Trend Session Lecture, C&C User Forum 2005

# Toward the Ubiquitous Society in which Humankind will Continue to be the Leading Actor

## – From "Technology Trends" –

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### 1. Changes in the Information Environment Resulting from the Advancement of the Ubiquitous Society

Today, we would like to introduce the efforts being made at NEC Central Research Laboratories surrounding the handling of information. Such efforts are expected to make a particularly important contributions to the advancement of the Ubiquitous society.

**(1) The Evolution of Information Technology and the Development of Society**

Information in various forms has been connecting human to human since the dawn of history. Aspects of the utilization of information range from the invention of letterpress printing by Gutenberg in the 15th century to the telephone and subsequently the large scale computers that were invented in the 20th century and on to the PCs that are recently being widely used in households. At present, the Internet is spreading rapidly, and Ubiquitous society advances with the use of PDA and mobile phones that allow communication "anytime, anywhere, with anyone and with anything."

When we review the change in the volume of information since the 15th century, the number of publications in Europe in the 15th century was 8500, which corresponds to 0.07 terabyte when converted into data quantity. According to a survey by UC Berkeley, the number of publications in the year 2000 was 65 million, or data quantity of 520 terabytes. Currently, the global information volume is 23 million terabytes, which includes the video and audio information flowing through the Internet. This is about 300 million times larger than that of the 15th century (**Fig. 1**).

When the information quantity is converted into per capita figures, it is 3.8 gigabytes, or 27 million times what it was in

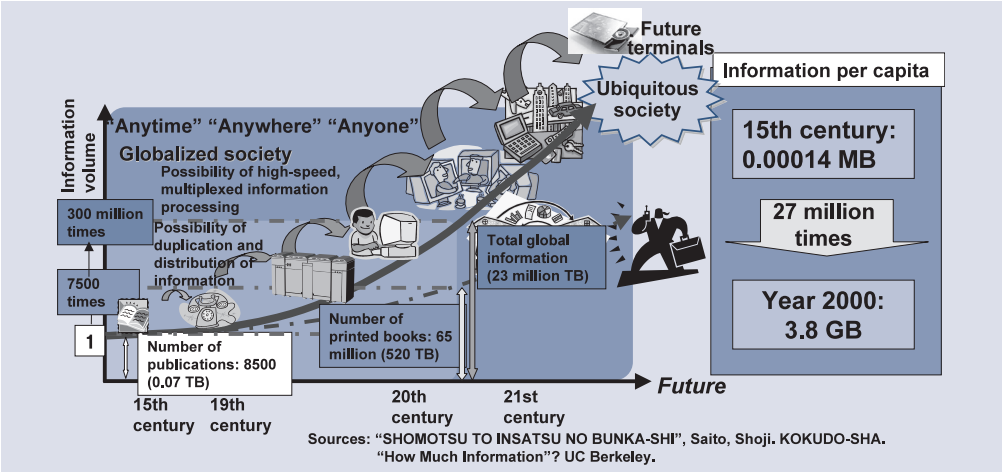


Fig. 1 Expansion of information circulation volume.

the 15th century (As of year 2000, assuming that the global population was 500 million in the 15th century and is currently 6 billion).

**(2) Expansion of the Information Circulation Volume – "Light and Shadow" in the Ubiquitous Society**

The quantity of information on the Internet is increasing every day. The total number of web pages globally has increased by 1000 times over 10 years and domestic traffic has also grown by the same ratio. It is expected that in 2010, as a result of further increase of the Internet and IC tags, the market size will increase by about 7 to 15 times and the information circulation quantity by even more.

While the expansion of the information circulation volume represents a positive aspect (light) of the Ubiquitous society, we should also consider the negative aspect (shadow). In 2004, there were 510 cases of personal information leakage in Japan, and the average damages per case were 1.4 billion yen. As a result, the Personal Information Protection Law was reinforced by penal regulations in 2005.

What is needed is to increase the "Light" while controlling the "Shadow". As an integral part of the IT industry, Research Laboratories at NEC are engaged in variety of activities to address the "shadows", such as leakage of personal information, increases in harmful contents, information gaps from digital divide, Cyber Terror, as well as contributing to the advances in future Ubiquitous society, and strengthening ties between information, technology, industry. In the next section, four research activities are introduced by representative researchers in their fields; (1) to (4).

## 2. NEC's Activities to Deal with Light and Shadow in the Ubiquitous Society

### 2.1 Information Utilization Technology to Cope with Information Explosion (Technology to Utilize Increasing Volumes of Information)

First of all, let us see how much information a person can handle. According to Encyclopedia PC written by Professor Nagano, University of the Sacred Heart Tokyo, the information quantity a person contacts in his or her life is $10^{56}$ bits and the information quantity acquired by reading throughout a lifetime is $10^{10}$ bits. This means that we cannot process or find a good majority of information in our lifetime, although the difference of $10^{46}$ bits do not apply entirely since information may also be available in forms other than books; e.g. audio and video information.

In fact, it is such information that is the mountain of treasure, and NEC is pursuing research envisioning that the way to effectively utilize such information will hold the key for business opportunities in the next generation.

For instance, the customer contact center receives a variety of information from the customer. We can process such information easily so far as it can be obtained in the form of data but, when we have to handle formless information such as voice information, it becomes important to transform it into tangible data as early as possible. To deal with this problem, NEC has developed a system for visualizing audio using voice recognition technology. We are also conducting research that seeks what the customer is thinking by mining what is in the database. These technologies are expected to be effective for the "real-time management of operations."

**(1) Speech Recognition Technology (Akitoshi Okumura, Senior Manager, Media and Information Research Laboratories)**

NEC began the development of speech recognition technology very early on. A voice typewriter based on this technology was developed jointly with Kyoto University around 1960, using a transistor-based electronic computer. Since then, NEC has continued to develop speech recognition technologies, and some of the most recent results are described in the following.

❶ Research outline

In 1991, we succeeded in developing with the aid of dedicated hardware, a speech translator between English and Japanese about the size of a large refrigerator and workstations. This device, which could recognize and translate about 500 words, was presented at the TELECOM exhibition of that year. Although the processing took a few seconds and its applications were limited it still attracted attention as an innovative technology of the times. Subsequently, a dramatic evolution in the hardware led eventually to the development and commercialization of software with a speech translation capability for PC use in year 2000. This system is capable of high-speed processing and other applications.

❷ Technology details

In general, preparing a large number of acoustic models enables accurate speech recognition by dealing with various phonemes. For example, even the phonemes of the Japanese vowel "a" and consonant "k" are variable depending on the phonemes before and after them as well as on the person pronouncing them. Therefore it is essential to prepare many models to cope with the contexts and variations between the

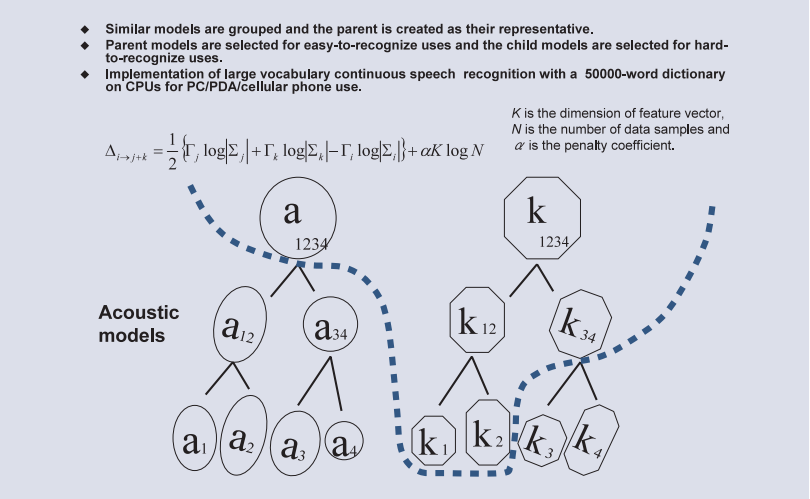


Fig. 2 Model compression based on information volume criteria.

speakers. However, the preparation of a large number of models is accompanied with a spinoff problem, in that it becomes harder to find the optimum model from all of them. We therefore decided to group the similar acoustic models and represent the group with a parent model, which consists of an approximate representation of the characteristics of the child models, as described below:

• A large number of models such as the phonemes of "a" and "k" are prepared in advance as child models then similar child models are collected in a group, and the parent model is assigned to the group as its common representative.

• The number of prepared models should be as small as possible so far as the speech recognition performance is not affected. In proceeding thus, an information criterion is introduced so that the parent model is used whenever its use does not deteriorate the recognition accuracy. If the use of the parent is expected to deteriorate the speech recognition accuracy, a specific child model is used as the representative one for more detailed phonemes.

The information criterion mentioned above is obtained by the addition of a value representing how optimally the selected models enable speech recognition of the given data and the value representing the number of selected models.

As this "compression technology based on information criterion" (**Fig. 2**) has enabled an algorithm breakthrough, we have succeeded in implementing a Japanese-English bi-directional speech translation of travel conversations using about 50,000 words on a PDA as well as on a PC.

❸ Future objectives

Our aim is to bring a new style of communication, in which people from different cultural backgrounds and ability levels can perform natural, high-quality communication in order to deepen mutual understanding and support cooperative activities.

A system that can recognize the intensions of people from the information exchanged between people and between people and objects can apply to other languages, as well as to Japanese. Such a system will also be able to process words in the form of tangible data, and the different phonemes of various people. All of our efforts are directed at creating such a system.

●Reference URL:

http://www.sw.nec.co.jp/effort/strategy/2005_1202/speech.pdf

**(2) Data Mining Technology (Kenji Yamanishi, Director of the Data Mining Technology Center, Research Fellow of the Internet Systems Research Laboratories)**

Data Mining is the research of discovering new knowledge from an accumulation of data such as inquiry information.

❶ Research outline

As the rise in the levels of user needs has caught up with the level of currently available technology, it is now urgent for us to hasten the development of technology to higher levels than at present. For these reasons we started the data mining research in 1998 on the basis of the machine-learning technology that we have developed more than for ten years.

❷ Technology details

For example, the significant information included in the large amount of customer data and the data input to the customer call center can be extracted in real time using the topic analysis and context-mining technologies as described below (**Fig. 3**).

• The inquiry and complaint data reaching the call center is categorized using the topic analysis engine "Topic Analyzer."

• Similar data are grouped together and a number of clusters are generated in real time.

• The topics distribution that varies as time passes is identified in real time.

In this process, we succeeded in identifying the emergence of new topic trends by using the original "dynamic model selection" technology that we had previously pioneered. When a new topic is generated, the context mining technology extracts its essence, or context characteristics. While the previous technology has only been able to extract characteristics at

the level of one word or a modification of two words, the new technology can extract the characteristics of a series of words such as "The white button does not exist on the side panel."
But this is not the only aspect of the mining technology that we are developing. Its strong point lies in the capability of real-time, adaptive mining of dynamic, heterogeneous data. This is the so called dynamic collaborative mining, a process that can be applied in reputation analyses, relational mining and anomaly detection technologies.
●Reference URL:
http://www.labs.nec.co.jp/DTmining/

❸ Future objectives

In addition to the basic technology, it is also expected that the technology applied to real data will increase in importance in the future. NEC has established a Data Mining Technology Center to enable the application of its advanced mining technology in various new solutions. These will include solutions for use in the effective utilization of data unused by the customer, the promotion of information value enhancement by turning it into useful knowledge and a reduction in information management costs.
●Reference URL:
http://www.labs.nec.co.jp/Overview/soshiki/internet/data_mining.html

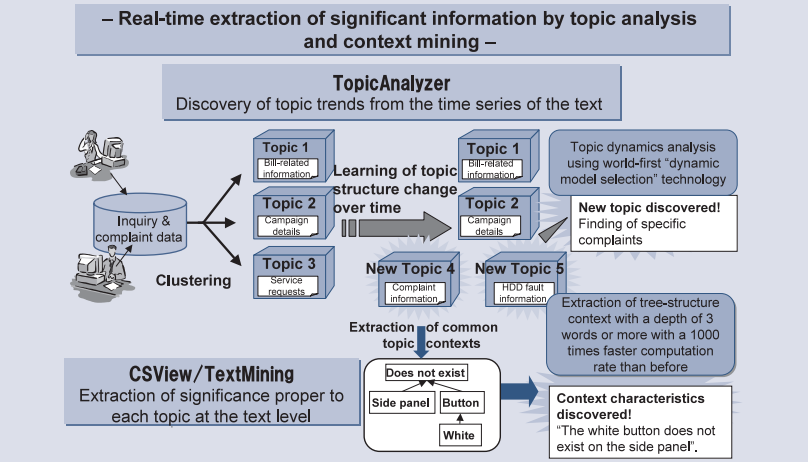


Fig. 3 Text mining

## 2.2 Secure Technology for the Elimination of Information Risks

An increase in the quantity of information naturally increases the risk of leakages, viruses, cyber terrorism and illegal information issues, thus making the security technology more important than ever. NEC is also studying the security issue in many ways, and its laboratories are conducting R&D into video surveillance systems, security platforms and quantum encryption technologies, etc.

**(3) Privacy Protection by Applying Encryption Technology (Kazue Sako, Research Fellow, Internet Systems Research Laboratories)**

This research topic deals with how users may systematically protect personal information.

❶ Research outline

Cryptography is not only used in ensuring secrecy of information, but also in ensuring the integrity of information as seen with the digital signature technology. We are conducting research into how to provide users with safety and security by combining the encryption and authentication technologies.

❷ Technology details

People often say that they feel insecure when they have to enter a credit card number for web shopping. We considered whether or not it is of necessity for a purchaser to submit his or her credit card number. All that the web shops want to know is the content and reception method of the goods they sell and they do not actually need the card numbers. We therefore contrived a system in which the user inputs the data ensuring payment by the credit card companies, called authentication data, in place of their card numbers.
This system encrypts the card information and performs authentication that the encrypted text contains a legitimate card information. The web shop cannot analyze the authentication

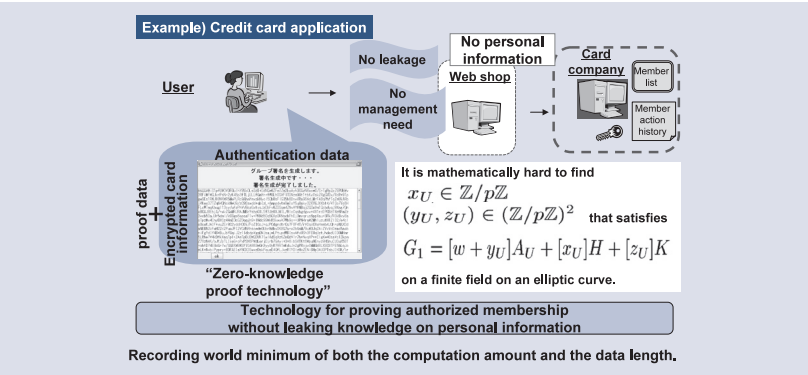


Fig. 4 Mechanism of the personal information-protection authentication technology.

data to identify the card information, but they can simply confirm that the card information contained in it is legitimate. And this is enough for transactions between the card user and the web shop. When the authentication data is sent to the credit card company, it uses the secret key that it holds to identify the card number and issue the bill to the user. We named this technology as the personal information protected type authentication technology (**Fig. 4**). The authentication data is much longer than the credit card number and falsifying this data would take more than two thousand years of computation even using the world's fastest supercomputer. This is ensured by the "zero-knowledge proof technology," which makes it possible to certify membership with zero knowledge on the personal information.

❸ Future objectives

The fact that encryption technology enables strict authentication of personal identity is very important and useful from the viewpoint of security but, if such strict identification is applied everywhere in order to ensure security in the Ubiquitous society privacy would become a serious problem. Therefore, our next challenge will lie in how to balance security and privacy and in evolving a technology that can ensure both of these needs.

●Reference URL:

http://www.nec.co.jp/press/ja/0507/2202.html

## 2.3 Device Technology Expanding the Role of Terminals

If we consider the functions required for the Ubiquitous terminals of the future (**Fig. 5**), it will be a critical issue as to how to reduce the power consumption while the number of applications such as the automatic interpretation and encryption described above will increase. The terminal sizes should also become slimmer and more compact.

### (4) Multi-Core Technology – Processor Technology for Reducing the Power Consumption and Size of Terminals (Masato Edahiro, Research Fellow, System Devices Research Laboratories)

It is expected that the number of cellular phone terminals will reach 211 million in year 2010 and that their total power consumption will increase by about 40% even when power saving technology has progressed from its present level. As improvements in power efficiency have previously led to a diminution in the computing performance, we began R&D for improving the performance under low power consumption and implemented power saving by means of the device technology described below.

❶ Research outline

Multi-core means the incorporation of multiple processors in a single LSI, and can be applied either to a supercomputer or a cellular phone. Both of these devices employ parallel processor designs but their power concepts are completely opposite to each other. The supercomputer uses multi-core technology to achieve a performance with a lower current drain that is impossible for a single CPU, while the cellular phone achieves the same performance as before. The multi-core processor for use in cellular phones is currently marketed by NEC Electronics under the model name of MP211.

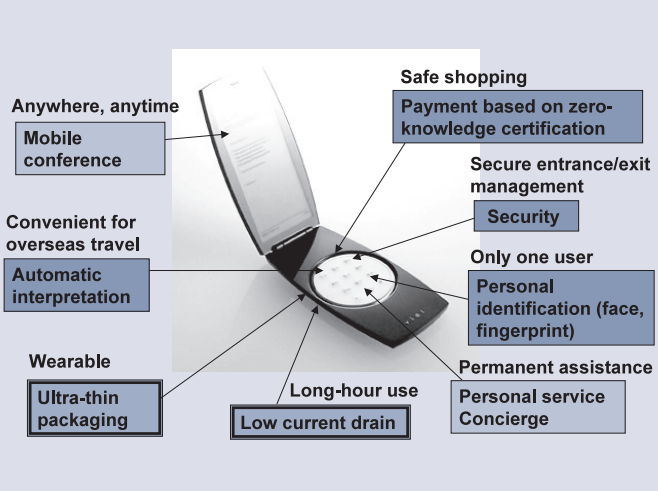


Fig. 5 Functions required for Ubiquitous terminals.

❷ Technology details

A similar performance to that available by conventional means can be achieved with a lower power requirement by implementing low-power processors in a multi-core design. Multi-core technology is essential if the performance of cellular phones needs to be improved under low current drain conditions and the technology for parallel processing of the processors will provide the key for achieving this function. The MP211 is a multi-core processor incorporating three CPUs, DSP, graphic engine, image processor and security engine, as well as "multi-core virtualization software" that features a parallel processing technology for facilitating the processor operations via applications (**Fig. 6**).

The multi-core processor offers the following capabilities.

• Execution of an application requiring a high-performance CPU using multiple CPUs.

• Execution of multiple applications using multiple CPUs.

• Construction of a secure platform on the terminal by executing applications obtained externally from the Internet, etc. on isolated processors.

❸ Future objectives

Device technology has made remarkable progress since the

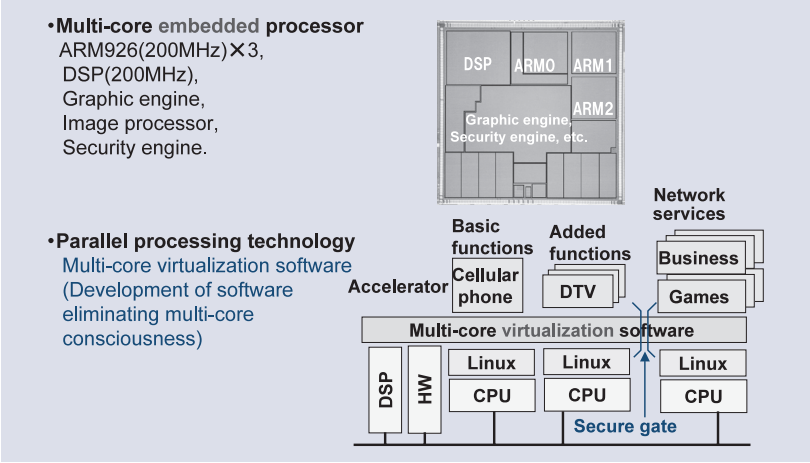


Fig. 6 The MP211 multi-core processor for use in cellular phones.

invention of the first microprocessor, and it now seems that its final goal is at the level of the performance of a human brain. We are determined to advance this technology further until we can realize an environment in which humans need not be concerned about having to adapt themselves to that of the computer.

●Reference URL:
http://www.necel.com/application_processor/ja/product.html

## 3. Toward the Ubiquitous Society In Which Humankind will Continue to be the Leading Actor

Information utilization technology to cope with information expansion, security technology to eliminate information risks, and device technology to expand the role of terminals, were described above.

**Fig. 7** shows the growth of Ubiquitous computing by assigning connectivity to the x-axis and mobility to the y-axis. However, while IT systems are supporting society and have become easier to use than before, there are still shortfalls in convenience and other areas. Our view is that the key will be in how humans and IT can co-exist, co-create and how such IT system, that jointly creates with humans, can be established.

There is a need to nurture technology that is safe, secure, and comfortable. By doing so, Ubiquitous computing can be raised to a different paradigm. This will then become the IT system that can jointly create with humans and we call this "Symbiotic Computing."

At Central Research Laboratories, we intend to continue R&D to advance from a simple IT system to the creation of an ever superior system that bonds Symbiotic Computing = Human interaction.

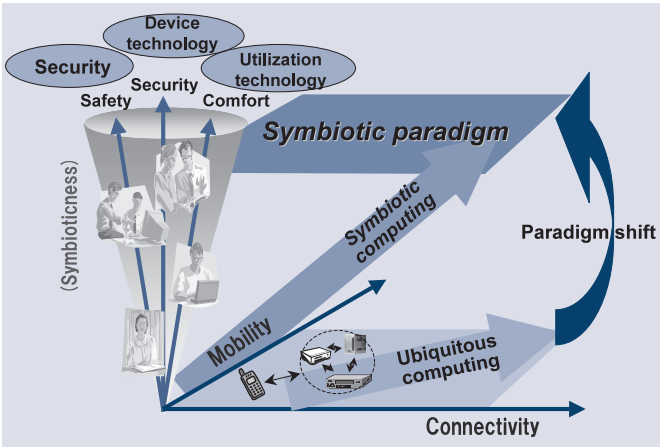


Fig. 7 From Ubiquitous Computing to Symbiotic Computing.