a way that did not grant benefits solely to specific people or organizations.

Finally, it was argued that, to develop an ICT that mediates between human beings and society such as ambient intelligence, the impact of the technology on people and society should be considered from a broad standpoint that included an ethical perceptive. In this connection, it was pointed out that it was difficult to forecast the future 50 years from now and that human or social systems might change in response to new technologies. Furthermore, there was an opinion that humanness was an important factor for human-interacting systems, so without a deep understanding of human beings through technology, it would be difficult to find solutions to the problems of how much humanness systems should have or what kind of relationship should be built between humans and systems.

#### 4. Assessment of the symposium

To learn the participants' impressions of the symposium, we distributed a questionnaire. We also put a questionnaire on the Internet after the symposium. 83 people responded, giving a response rate of 36%. In a

yes/no section of the questionnaire, we asked for comments on several aspects of the symposium, and the vast majority of participants gave favorable answers (**Table 1**).

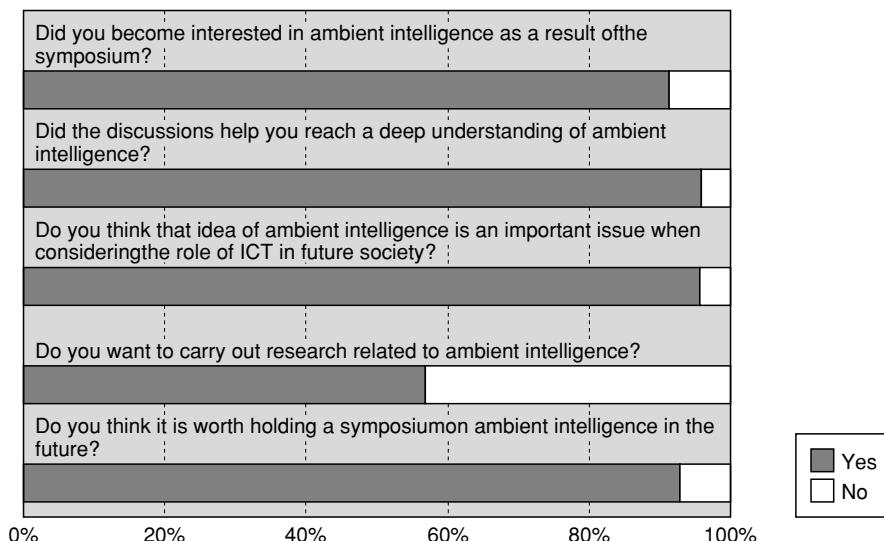
Furthermore, in open questions we asked for opinions about the issues that were raised and the content of the panel discussions. We obtained the following comments: "The symposium has made me think about the direction in which our society is heading from various perspectives related to the theme of ambient intelligence, and it has made me notice previously unconsidered issues" and "I think that we have to have thorough discussions from the ethical side and the dark side of science as well as the technological side". These comments suggest the symposium successfully created the opportunity to enrich discussions on the issues of the future ICT from a broad range of viewpoints.

Meanwhile, it was also stated that "the discussion topics were so broad that the points of the issues tended to diverge". While we have to paint the issues in broad strokes, it is also important to generate discussions that focus on each of the issues presented in the symposium.

#### 5. Conclusion

In this symposium, we raised issues related to the possibilities, future visions, and problems of ICT with a focus on ambient intelligence, and we successfully addressed various problems related to the future of ICT through discussions between the panel mem-

Table 1. Results of the questionnaire about the symposium.



bers and the audience. The discussions helped us to realize that the concept of ambient intelligence could provide a valuable basis for a profound discussion of the future visions of ICT. We shall continue to investigate the problems related to ICT deeply and conduct research and development designed to solve these problems. A video of the symposium is available at the symposium homepage [1] for those interested in seeing and hearing the symposium discussions in full.

## Reference

- [1] <http://www.kecl.ntt.co.jp/KCS2006/> (in Japanese).



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