A CASE STUDY OF THE E-MONEY APPLICATION IN JAPANESE PUBLIC TRANSPORTATION

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Abstract: Japan leads the world in the field of a rechargeable contactless smart card used as a fare card of public transportation. The card triggered off the spread of Japanese e-money, however, the e-money situation has various intricate problems to tackle. Therefore, we have surveyed the spread process of the e-money and special circumstances of Japanese public transportation. In this paper we describe the business success factors and background. We also analyze and propose the solution against the problems and objectives for globalization of the market.

1 INTRODUCTION

Recently, the application of e-money has expanded into a means of payment of public transportation. The e-money for the fare is generally implemented by a smart card, particularly a contactless RFID smart card. Such a contactless smart card is used all over the world, e.g., Octopus card in Hong Kong, Suica card in Japan, Oyster card in London, Navigo card in Paris, T-money in Seoul, Compass Card in San Diego, Riocard in Rio de Janeiro, GoCard in Nigeria, and so on. Above all, Japan is an advanced country of the contactless smart card.

The spread process of Japanese e-money is very unique. Japanese people had not had interest in e-money at all, until the fare contactless smart card became practicable. After the card appeared in major rail services, e-money has spread rapidly, because a commuter can pass without stopping the very crowded ticket gate during the Japanese rush hours. The card can also be used at kiosks and vending machines inside stations. Moreover, recently the card has been able to be used at convenience stores, supermarkets, eating houses and the other shops outside stations. In addition, the bus trade has introduced the card. Thus various Japanese transportation companies have issued such a card with e-money. One innovative service with the card is coming out after another in quick succession and entry of the other trades into the market is increasing. Now the business of the contactless smart card with e-money in Japan has been a great success.

However, the e-money market has some problems to solve. Since each transportation company has issued its independent card, the Japanese transportation trade is flooded with many kinds (about 40) of contactless smart cards. The introduction of the card system is also very expensive, thus small companies which do not sufficiently have the capital strength (e.g., a local bus company) cannot even introduce the card and they are outdistanced. Moreover, FeliCa, the Japanese de facto standard of the contactless smart card, is not certified by the RFID international standard ISO/IEC 14443, that is, it is not global standard. The business of e-money in Japan is overly concentrated on the domestic market only. There is very little room for entry of overseas enterprises.

So far only the technological side of a contactless smart card and its system has been highlighted (Shiibashi, 2007). No studies have tried to survey the trade all over and to summarize the business success factors. Therefore, in this paper we survey the evolution process of e-money in Japanese public transportation and clarify the background and the problems which are caused by special circumstances of Japanese railways. We also discuss the secrets of success and solutions against the problems of compatibility and localization. The results in this paper open the Japanese e-money market and help its globalization. Moreover, they systematize the introduction of a contactless smart card into public transportation. Consequently, it will enliven the e-money market all over the world.

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2 THE CARD SITUATION

2.1 Early History of Japanese e-Money

In 1998, the first Japanese e-money, VISA Cash, was introduced experimentally. However, this experiment has ended in failure. VISA Cash was implemented by a contact smart card. The user had to take the card from a holder and input the PIN code. Japanese people did not accept such troublesome operations.

In 2001, the first contactless smart card with e-money, named Edy, appeared. Edy is a prepaid rechargeable contactless smart card, which uses Sony's FeliCa technology. FeliCa allows to send/receive data at high speed and with high security (Kurosawa et al., 2003). It does not need a battery to operate. Further details of the FeliCa technology will be presented later. Edy was able to be used only at convenience stores then. Japanese people did not particularly interest in Edy yet, because e-money did not have a good image at the time owing to the former e-moneys.

In the same year, the Suica service started in the metropolitan area (Shirakawa and Shiibashi, 2003). Suica using the FeliCa technology is a rechargeable contactless smart card used as a fare card on train lines. Suica was able to be used only as the fare payment in the limited lines then; nevertheless it had a circulation of one million only in 19 days and two million only in two months. The service has been expanded besides the fare payment after 2004 successively.

The e-money trade has been an arena of rival cards since Suica achieved a great success. Many public transportation companies followed the service and issued similar cards. We describe details of such cards and their development in the following subsections.

2.2 The Cards in Public Railways

Japanese railways are classified into two types; JR (Japan Railways) or non-JR. JR used to be the national railway JNR (Japan National Railways), which dissolved and separated into seven (six passenger railways and one freightage) JR companies in 1987. The passenger railways are separated by region. Figure 1 shows each JR company's area.

Although Japan is a small island country, the characteristic of the people of each region varies according to the locality. For instance, consumer behavior and interest differ from the Kanto region (Tokyo) to the Kansai region (Osaka/Kyoto) very much. Each JR company has to work out management policies which bear closely on the needs of local people. Each JR company also considers the other JR companies competitors which scramble for business chances. Therefore, the companies developed their own cards shown in Table 1. All the cards are implemented by FeliCa.

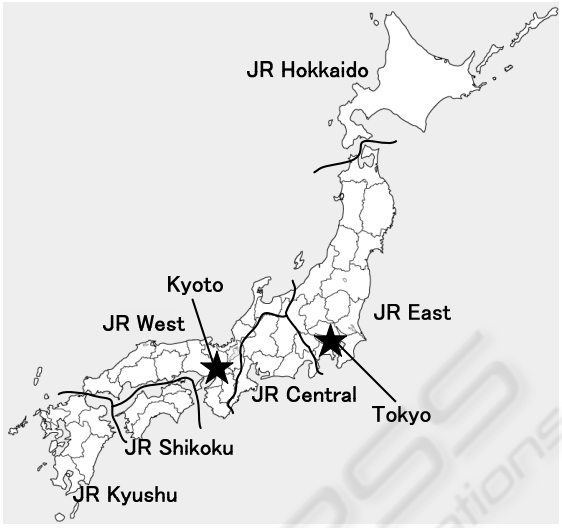

Figure 1: The region of JR companies.

Table 1: The contactless smart cards of JR group.

Company	Card name	Number of stations
JR Hokkaido	Kitaca	465
JR East	Suica	1705
JR Central	TOICA	404
JR West	ICOCA	1222
JR Shikoku	–	259
JR Kyushu	SUGOCA	560

A user can charge money on to the card at ticket vending machines inside each station. The charged money is a profit of the JR company in the card region. Thus, at first each card was not able to use in the other regions. The introduction of contactless smart cards to the Shinkansen line, which is a high-speed railway line, had also been put off for some years. The Tokaido Shinkansen line is the main artery crossing the Japanese mainland. JR Central has jurisdiction over the line. Because the line lies across the regions, JR Central and the other JR companies have been at odds with each other over the profit at the stations in the Tokaido Shinkansen line.

The specification of each card system is also different from the others. For example, the Suica system closes a ticket gate if e-money on the card is under the starting fare when a passenger enters. Meanwhile the ICOCA system does not close it unless the e-money is empty, since the Kansai region people generally tend to dislike a time-consuming operation. TOICA accepts the empty card. Moreover, the fare adjustment

rule of each JR company is different. The difference is also caused by the introduction order. The JR companies following the formers can watch the response to the card. The year of each introduction is shown in Figure 2 (the number in parenthesis). The compatibility is implemented by a software program in the card reader, however, each card system must have the programs against all the other cards.

2.3 The Cards in Private Railways

The private railways (non-JR railways) also started the fare contactless smart card service. The services are classified into a joint capital type or an independent type. In the metropolitan area, the private railways established a new association PASMO Co. Ltd. of the contactless smart card business by joint capital. The PASMO card is perfectly compatible with Suica. Therefore, transfer of JR lines and private/underground railways has been very convenient; we can change one line to another only with one contactless smart card in the Kanto region. It was the epochal event of Japanese railways history, because JR and non-JR had been always competitors one another. Similarly, the Kansai region private railways have issued the common card PiTaPa. PiTaPa is a novel card in Japanese public transportation, which is a postpay type card like a credit card for the impatient Kansai region people. PiTaPa also implements various discount services. The private railways in the other regions have also issued their own cards shown in Table 2.

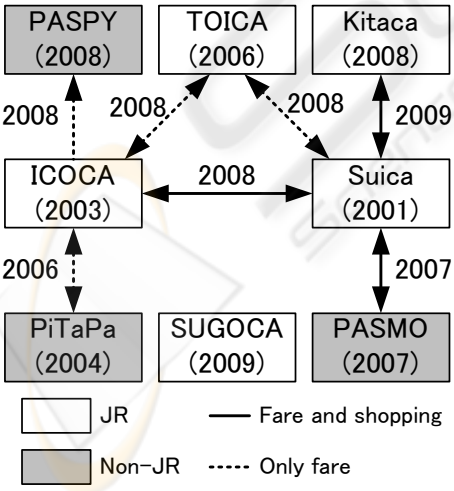

Figure 2: The compatibility of the cards.

The private railways cards have the problem of compatibility. Each card is compatible only with the JR card in its same region (see Figure 2). For example, the PASMO card can use only in the JR East (Suica) region and is not compatible with any other cards. Thus the member companies which have fully the capital strength want to cooperate with the other regions; on the other hand the small member companies oppose it. Each member company has to pay a membership fee and maintenance costs of several hundreds millions Yen (about several millions USD) every year. Moreover, it must pay several millions Yen whenever changes of the system happen. The small or local companies do not interest in use in the other regions, because they cannot make a profit on the mutual use any more.

Table 2: The contactless smart cards of the private railways.

Region	Card name	Number of members
Kanto	PASMO	103 (77)
Kansai	PiTaPa	37 (17)
Hokuriku	ICa	4 (3)
Chugoku	PASPY	13 (9)
Shikoku	DESUCA	5 (4)
Kyushu	RaPiCa	4 (3)

Besides the cards in Table 2, some local private railways had to issue their independent card for lack of an alternative. Such cards do not have any compatibility.

2.4 Bus Companies

The bus companies have joined the association of the private railways. The number in parenthesis in Table 2 shows the number of bus member companies out of the total. The bus companies' case also has the same financial problem as well as the private railways case.

The bus member companies of PASMO have about 15,000 buses in all, however, the contactless smart card system has been introduced into only 30% of the buses. Because besides the membership fee and maintenance costs, the introduction of the system requires from seven to eight hundred thousand Yen (from eight to nine thousand USD) per bus. Nowadays Japanese people think it a matter of course that the contactless smart card can be used in public transportation. The bus companies which have not introduced it may lose customers.

3 THE CARD TECHNOLOGY

In this section, we describe why the card has spread rapidly from the technology viewpoint.

3.1 Why Contactless?

Japanese railways have special circumstances which other countries do not have (and cannot understand). Almost all Japanese people in the metropolitan areas take the train daily to work. Therefore, a station and a train are terribly crowded in rush hours. About 60 commuters per minute pass a ticket gate in peak hours. In Europe, it is 30 per minute. Additionally, Japanese train service is strictly on time. The machine of Japanese ticket gate requires high throughput.

There are many kinds of train tickets in Japanese railways. The ticket gate must examine varied train tickets. The gate also does not care insertion direction and the front/back of a ticket. One ticket gate accepts both of entry and exit of passengers (Figure 3). The Japanese ticket gate is a very complex machine. Therefore, the ticket gate machine tends to break down and its maintenance cost comes high. If the physical contact can be avoided as much as possible, the maintenance cost is reducible.

Consequently, a contactless smart card has been suitable against the foregoing circumstances. The first and most successful card Suica of JR East has succeeded in cutting down the maintenance cost by 1/3.

Figure 3: The ticket gate machine.

3.2 FeliCa Technology

Almost all Japanese contactless smart cards are implemented by FeliCa. To solve the congestion mentioned above, JR East invited tenders for the card system which can examine one card in 0.1 second. That is, it has to communicate at 211.875 kbit/s. It was very high level of specification. Moreover, JR East requested that the card reader should examine two or more cards in piles. Only FeliCa had satisfied these requirements. Since FeliCa had been already introduced into public transportation in Hong Kong, it was also reliable (Chau and Poon, 2003). After JR East adopted FeliCa, it has become the de facto standard.

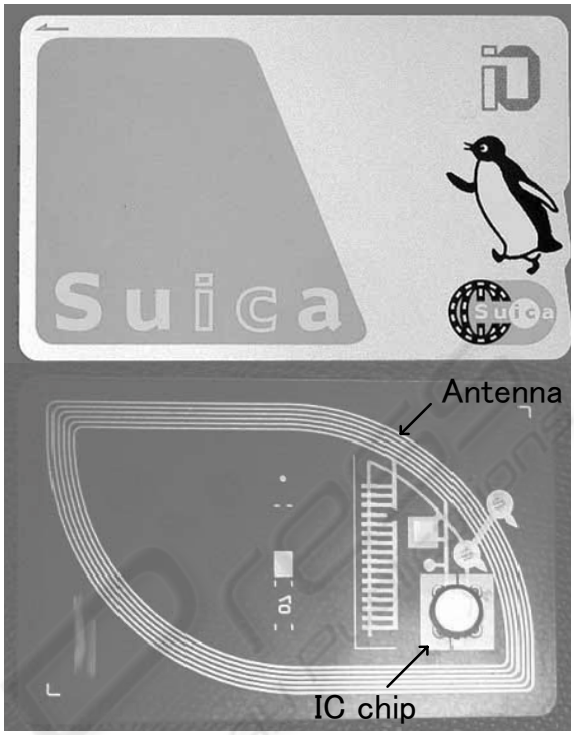

Figure 4: The Suica card and its cutaway drawing.

FeliCa uses Manchester coding at 212 kbit/s in the 13.56 MHz range. It can also operate without a battery using the electromagnetic induction. Thus it is thin and light in weight. The coil like a leaf shown in Figure 4 is an antenna. The leaf form is a device for reading two or more cards. When the antenna comes close to the reader, an electric current is generated. FeliCa reads and writes data with the power. It can implement various applications, if only software in the reader is rewritten. Moreover, the security of FeliCa has been certified by ISO/IEC 15408. These FeliCa functions are suitable for the smart card of public transportation.

However, FeliCa has been rejected by the RFID international standard (ISO/IEC 14443, 2008). It has been certified by the NFC (Near Field Communication) international standard later (ISO/IEC 18092, 2004). ISO/IEC 14443 provides two types of the RFID card. The type A uses Modified Miller coding at 106 kbit/s, which is developed by Philips in Netherlands. The type B uses NRZ (Non Return to Zero) coding at 106 kbit/s, which is developed by Motorola in the U.S. The type A is most widely used in the world. Nevertheless, the type A and B are hardly used in Japan.

4 DISCUSSION

Nowadays, 50% of Japanese people in the major cities have more than one contactless smart card with e-money. Suica certainly triggered the spread of e-money. Japanese people have understood convenience of e-money by Suica. The graph shown in Figure 5 backs up this fact. The Edy e-money only for shopping has been gradually increasing, since Suica appeared. The spread of the mutual use among

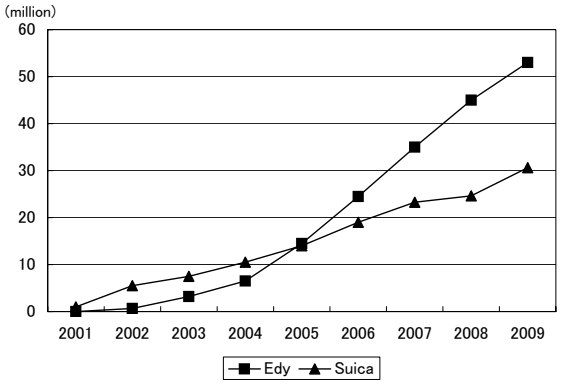

Figure 5: The number of Edy and Suica cards.

the cards will promote competition among the major companies and improve the quality of the service. On the other hand, it may merely encourage the disparity between local areas and metropolitan areas. Japan is a conspicuous aging society. Therefore, the local transportation companies aim to revitalize depopulated areas using e-money with the contactless smart cards. However, the mutual use has few merits for the local transportation companies. In addition, it requires the software development, but the local transportation companies do not have software engineers. They have to request a software vendor to develop it: the development cost is about one million Yen (10,000 USD). Now the government partially supports the local companies only in the initial costs. It should support them further.

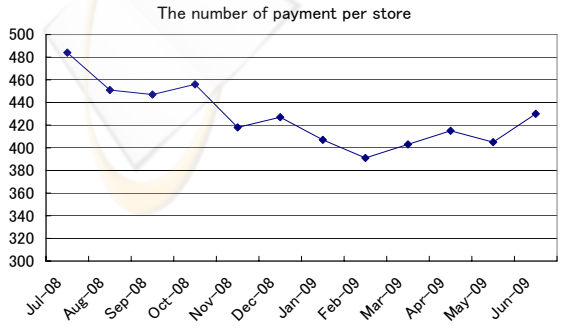

Figure 6: The number of payment per store with Suica.

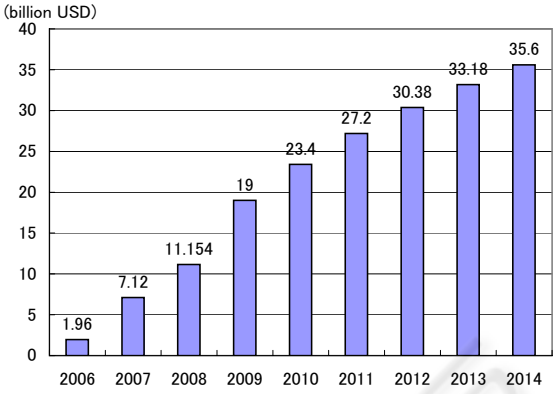

Figure 7: The prospect of the e-money market in Japan.

5 CONCLUDING REMARKS

The number of the contactless smart cards in Japan has virtually reached the ceiling; nevertheless the number of the payment per store is gradually decreasing (Figure 6). For the further spread, each company or association has to increase member store inside and outside stations and to propose novel and attractive privileges. JR East has made full use of the advantage in the metropolitan area. Suica money is mutually exchangeable for the mileage point of ANA (All Nippon Airways). Suica is also developing novel services using data-mining from the use records as lifelogs.

The contactless smart cards with e-money have spread in the world. For instance, PayPass of MasterCard has a circulation of 60 millions. Sooner or later Japan must open the contactless smart card market. Before opening the market, the Japanese e-money trade has to solve the problem of the mutual use among FeliCa, the type A and the type B of ISO/IEC 14443. ISO/IEC 18092 standardizes NFC, which has unified FeliCa and type A. Similarly, type B has been added to NFC (ISO/IEC 21481, 2005). The card reader adapting to NFC can use FeliCa, type A and type B. Such reader is spreading; however, NFC is upward compatible for the hardware protocol. The system must have software applications for every chips. Thus, NFC cannot become a radical solution. Moreover, FeliCa has a serious problem. Generally, a recent mobile phone has a contactless smart card built-in. In response to the situation, GSMA (Global System for Mobile communications Association, 2010) has standardized a contactless smart card system for a mobile phone and adopted type A and type B as a global standard. All over the world, e-money services with such mobile phones have already begun. Since Japanese mobile phones, which are equipped with FeliCa, have the protocol stack different from the mobile

phones with type A/B, Japan may be isolated in the mobile field too. In the future, Japanese mobile phone should have not only FeliCa but the other global IC chip and use different applications for every chips.

Nomura Research Institute showed very interesting statistics shown in Figure 7 (Nomura Research Institute, 2008). They expect that the e-money market in Japan will be expanded further. Thus there are many business chances for the domestic and foreign companies. The foreign company which entries into the Japanese market must understand the national character and special circumstances of Japanese public transportation. The architecture of the payment system with contactless smart cards in Japanese public transportation has been referred to the IFMS (Interoperable Fare Management System) standard (ISO/IEC 24014, 2007). Japan has been nominated for the editor of ISO/IEC 24014 Part 2: recommend business practice for set of rules. The organization is currently summarizing the business model as the technical report. This standardization will be certainly helpful for the spread of the e-money application of public transportation in the world.

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