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Trends in RFID Technology

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4.1 Introduction

4.1.1 Every "physical object" will be networked before long

The Internet, on which research started more than 30 years ago for military purposes, was originally a network connecting only four U.S. research institutes. The technology continued to develop for academic applications until its commercial use by for-profit organizations was allowed in the 1990s, a change that led to an explosive spread of the Internet across a wide range of regions and users, driven by the improved capability of personal computers (PCs) and the establishment of the backbone network infrastructure. More recently, with the increased user population of mobile information terminals such as PDAs and Internet-enabled cellular phones and with the commercialization of networked digital home appliances, we have seen the approach of a ubiquitous network society in which every individual can gain access to the Internet anytime, anywhere.

Some say, however, this is only the beginning.

Devices that formed the networks have been electronic equipment, typically the computer, and thus the "virtual" world they created has been separated from the "physical objects" in the real world. The data running through the networks have been nothing but the information held by electronic devices, while the data regarding the "physical objects" existing in the real world beyond such information has been exchanged on a limited basis.

Today, as every electronic device is being networked, it is becoming more realistic that, as a step toward the next phase, the "physical objects" in the real world will also be networked before long.

4.1.2 Higher need for traceability

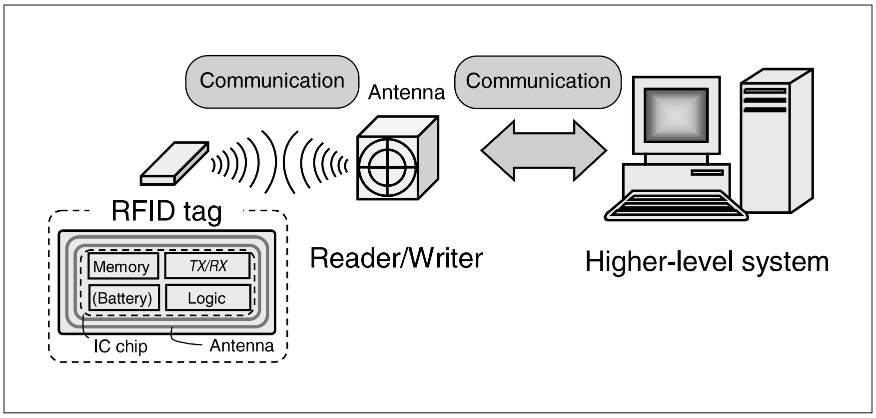
Aside from the above technological development, a demand for complete traceability of every object is surging in society for the reasons listed below.

(1) More efficient supply chain management
(2) Protection against loss of merchandise due to theft such as shoplifting
(3) Ensured security and strengthened counterterrorism
(4) Ensured safety of food and other products

In the distribution industry, supply chain management, which helps minimize inventory while eliminating loss of sales opportunities by preventing stock shortages, is an important tool for securing profits. In addition, given a report[1] that estimates there is a significant amount of loss of merchandise during distribution and sale due to freight theft, shoplifting and other forms of theft in the U.S., the establishment of a system to track and trace products (traceability) is an urgent issue especially for producers and distributors. This motivated the 1999 foundation of the Auto-ID Center[2], a consortium that is pushing for the development of a distribution management system as a replacement for bar code systems under the sponsorship of such leading manufacturers and retailers as Procter & Gamble, Gillette and Wal-Mart.

Since 9/11 and the subsequent anthrax cases, the U.S. government, for improved security, has been more seriously urging the real-time management of any flow of goods into and any distribution within the nation, including their history records. Now, the target is being expanded beyond commodity products to cover every object. Meanwhile, in the wake of the outbreak of widespread E. coli food poisoning,

Figure 1: Basic structure of an RFID system



BSE (Bovine Spongiform Encephalopathy) and a series of false indications on the origin of food products, a need for traceability is increasing in Japan, even among consumers, who demand ensured safety on what they purchase.

In the technology domain, the recent advancement and further integration of LSI technology, in addition to the development of computers and networks, are enabling commercial use of the technique to embed miniature IC chips for identification into every object at reasonable costs.

These are why radio frequency identification (RFID), or using radio waves for automatic identification, has become a recent focus of attention as a concept of enabling direct exchanges of information between networks and "physical objects." Allowing networks, which have been completely "virtual," to exchange information with "physical objects" will have a significant impact on society. Not only will it change the living environments of individual persons, but will generate new values, services and problems no one has ever seen. This report provides an overview of recent trends in RFID, followed by a discussion on RFID's potential impact on society.

4.2 What is RFID?

4.2.1 Basic structure of an RFID system

Figure 1 shows the basic structure of an RFID system. An RFID tag, which consists of an IC chip and an antenna and has a unique identification number, communicates with a reader/writer, a device that reads the ID number, to exchange information using radio waves. While the tag is usually called an RFID tag when embedded in an object, it is referred to as a "contactless smart card" when being carried by a person, even if both provide the same functionality. The key feature here is that exchange of information between an RFID tag and a reader/writer occurs automatically, with no human assistance. This is in contrast to existing bar code technology, which requires people to scan tags. RFID is also different from bar code systems in that information contained in an RFID tag can be rewritten as needed while bar codes are read-only. The IC of an RFID tag is run by the power drawn from the reader/writer through electromagnetic induction over its antenna. In addition, some RFID tags have a built-in battery. IC chips in RFID tags can have either read-only or read-write memory.

Data that is automatically read/written on an RFID tag through radio communication are exchanged, together with the records of such revisions, with a higher-level computer via the network. The data including the revision history is stored on the network's host computer or in the internal memory of the RFID tag for accessibility from the outside as needed.

4.2.2 Movement of objects and the flow of information

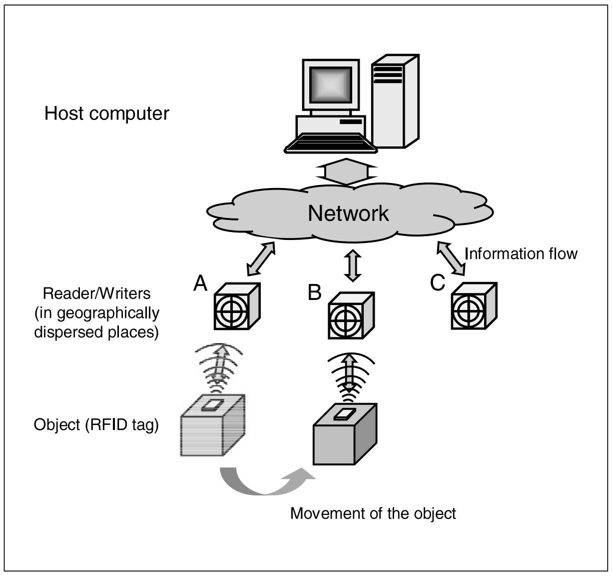
Let us look at a situation where multiple reader/writers are installed in geographically dispersed places and RFID tags maintain communication with the closest one of them at all times (Figure 2). In such a situation, it is possible to track down the current location of a specific object, based on the location information captured by the reader/writers, by constantly monitoring which reader/writer communicates with the object containing the RFID tag with the specific ID number. Even when switching from reader/writers as the object moves, continuous monitoring of the communications status enables the tracking of temporal changes in its location, which provides the item's distribution details including the history. This is how constant communications between RFID tags and reader/writers can make the online location information completely identical to the physical location of objects.

When capturing the location information of physical objects so as to be linked with online data, three different cases as shown in Table 1 are possible depending on how data processing tasks are shared between the RFID tag and the host computer.

Case 1 assumes that all the information about the distribution history is sent through the network to the host computer for storage. This helps minimize the functionality loaded on the RFID tag. Case 2, the opposite concept of Case 1, maximizes the capability of the RFID tag. Case 3 is a mixture of Case 1 and Case 2.

Since Case 1 allows for narrowing the functions of the RFID tag, possibly enabling reduction of the cost of RFID tags, its commercialization will most likely start in cost-oriented areas such as the replacement of bar codes. Case 2, by contrast, requires the most complicated capabilities among the three to be added to the RFID tag, resulting in higher costs. However, this type of system will prove effective where security and privacy are given the highest priority, as in the case with smart cards intended to be carried by people, and where network loads must be reduced. Developers of each type of technology are vying for more applications and setting up technical standards.

Figure 2: Movement of objects and the flow ofinformation



In RFID, information may be exchanged between tags and the host computer either globally through the Internet or locally through a LAN. The network configuration, the RFID tag's data structure and the volume of information traffic vary depending on the type of network to be used. Technologies for exchanging distribution information worldwide through the Internet are expected to grow toward the future. For applications that are designed only for reading the ID numbers of goods in a closed network, there are already many examples of the commercial use of the RFID tag combined with a POS*1 system in a local environment as a replacement of bar codes. Table 2 compares features of traditional bar code technology with those of its possible successor, RFID.

4.2.3 RFID's history and recent trends

RFID is said to have originated in World War II, for which Britain developed the technology to distinguish between friendly and enemy aircraft. In the 1970s, research and development on its basic technologies

Table 1: Scenarios for information processing

	RF tag function	Object's history	RF tag costs	Network loads
Case 1	ID number only (Read-only memory)	Stored on the host computer via the network	Low	Heavy
Case 2	ID number and history (Read/write memory)	Stored on the RF tag	High	Light
Case 3	ID number and history (Read/write memory)	Stored on the RF tag and the host computer	Mid to High	Mid to Heavy

Table 2: Bar code vs. RFID features

System	Bar code	RFID	Notes
Reading method	Optical	Electromagnetic induction	
Max. read range	up to 50 cm	Several meters	RFID's range depends on the radio wave's frequency, etc.
Human assistance in reading	Yes	No	With RF tags, no cashier is needed at checkout counters
Susceptibility to environments	Large	Small	Soiled labels, etc.
Data capacity	1 - 100 Bytes	128 - 8K Bytes	Several Kbytes in two-dimensional bar codes
Simultaneous reading of multiple codes	Not enabled	Enabled	
Unauthorized copy	Easy	Difficult	
Costs	0 - several yen	Up to 10 yen	For RFID, current costs for Rread-only
Reading occurs	Limited times	Fequently	

was conducted in the U.S. with an eye to application to cattle tracking, identification of railroad cars and so forth. In the 1980s, RFID was used at manufacturing sites in Japan for automated distribution control. The technology gained widespread recognition in the 1990s, when automatic ticket gate systems that use contactless smart cards instead of conventional magnetic cards became commercially available in Hong Kong and Singapore.

In recent years, contactless smart cards have been moving into actual use in Japan as well. Applications include automatic ticketing systems such as East Japan Railway's Suica, employee entry/exit registration, automatic lift ticketing and cashless payment systems in ski areas, and electronic toll collection (ETC) systems for highways.

In the low frequency range (125 kHz), which is the range most proven for the use of RFID tags in Japan, the technology has found application in areas such as the entry/exit control of uniforms sent to the laundry, rail containers, and at the checkout in revolving sushi bars. Table 3 shows typical application examples. Because of the Radio Law, radio wave output in the HF shortwave band (13.56 MHz) has been restricted more in Japan than in other countries. Since the communication range was limited to only about 30 cm under the law, the use of RFID tags was not as prevalent in Japan as overseas. However, the Radio Law was finally revised in September 2002 to relax domestic restrictions on this frequency band to levels equivalent to other nations, a change that is expected to contribute to increased applications of RFID tags in years to come.

4.2.4 Developments surrounding standardization

In the RFID arena, just as in the case with contactless smart cards and RFID tags, which are replacing magnetic cards and bar codes respectively, commercialization has begun with applications aiming at adding functions to and improving the reliability of existing systems. In the near future, these systems based on traditional local networks are expected to be transformed, through interconnected networks and other means, into systems that use worldwide networks to cover wider areas. A hurdle for RFID technology in expanding its application fields is technical standardization.

Table 4 shows recent developments in RFID standardization.

A physical communications protocol for RFID tags, for example, is being established under the leadership of the ISO, which intends to issue an international standard in 2003. In an effort independent of the ISO-led standardization, the Auto-ID Center is scheduled to propose the first version of its original technical specifications in September of this year. In Japan, with a view to realizing a ubiquitous society, the Ubiquitous ID Center was established in March 2003 as part of the TRON Project. As described above, there has been no unified standardization activity for RFID technology so far, leaving individual institutes to develop their own drafts.

Table 3: Major RFID applications

Field	Application purpose or system name	Operator	Status	Format
Train/bus tickets	Town-operated bus fare collection	Toyoda-cho, Iwata-gun, Shizuoka	Deployed in 10/1997	Smart card
	Daikanyama loop-line bus fare collection	Tokyu Transe	Deployed in 07/1998	Smart card
	Bus tickets/commuter passes	Yamanashi Kotsu	Deployed in 02/2000	Smart card
	"Suica" ticketing system	East Japan Railway	Deployed in 11/2001	Smart card
Highways	"ETC" automatic toll collection system	Japan Highway Public Corporation, et al.	Deployed in 03/2001	Smart card
Sports and amusement facilities	Ski lift ticket gates	Shiga Kogen Ski Cable Association	Deployed in 11/1992	Smart card
	Cashless payments within the pool area	Toshimaen	Deployed in 06/1996	RF tag
	Information management within the facility	"Yunessun" spa resort	Deployed in 01/2001	RF tag
Entry/exit control	Entry/exit control and cafeteria payments	Komukai plant, Toshiba	Deployed in 02/1989	Smart card
Vehicle control	Entry/exit control ofin the underground parking	Ebisu Garden Place	Deployed in 10/1994	Smart card
Distribution	Airline baggage control	Land, Infrastructure & Transport Ministry and airport authorities	Field tested in 10/2001	RF tag
	Product traceability	Economy, Trade & Industry Ministry	Study group formed in 02/2003	RF tag
Retail	Book sales management	Publishing trade group	Initiative launched in 03/2003	RF tag
Others	Rail car number reading	East/Central Japan Railway	Deployed in 1991	RF tag
	Automatic checkout counters in cafeteria	Nippon Steel Trading	Deployed in 04/1994	Smart card
	Revolving sushi bar checkout	Japan Crescent	Deployed in 2000	RF tag
	Library checkout	Kitakata-cho, Miyazaki	Deployed in 05/2001	RF tag

Source: Authors' compilation based on a reference[3]

Table 4: Activities at individual organizations

Organization	Year					
	'99	'00	'01	'02	'03	'04
International Organization for Standardization / International Electrotechnical Commission					RF tag standards (communications protocol) ▼ Final draft (May) ▼ Publication (Nov.)	
Auto-ID Center (MIT)	▼ Inauguration				▼ Establishment of Japanese unit (Keio Univ., Jan.) ▼ Technical proposal (Sept.)	
Ubiquitous ID Center (TRON Project)					▼ Inauguration (Mar.)	

4.3 Standardization activities

4.3.1 The frequencies for RFID

As RFID uses radio waves to allow RFID tags to communicate with reader/writers, the frequencies for these radio waves must be secured first, in addition to the physical specifications such as the communications method. In an era of distribution across borders, development of an international standard for built-in RFID tags is also indispensable if RFID tags are to be shared across different countries. However, a major hurdle exists before standardization because parts of the spectrum available for RFID, which serve as the standard for the initial physical interface (air interface) between the RFID tag and the reader/writer, are sometimes varied across nations depending on their allocation of the spectrum.

The first step is to decide, from a technical point of view, which band of the spectrum should be used. Factors such as the range of radio waves, directivity and antenna size must be taken into consideration in choosing the band appropriate and suited for each expected application. Contactless smart cards, which are intended to be carried by people, should preferably be in sizes that are easy to handle. These cards are available in the same form as magnetic cards and are increasingly replacing magnetic cards as they become more widely available, driven in part by the fact that they can have a relatively large antenna and use the HF shortwave band (13.56 MHz) as standardized by ISO.

In the case of embedded RFID tags, on the other hand, developers cannot help but move toward miniaturization of tags, including antennas, to reduce costs for the purpose of displacing bar codes. As smaller antennas have characters that are more fitted for higher frequencies, frequencies higher than the HF band will be needed for them. Frequencies around 13.56 MHz of the HF band, in which the RFID tag will communicate with the reader/writer through electromagnetic induction, provide poor antenna directivity and a short read range of no more than a few tens of centimeters. If an RFID tag is embedded in an object larger than this size, reading may be impossible, rendering the HF band an undesirable choice. In much higher frequencies such as the microwave frequency band (2.45 GHz), by contrast, radio waves are attenuated by molecules of water, limiting application to objects with high-water content such as food products. The above discussion leads us to the conclusion that the UHF band[*2] is the most prominent candidate to win the position of the most preferable frequency band for RFID tags, because it provides better directivity and longer read ranges.

In the development of international standards in ISO/IEC[*3], working draft proposals on the air interface standards targeting the frequencies ranging from low to as high as 5.8 GHz were followed by additional proposals from the U.S. and Europe on 860-930 MHz (ISO/IEC 18000-6) and 433 MHz (ISO/IEC 18000-7). Table 5 shows the proceedings of the discussions on the air interface standards (ISO/IEC 18000) in ISO/IEC.

Table 5: Proceedings of the discussions on the air interface physical standards

Name	Number	Frequency	Working Draft (WD)	Committee Draft (CD)	Final CD (FCD)	Final Draft of IS (FDIS)	International Standard (IS)
Air Interface	18000-1	(Generic Parameters)	2000.12	2001.09	2003.02	2003.05	2003.08
	18000-2	Below 135 kHz	2001.03	2002.03	2003.02	2003.05	2003.08
	18000-3	13.56MHz	2000.12	2002.03	2003.02	2003.05	2003.08
	18000-4	2.45GHZ	2000.12	2002.03	2003.02	2003.05	2003.08
	18000-5	5.8GHz	2002.06	2002.11	withdrawn		
	18000-6	860-930MHz	2002.06	2002.11	2003.05	2003.08	2003.11
	18000-7	433MHz	2003.01	2003.01	2003.05	2003.08	2003.11

Source: Authors' compilation based on references[3,4]

It demonstrates that while ISO/IEC 18000-1 to 18000-4 took more than two years to evolve from the working draft to the final committee draft, ISO/IEC 18000-6 and 18000-7, the late proposals, were quickly developed into standards. Although this was probably in response to the strong market demands, expeditious formulation of standards can act in favor of specific companies that promote the individual proposals. The issue is particularly critical to Japan, where both ISO/IEC 18000-6 and 18000-7 frequency bands have been assigned for other uses*4. As it is obvious that Japan cannot adopt the standards, if established as-is, without any impact on its existing systems, Japan must speak up to have its point of view reflected in international discussions.

The U.S., as part of its antiterrorism measures, is already moving toward enforcing the government-designated RFID tags to be attached to any item imported into the country in 2004 and later. If they start using tags that are incompatible with the tags used in Japan, this will have an immeasurable economic impact on Japanese industries that are highly dependent on exporting to the U.S. Furthermore, as long as the designated frequencies are not available in Japan, no one in Japan will be able to verify even the correctness of data stored in U.S.-designated RFID tags attached to goods imported from the U.S. or other nations. For the time being, Japanese companies could adopt such temporary approaches as dual mode*5, in which they need to affix their original RFID tags at additional costs. Over the long term, measures at the government level, including measures for reviewing the current spectrum allocation, will have to be taken.

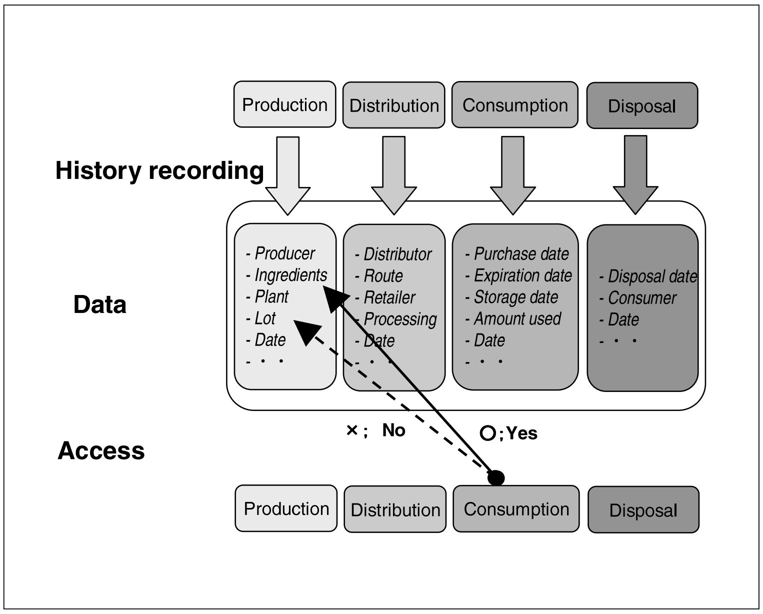
4.3.2 Coding scheme

What needs to be standardized after the frequency and other physical communications methods for RFID is the format of information to be communicated. This is equivalent to unique codes assigned to individual items in bar code systems. Currently, there are some different coding schemes for the bar code and, as different industries use different coding schemes, existing systems are not tailored for packaging and specifications that vary as the product goes through a number of production and distribution stages. To cope with this problem, the International Article Numbering Association (EAN International*6), which finally became a unified organization with the participation of the Uniform Code Council, Inc. (UCC*7) in the U.S. in November 2002, has just begun discussing coding standards specific to individual products and their types of packaging. The coding structure for RFID tags will probably follow the general concept of the bar coding scheme or, in some cases, will possibly secure backward compatibility with it. What should be noted here is the data length of the code. The greatest challenge for RFID in replacing existing bar code systems is its costs. Given that research and development for smaller antennas and IC chips[5] to reduce costs to the minimum is ongoing, the IC chip's memory should also be given minimal memory capacity, which means that the data length of the code to be assigned should remain at the shortest possible size.

The data length of the code, which is in direct relation to the data volume that runs on the network, is also dependent on the type of information transmitted over the network. This can affect the configuration of networks and host computers in the future. If all of the distribution information comes to be exchanged over the Internet, there may be considerably more frequent sending and receiving of data than is now occurring between PCs. Perhaps there is no need to connect even an item as small as a pencil to the Internet worldwide. In this context, it would be safe to say that all we need to track and trace goods imported or exported across borders is their information by the actual distribution unit such as the container or the pallet, as long as the location of individual items can be captured locally during packing.

The Japanese media more often reports on activities in the Auto-ID Center and the Ubiquitous ID Center. The Auto-ID Center is working toward assigning 96-bit code to individual objects, with a plan to extend the code up to 256 bits. The fact the Center seeks to promote the code allocation in collaboration with EAN International suggests that the Center is aiming for a de facto world standard with its

Figure 3: Conceptual illustration of access to product history



scheme. In the technology advocated by the Auto-ID Center, only code is assigned to objects with all the remaining information stored on the host computer on the network (Case 1 in Table 1). In contrast to this approach, the technology proposed by the Ubiquitous ID Center gives RFID tags more sophisticated functions with an eye to enabling the terminal to process information on the spot (Case 2 in Table 1). This will take part of the load off the network and allows RFID tags to process information in real time. Adding a multitude of functions to the RFID tag, however, results in more expensive tags, posing a number of challenges in terms of costs that must be overcome before embedding RFID tags in every object. It is likely that the Auto-ID Center, which seeks to make the most of network capacity, and the Ubiquitous ID Center, which moves toward integrating functions into the RFID tag that is expected to act like a microcomputer, will continue to contend for the development of an ideal technology.

4.3.3 Restrictions on data usage

In a traditional bar code system, the code given to an object is not read so frequently, partly because code scanning cannot be completed without human assistance. Typically, a code is scanned only once, at the cash register for checkout, or if more often, a few times at most. Thus the use of the information captured is limited, for instance, to checking whether the item has passed through a checkout counter. In RFID, on the other hand, codes are automatically read at desired places as often as the number of reader/writers in operation for the system. The captured data, which contains any kind of distribution history of the object, is accumulated over time on the online host computer and/or in the built-in memory of the RFID tag itself.

A database of the distribution information accumulated in this way should include every data element, whereas in contrast reference to the database would require varied levels of restriction from user to user (Figure 3). In the case of food products, for example, what kind of ingredients were used to produce them and whether any allergenic substance is contained in them are the information most demanded by consumers. Such information, except for the trade secret part, would have to be made accessible to consumers. However, information related to detailed production control, such as the production site and the lot number of individual products, would not have to be made directly available to consumers. Also, access to the distribution information after the product has been purchased by a consumer should only be given to such consumer for the protection of privacy.

This indicates that the data must be either structured to begin with or hierarchically stored in such a way that allows for user-specific access control to the accumulated data containing the product's history and other information.

4.4 RFID business models

Whether or not RFID technology comes into widespread use in the future will be determined by how it will be able to improve the efficiency of existing businesses and generate new added values. The initial objective for a U.S. company to deploy RFID is assumed to be for improved efficiency in its overall distribution supply chain. By replacing RFID with its existing bar code system, the company could expect a range of improvements such as enhanced operational efficiency, prevention of human errors and less frequent checks at various stages of distribution. Outside the supply chain, there would also be improvements in the following areas, for example:

(1) Ensured safety and human error prevention in businesses handling hazardous materials;
(2) Improved productivity and minimized equipment downtime in the manufacturing industry; and
(3) Enhanced customer service in the retail industry.

Through the deployment of bar code systems, which enable operators to scan bar codes instead of keying in merchandise information, companies must have successfully improved efficiency in their supply chain. RFID can bring additional benefits as it allows input of information to terminals with no human involvement. With RFID, businesses will be able to further reduce labor, eliminate errors and speed up operations. The diffusion of the technology in the distribution field is dependent on whether or not RFID can improve operational efficiency to the extent that compensates for the deployment costs or can produce new added values.

In terms of increasing corporate profits, loss of merchandise due to theft is another area that requires consideration. Earlier this year, Gillette attracted attention when it announced a plan to buy a total of 500 million RFID tags in the next three years to conduct a market test of RFID. While the company stated that the implementation was intended for the reform of its supply chain management, there was a report that pointed out Gillette took the measure to actually prevent loss of merchandise due to theft[6]. When retailers have an average profit margin of around 3%, it is said they lose as much as 2% of sales to loss of merchandise arising from internal and external theft. Stolen product problems should be discussed from two points of view: direct damage from theft and the impact to the supply chain deriving from gaps between the number of products registered on the system and the actual product count. This is becoming an issue of vital importance to bookstores, as it is reported bookstores across Japan suffer an average annual loss of 2.10 million yen (1-2% of sales) per store due to shoplifting[7]. A problem here is “who will pay” the cost for implementing RFID, because the party who will benefit from the system is, in general, not the party who will have to pay. This is not an issue related to a single company or a single store, but an issue involving the entire supply chain. An industry-level approach from a long-term perspective is required to solve this problem in combination with the standardization of specifications.

In another move led by the Ministry of Land, Infrastructure and Transport, application of RFID to manage air travelers’ baggage is being planned. Their scenario is attaching an RFID tag to a packed suitcase when it is picked up at the traveler’s home by someone from the baggage delivery company. The tag is automatically passed to the airline company and tracked until the traveler receives the suitcase at the destination. In this application example, not only will travelers benefit from the service, but also delivery service operators will profit because the RFID system will save them the trouble of issuing baggage slips and passing them along. In addition, the system may even help immigration officers detect the possession of hazardous materials or drugs. In developing such a system, all of the four parties—travelers, delivery companies, airlines and the immigration authorities—need to participate in the discussion on how to implement RFID.

4.5 Hurdles before widespread use in society

From this August, Basic Resident Register cards will be distributed to the residents across the nation. It is understandable that rigorous security measures are needed to protect these contactless smart cards on which the resident identification number and other sensitive information to verify the identity of the holder are to be encoded. However, for the Suica system, a precedent application of the smart card, a small reader designed specifically for the system, with which anyone can easily read out from a Suica card information on when and where the card was used, is already commercially available[8]. Figure 4 shows an example of the usage status of a Suica card displayed on a PC. The card reader, which should do no harm as long as it is used by a cardholder to review what has been written on the card, can be a threat to privacy in some cases.

Compared to these smart cards, what are the potential risks of having RFID tags attached to objects? Since the RFID tags, which are intended to replace bar codes, must be inexpensive, they are read-only and thus no accumulated information is stored in the tags. Instead, all the history of a person's belongings is sent over the network to the host computer for storage. If you happen to be carrying any item with a built-in RFID tag, its signal might be captured by a reader without your knowledge, allowing the reader to recognize what you have. If you were carrying a few things such as a laptop, a digital camera and a magazine, for example, you would be easily identified based on that information. This poses a risk of enabling others to keep close track of specific individuals, a situation that must be avoided.

We should keep in mind that RFID is a technology that can potentially cause an invasion of privacy.

Other than the privacy issue, there are other areas that should be addressed. Once the RFID system has been implemented, how is it going to be operated, how are the new values, services, and problems going to be managed and by whom? As the system covers any "object," there are a number of ministries and agencies concerned. They include not only the Ministry of Public Management, Home Affairs, Posts and Telecommunications and the Ministry of Economy, Trade and Industry, which both have already been working toward setting up technical standards, but also the Ministry of Land, Infrastructure and Transport, which should take the initiative in discussions regarding transport and traffic, and the Ministry of Agriculture, Forestry and Fisheries, which should lead activities for the use of RFID to establish traceability that can ensure food safety. With respect to the distribution of medical supplies, the Ministry of Health, Labour and Welfare could make proposals on new applications with some attention to the prevention of malpractice as well as to the establishment of traceability. In the security and privacy domains, the National Police Agency and the Ministry of Justice should promote debates on the legal aspects of RFID applications.

Figure 4: An example of usage status read out from a Suica card

To allow RFID technology to widely penetrate into society in the future, not only standardization of technical specifications is needed but also building a social infrastructure that supports the technology. This means that simply considering RFID as one of the new technologies is not appropriate. Now is the time for government and society to thoroughly discuss the issue of RFID as a technology that has the potential of developing into an element of the social foundations and of changing the future social system as well as individuals' living environments.

Notes

*1 Point of sale is a system that records merchandise sales data at the time of sale in a store, so that the collected information can be used for inventory management and marketing.

*2 The Auto-ID Center and the EU have been developing technologies based on 915 MHz and 868 MHz, respectively.

*3 These international standards have been instituted by Sub Committees (SC) of the Joint Technical Committee (JTC 1), an organization subordinate to both the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC). RFID is discussed in the technical direction "Data Capture and Identification Systems" in Sub Committees 17 and 31, whose secretariats are held by Britain and the U.S. respectively.

*4 In Japan, the frequencies of 433 MHz and 860-930 MHz have been assigned for amateur radio and mobile telephone use, respectively.

*5 The RFID tags that are designed for use at two different frequencies. They require a larger number of components and higher costs.

*6 The International Article Numbering Association was originally established in 1977 under the initiative of European countries to supervise the use of the European Article Numbering system, which has now become an international article coding system supported by an increasing number of member states around the world. The current membership consists of 97 countries.

*7 The Uniform Code Council, an organization established in 1973 and consisting of two member states (the U.S. and Canada). The code given according to UCC standards is called Universal Product Code (UPC).

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[3] "2003 Guidebook to Contactless IC Cards and RFID", edited by Committee to Promote Contactless IC Cards and RFID (in Japanese)

[4] http://www.uc-council.org/

[5] http://www.alientechnology.com/

[6] "Nikkei Computer," March 10, 2003, p.17 (in Japanese)

[7] Web site of the Ministry of Economy, Trade and Industry, http://www.meti.go.jp/policy/media_contents/downloadfiles/1024Manbiki_gaiyou.pdf

[8] http://www.sony.co.jp/Products/felica/pcrw/sfcard_dl.html

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