Smartcard Ticketing Systems for More Intelligent Railway Systems

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OVERVIEW: The smartcard ticketing systems whose scope is expanding across Japan are now starting to be used not just for public transport ticketing services but also to provide users with an infrastructure that they use in their daily lives including electronic money and mobile services, credit card integration, building access control, and student identification. Hitachi has already contributed to this process through the development and implementation of smartcard ticketing systems for different regions and is now working on the development of systems that support the implementation of smart systems that underpin society and combine information and control to provide new social infrastructure for the foreseeable future.

INTRODUCTION

A number of smartcard ticketing systems have been introduced in different parts of Japan since the Suica[*1] service of the East Japan Railway Company commenced operation in November 2001. As of March 2009, systems of this type had been introduced at about 25 companies including both JR (Japan Railway) Group and private railway companies (see Table 1).

The East Japan Railway Company is the leader in this field and its aims in introducing the Suica service include providing its passengers with greater convenience, facilitating cashless operation at railway stations, reducing the cost of terminals and other station service equipment, and improving security. Since then the company has progressively expanded the scope of both its own services and interactive operation of other railway operators' systems while also extending its services and businesses in other ways including making the electronic money and mobile services more convenient to use. In accordance with their respective regional, business, and other characteristics, other public transport operators have also used smartcard ticketing systems to provide the infrastructure for expanding their businesses into distinctive fields such as allowing the cards to be used for the Shinkansen reservation service and tying-in of them with loyalty points systems run by retailers.

Smartcard ticketing services have a hierarchical structure made up of the smartcards (including mobile smartcards) that are the basis of the service, railway station terminals such as ticket gates and ticket vending machines, bus ticket reading machines, the relay

*1 Suica is a registered trademark of the East Japan Railway Company.

TABLE 1. Smartcard Ticketing Systems in Japan
Smartcard ticketing systems have spread right across Japan over the last 10 years.

Service commenced	Smartcard name*	Operator
November, 2001	Suica	East Japan Railway Company
January, 2002	Nagasaki Smartcard	Transportation Bureau of Nagasaki Prefecture and others
March, 2002	IC TEIKIKEN	Saitama Railway Co., Ltd. (switched to PASMO)
April, 2002	Monorail Suica	Tokyo Monorail Co., Ltd.
July, 2002	Setamaru	Tokyu Corporation
December, 2002	Rinkai Suica	Tokyo Waterfront Area Rapid Transit, Inc.
November, 2003	ICOCA	West Japan Railway Company
August, 2004	PiTaPa	Surutto Kansai Association
August, 2004	NicePass	Ensyu Railway Co., Ltd.
December, 2004	ICa	Hokuriku Railroad Co., Ltd.
February, 2005	IruCa	THE TAKAMATSU-KOTOHIRA ELECTRIC RAILROAD Co., Ltd. and others
April, 2005	Rapica	Kagoshima City Transportation Bureau and others
August, 2005	IC E-card	Iyo Railway Co., Ltd
April, 2006	passca	Toyama Light Rail Co., Ltd.
October, 2006	Hareca	Okayama Electric Tramway Co., Ltd. and others
October, 2006	LuLuCa	Shizuoka Railway Co., Ltd.
November, 2006	TOICA	Central Japan Railway Company
March, 2007	PASMO	PASMO Co., Ltd.
January, 2008	PASPY	Hiroshima Electric Railway Co., Ltd. and others
May, 2008	nimoca	Nishi-Nippon Railroad Co., Ltd.
October, 2008	Kitaca	Hokkaido Railway Company
January, 2009	SAPICA	Sapporo City Transportation Bureau
March, 2009	SUGOCA	Kyushu Railway Company
March, 2009	Hayakaken	Fukuoka City Transportation Bureau
February, 2011	manaca	Tranpass IC Council

* The smartcard names are registered trademarks, trademarks, or names of their respective operators.
: Systems in which Hitachi was involved.

servers that put together the data read by them, and the center servers that handle tasks such as managing the smartcards and processing monetary balances. Hitachi has been involved in their development since the Suica service first started and been developing an ID (identification) management system that is the center system. Hitachi has also supplied ID management systems as well as various peripheral systems and equipment to other operators.

This article gives an overview of smartcard ticketing systems and describes the outlook and potential of future smart systems that underpin society.

TRENDS IN SMARTCARD TICKETING SYSTEMS

The following lists the main objectives for smartcard ticketing systems when they were first introduced.

(1) Improve convenience for passengers by allowing fare payment at automatic ticket gates and a service for reissuing lost cards.

(2) Enhance security to prevent unauthorized use of forged, modified, or lost cards.

(3) Reduce costs by adopting smartcard technology to cut maintenance costs and reduce the required number of equipment.

More recently, these have been complemented by improvements to customer convenience and service through the addition of schemes such as allocating points based on the value used as well as electronic money services for purchases at railway station shops, convenience stores, vending machines, and other retail outlets; tie-ups with credit companies to provide auto-charge functions that can automatically top-up the SF (stored fare) in the smartcard; and mobile services provided via mobile phone.

In addition, a wide range of other uses for the cards have been researched and implemented including office access control, student ID, and tie-ups with bank cards or resident cards (see Fig. 1).

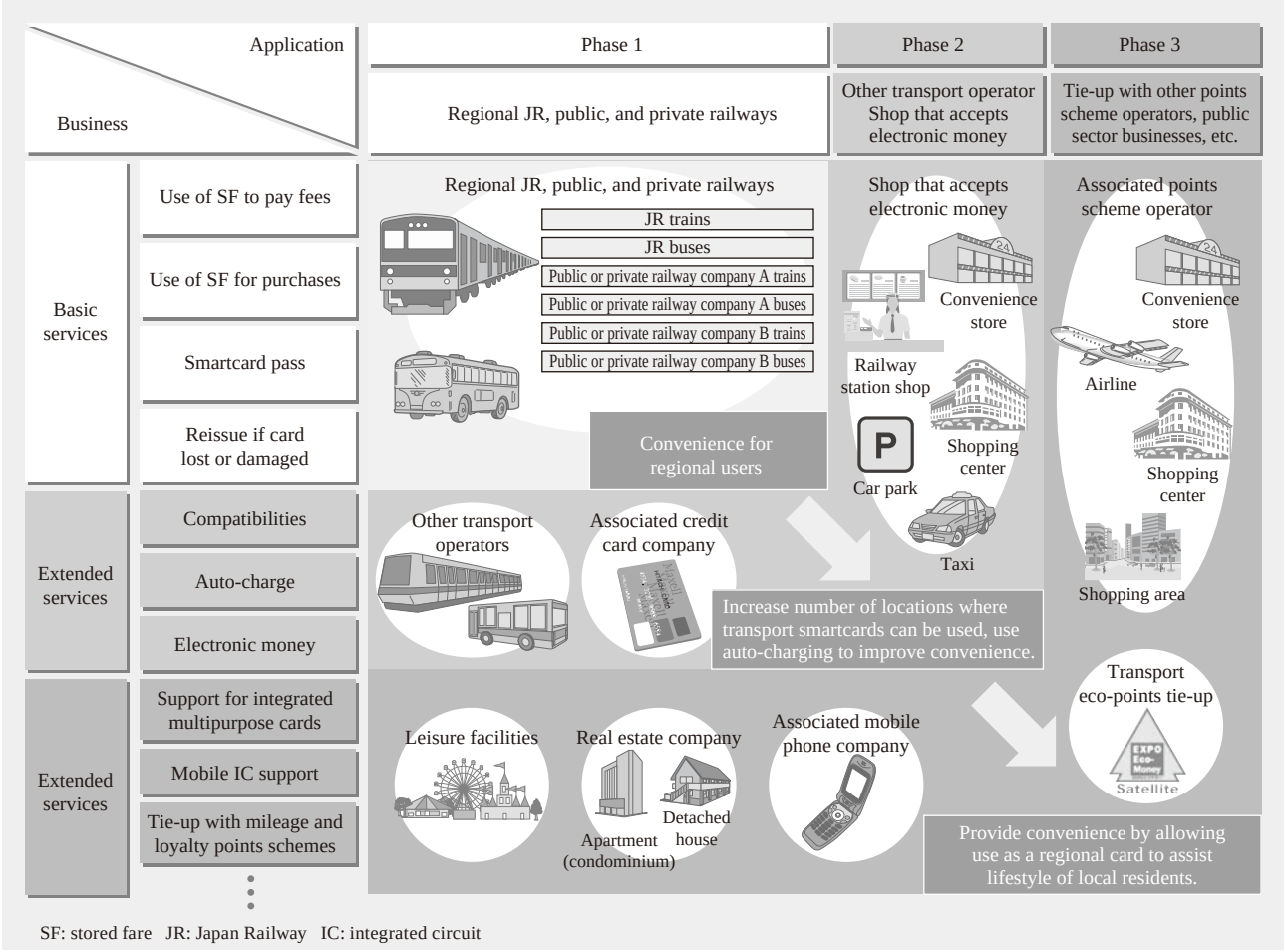

Fig. 1—Service Expansion for Smartcard Ticketing Systems.
The services that smartcard ticketing systems offer their users are expanding beyond public transport to encompass lifestyle infrastructure systems.

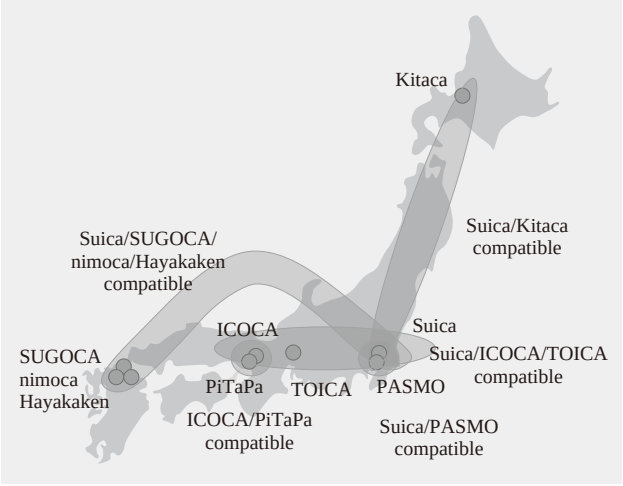

Fig. 2—Compatibilities of Smartcard Ticketing. Smartcard ticketing systems are becoming increasingly compatible with each other throughout Japan.

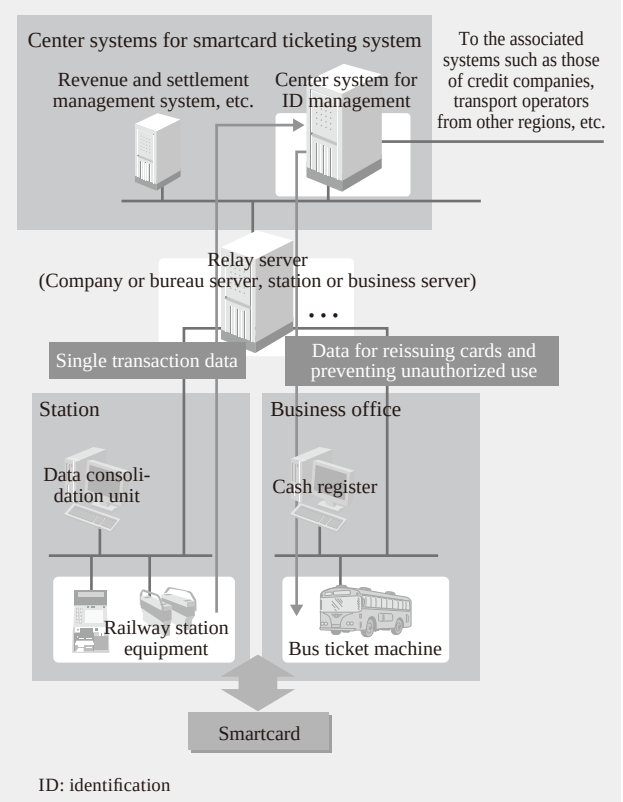

Fig. 3—Overview of Smartcard Ticketing System. Data on smartcard use (itemized transaction data) is sent from terminals to the center system and the accumulated data used for reissuing cards and preventing unauthorized use.

Schemes allowing co-recognition of cards across different regions and transport operators have also been introduced, starting with co-recognition of Suica and ICOCA[*2] (West Japan Railway Company) in 2004 which tied together East and West Japan and followed by ICOCA and PiTaPa[*3] (Surutto Kansai Association: a consortium including private railway, tram, subway, and bus operators from the Kansai region) in 2005; Suica and PASMO[*4] (PASMO Co., Ltd.: a railway and bus operator in the Tokyo region) in 2007; Suica, ICOCA, and TOICA[*5] (Central Japan Railway Company) in 2008; Suica and Kitaca[*6] (Hokkaido Railway Company) in 2009; and Suica, SUGOCA[*7] (Kyushu Railway Company), nimoca[*8] (Nishi-Nippon Railroad Co., Ltd.), and Hayakaken[*9] (Fukuoka City Transportation Bureau) in 2010 (see Fig. 2).

As this demonstrates, the smartcards provided by current smartcard ticketing systems can be used for much more than just certain forms of public transport and their use has been expanded to cover all aspects of people's way of life including compatible use in the different regional divisions of JR and other public and private railways as well as services that span different types of business. As a result, they have become a genuine form of lifestyle infrastructure and an integral part of people's daily lives.

OVERVIEW OF SMARTCARD TICKETING SYSTEMS

Smartcard ticketing systems consist of smartcards (transport passes), the terminals that access the cards (bus ticket machines, railway station terminals, etc.), relay servers that forward the data to its destination (company or bureau servers and station or business servers, etc.), and ID management systems that manage the smartcards.

Users top-up the smartcards with funds (SF) then hold them over a terminal device (bus ticket machine, railway station terminal, retail terminal, or similar) to deduct the appropriate amount from the balance of funds on the card to pay for the use of public transport, product purchase, or other service. The system works by having the terminal update the smartcard with the amount topped up or spent while also sending details of the transaction (single transaction data) to the ID management server. To handle functions such as reissuing lost cards and preventing unauthorized use, relay servers located in each railway station collect the data generated by each transaction at the ticket gates, card vending machines, and other railway station

*2 ICOCA is a registered trademark of the West Japan Railway Company.
*3 PiTaPa is a registered trademark of Surutto Kansai Association.
*4 PASMO is a registered trademark of PASMO Co., Ltd.
*5 TOICA is a registered trademark of the Central Japan Railway Company.
*6 Kitaca is a registered trademark of the Hokkaido Railway Company.
*7 SUGOCA is a registered trademark of the Kyushu Railway Company.
*8 nimoca is a registered trademark of Nishi-Nippon Railroad Co., Ltd.
*9 Hayakaken is a registered trademark of the Fukuoka City Transportation Bureau.

terminal devices, and the data from each station is in turn collected by the ID management system (see Fig. 3).

The ID management system uses the itemized transaction data and other information received in this way to maintain and administer the SF, card, and other data for each smartcard such as its balance of funds and usage history. In this way, it performs centralized management throughout the lifecycle of the card which includes issue, sale, use, and top-up (see Fig. 4).

EXPANDING RANGE OF USES FOR SMARTCARD TICKETING SYSTEMS AND THEIR FUTURE POTENTIAL

A compatibility network based on Suica was completed in March 2010 with the result that smartcard ticketing now allows users to travel on trains from Hokkaido to Kyushu using the same card. Around Japan, the range of areas where the cards can be used is continuing to expand along with the number of stations that support the cards thanks to measures such as the installation of equipment to allow unmanned railway stations. In the Tokyo region in particular, use of smartcard ticketing on trains has become more than 80%. User convenience is also being improved by a growing number of different pass types including express passes and green (1st class) passes.

The number of places where the cards can be used as electronic money is also increasing beyond just railway station shops to include other retailers, particularly convenience stores, discount stores, and vending machines. With the advent of comprehensive schemes that award loyalty points based on electronic money expenditure, further increases in card use look likely.

In recognition of the high level of security inherent in smartcards, there have also been an increasing number of examples in which smartcard passes have been used not as a payment method but as keys in applications such as office access control and home security locks.

In addition to using smartcards directly, cards can be incorporated into mobile phones to provide services that take advantage of the communication, display, and data entry functions of the mobile phone to deliver the types of functions provided by railway station terminals such as vending machines for tickets or passes (such as monthly or other time-limited passes and reserved-seat tickets).

It is also possible that records of journeys, purchases, and other transactions made using these smartcards will be used for marketing in the future.

This enlargement in the scope of applications for smartcard ticketing is expected to cause dramatic growth in the number of transactions and it is anticipated that the implementation of high-speed processing architectures will be needed to cope with the even larger data processing volumes.

CONCLUSIONS

This article has given an overview of smartcard ticketing systems and described the outlook and

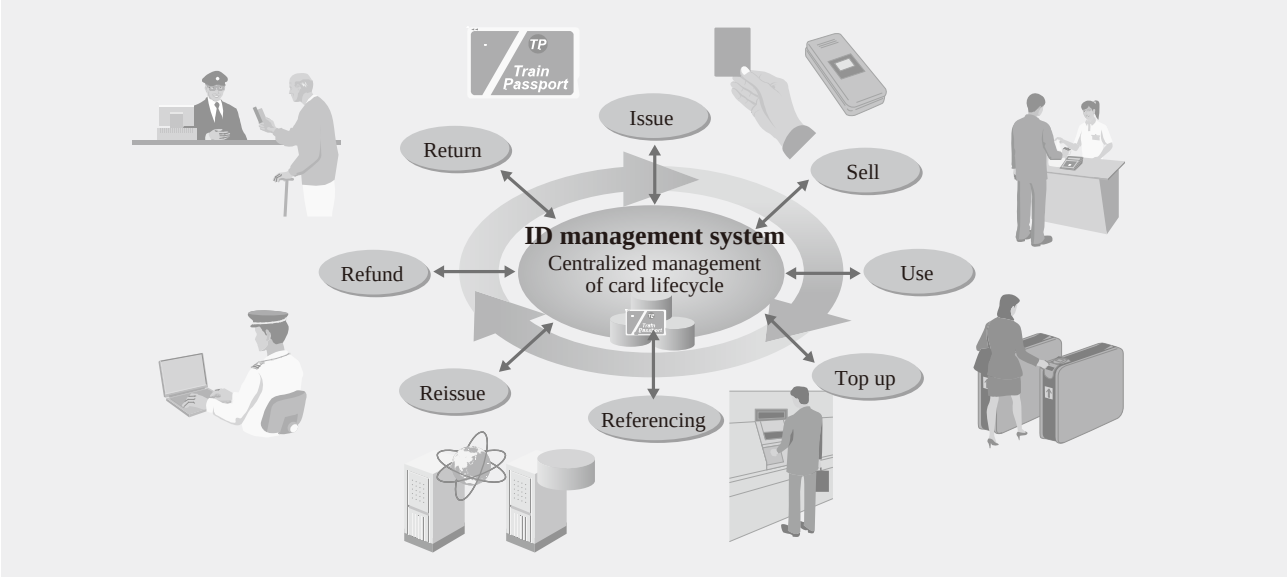

Fig. 4—Smartcard Lifecycle.
ID management systems perform centralized tracking of smartcards throughout their lifecycle from issuing to return.

potential of future smart systems that underpin society.

Use of smartcard ticketing has become part of the framework of our way of life in ways that extend from simple transport uses to retail and other applications and it is evolving into a service that offers even further potential by linking to usage and other data obtained from smartcard ticketing control.

By participating in the development and implementation of smartcard ticketing systems, Hitachi intends to continue contributing to the expansion of these services with the aim of creating new smart systems that underpin society.

REFERENCE

(1) A. Shiibashi, "Autonomous, Distributed, High-speed Processing Technology for Smartcard Ticketing Systems and its Application," Industrial Transactions of The Society of Instrument and Control Engineers **4**, No. 7, pp. 41–49 (2005) in Japanese.

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