The concept and a trial operation of multipurpose electronic ticket in Japan

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Abstract

The Ministry of Transport started a project for multipurpose electronic ticket using contactless smart card. “Contactless” and “common use” are the key concepts of this ticket. After the discussion on its concept, its specification was drawn up and a prototype system is now under development. We are going to put it in a trial operation on a subway line and some bus lines in business. In the final stage of this project, the standard of multipurpose electronic ticket for Japanese railways will be established.

1 Introduction

In 1971, Japanese railways began to install AFC. Owing to AFC, the railway operators could reduce the ticket related personnel, however, it brought commuter ticket passengers rather inconvenience. In recent years, many Japanese railways introduced stored value(SV) card. It makes us conveniently pay our fares at the gate. Actually, we only have to put a SV card directly into the slot of gate machine. We need not check for the fare to buy our tickets. Some railway operators approve each other the use of SV card issued by any of them.

At the end of 80’s, observing the innovation in LSI technology, people in railways were interested in the application of contactless smart card to railway ticket. During the past decade, East Japan
Railway Co. repeated the trial manufactures and field tests of it[1,2].
Looking at the cities overseas, we must pay attention to Hong Kong
and Seoul. People in Hong Kong purchased millions of contactless
smart cards to pay the fare of multiple mode transports and the
contactless smart card has already taken root in their daily life[3,4].
People in Seoul use contactless smart card to pay their bus fares. In
the West, contactless smart card is also used in public transport, the
amount of card holder is not as much as in the Far East though.
Electronic cash on smart card remains stagnant in Japan, however, we
believe that ticket oriented contactless smart card will get strong
support from railway customers.

In Japan, because the existing AFC is well-developed, the need
for replacing magnetic ticket with contactless smart card is not
conspicuous for the present. However, in addition to the convenience
of “contactless”, the operators are interested in its large capacity and
high security. In this paper, we describe its concept, its trial operation
and several issues towards its practical use.

2 A project for multipurpose electronic ticket

The magnetic ticket AFC in Japan has a history of over twenty five
years. It is ingeniously devised, so as to adapt to the heavy traffic at
the station barrier and the complicated fare system in Japanese
railways. However, it has several defects to be removed. The idea of
multipurpose electronic ticket aims at overcoming the defects and
realizing the advanced functions suitable to the information society in
the future.

2.1 Passenger’s inconvenience and operator’s discontents

It is quite inconvenient for passenger to take out commuter ticket and
put it in the gate machine whenever he or she passes the station
barrier. Even for an ordinary person, it is tiresome and causes the
barrier to be congested. It is undoubtedly still more difficult and
unpopular for the disabled and aged. When the passengers with
commuter ticket are to adjust the excess fare, they often wait in line in
front of the fare adjustment equipment.

The maintenance cost for gate machine is clearly the major
concern of operators. The mechanism of magnetic AFC gate machine
in Japan is quite delicate, so as to control the positioning for different
ticket size. Actually, it is sometimes disturbed by the worn-out part or
dust, leading to the maintenance owing to improper motion. In order to prevent the use of invalid ticket, we must install a gate machine at each barrier in every station. However, economically difficult is putting one in the station where the number of getting on and off passengers is quite small.

2.2 The research and development project of TRAMET card

The Ministry of Transport paid attention to the possibility of contactless smart card application to transport ticket in the future. In 1996, it started a research and development project on multipurpose electronic ticket. We gave a name to this ticket: TRAMET card (TRAnsport oriented Multipurpose Electronic Ticket). It should be used commonly in almost all transports in different modes and by different operators. It may also be combined with financial card. This project has been promoted under the close cooperation of three organizations: a concept study committee, a technological research association and the Council of Japan Railway Cybernetics. Among several targets of this project, “contactless” and “common use” are the most essential and noticeable themes. By the end of 1999, the basic specification of TRAMET card will be settled by the discussion of railway operators in the Council.

3 The concept of TRAMET card

It is a matter of course that TRAMET card AFC has superior property, performance and function to magnetic ticket AFC. Customers, operators and government officers were represented the committee and studied the concept of TRAMET card. An image of TRAMET card usage is shown in Figure 1.

3.1 The property and performance of TRAMET card

Contactless smart card communicates with the gate machine by radio. The maximum communication distance is very important factor for railway ticket application. The property and performance TRAMET card aims for are as follows.

a. Considering the discussion about international standardization, a short wave of radio frequency 13.56 MHz is used.

b. The maximum communication distance is not longer than 20 cm in order to prohibit the cross talk with the adjacent gate machine.
c. It should be rechargeable.
d. It should be proof against the external attack as forgery and alteration.
e. It should have higher reliability than magnetic ticket.
f. It should be processed more quickly than magnetic ticket in order to cope with the traffic through station barrier.
g. Commuter ticket data can be rewritten on its face when a new one is issued.
h. It should be competitive against magnetic ticket through the life cycle in AFC.

Figure 1: An Image of TRAMET card usage

3.2 The basic function of TRAMET card in AFC

TRAME card has rooms for both commuter ticket and SV card. It is repeatedly used as a transport ticket during its life.
a. It can work as both commuter ticket and SV card.
b. Commuter ticket in the card can be renewed repeatedly.
c. Stored value in the card can be recharged by cash or bank card.
d. The lack of fare in commuter ticket usage can be automatically adjusted by using SV at the gate machine.
e. The card holder can confirm the remaining SV on appropriate displays.
f. The content of the card may be preserved by AFC to support the fault or damage of the card.

g. The invalid use of lost or stolen card should be prevented, so as to make it possible to reissue a new one for original card holder.

h. Railway operators can mutually clear the SV which they accept at the gate machine.

4 The trial operation of TRAMET card

The research association is going to carry out a trial operation of TRAMET card in cooperation with Tokyo Metropolitan Government. In this operation, the participants selected from ordinary passengers will carry a TRAMET card to use it in the same way as in practical use. We would like to evaluate the property and performance of TRAMET card and the system function of TRAMET card AFC.

4.1 The objectives of the trial operation

The research association develops a prototype of TRAMET card AFC by materializing the concept described above. In addition to TRAMET card and reader/writer, ticket related new equipment is developed and the existing AFC is converted. We expect to receive good appraisal from the participants. The major objectives of the trial operation are as follows.

a. Verifying the easiness to use it and the related equipment in real environment.

b. Finding problems related to it in the prototype system.

c. Trying commuter ticket fare adjustment at the gate.

d. Trying its identification control.

e. Trying card reissue if lost or stolen.

f. Obtaining know-how to incorporate it into the existing AFC.

4.2 Configuration of the prototype system

Because the test field is in business, the TRAMET card AFC should go together with the existing AFC. Two gate machines of each station and the fare box on each bus are converted to accept TRAMET card. In this operation, considering several constraints in the business system, we gave up direct issue of commuter ticket in the card and the recharge of SV by cash. In stead, participants are requested to
purchase magnetic commuter ticket and magnetic SV card first. Then, their content is transferred to TRAMET card by card processor or value transfer machine. When the transfer finishes, the magnetic information in the original commuter ticket and stored value card is invalidated. However, this invalid commuter ticket is helpful because we can use it as a substitute of TRAMET card face printing.

TRAMET center is responsible for the control of the whole prototype system. Especially, the information about each TRAMET card, e.g. the remaining SV and validity, is maintained in the database. A black list of invalid card is prepared in TRAMET center, then it is sent to all the related equipment in the prototype system. There is online connections between TRAEMT center and all the individual equipment in the subway stations. On the other hand, the connection between TRAEMT center and all the buses is not online. A handy type of LSI chip card is used for the information exchange between TRAMET center and the buses. We are going to expand the prototype system to include cashless charge by using bank card and the small payment at the vending machine in the station. Configuration of the prototype system is shown in Fig.2.

![Figure 2: Configuration of the prototype system](image-url)

### 4.3 Design specification of the prototype system

Except for 3.1b,3.1e,3.1h, most of the properties and performance described in 3.1 can be materialized in the TRAMET trial card. The
concept of 3.1b required 20cm communication distance, however, we decided to realize 10cm, considering our technical confidence at present. Concerning 3.1e, the prototype card may have been designed to have higher reliability than magnetic ticket. However, we would rather obtain the actual data about the fault and damage of TRAMET card. From our experience of AFC to date, we set the time to 200ms for 3.1f. As we mentioned above, we do not realize to print on the face of TRAMET card. On behalf of rewriting, we use the magnetic commuter ticket itself as a substitution for face printing. Therefore, 3.1g is realized in another way. After the specification of TRAMET card has fully settled, the concept of 3.1h will be discussed and materialized among railway operators.

Concerning the function of TRAMET card in AFC, the concept of 3.2 is materialized in the prototype system, except for 3.2h. Because this trial operation has one operator participated, the function related to common use is not completely realized. 3.2a, 3.2b, 3.2c and 3.2d are the basic functions of the prototype system. In the trial operation, participants can get the content of their TRAMET cards using the functions 3.2e and 3.2f. Whenever the trial card is used on the related equipment, the particular data related to the usage will be sent to TRAMET center as is shown in Fig. 3. On the contrary, when an invalid card is reported to the operator, a black list of invalid cards will be sent in the reverse direction. The information exchange between TRAMET center and each related equipment is carried out once or twice a day, therefore, it takes a few days until the functions 3.2f and 3.2g work satisfactorily.

![Data exchange between TRAMET center and related equipment](image)

**Figure 3:** Data exchange between TRAMET center and related equipment
4.4 The scale of the trial operation

The test field of the trial operation is a subway line and five bus lines in Tokyo. About 2,000 passengers will participate the operation. They use TRAMET card in daily life to take the subway and buses. TRAMET card gate machine is installed in all the twelve stations of the subway and so is TRAMET card fare box in all the eighty three buses. The test period is scheduled from June 1998 to May 1999.

5 Issues towards practical use

TRAMET card will solve the magnetic ticket AFC problems mentioned above and it will bring benefit to both passengers and operators. However, in the near future, the implementation of TRAMET card does not necessarily imply the abolition of magnetic ticket. Both of them should go together. Railway operators may regard it as a double investment to AFC. Therefore, They should study the whole AFC from all angles, so as to justify the investment in TRAMET card. We are discussing several issues in the project.

5.1 Transport card in common

From passenger’s point of view, it seems ideal to use one TRAMET card in all the transports in one area. However, if they are competitive in market, the situation may be different. For example, the establishment of a clearing house or an organization to issue TRAMET card in common must contribute cost and price reduction. It can be beneficial to them, however, some operators may have a strategy for issuing their own TRAMET card. They would rather provide their original service for their customers, because most of them are private enterprise and have a business-oriented culture.

- How many memory areas should be in common?

At present, some magnetic card has a premium in Japan. For example, the common bus card in Tokyo has a 10% to 17% premium. The SV with a premium should have different memory area from SV without a premium. And, premium must change according to the business strategy of each operators. Consequently, some part of the memory will be used in common and the rest should be left to railway operators hand. They could utilize it freely for their applications on their own business.
Who has the right to use the deposit?
The cash corresponding to the SV in TRAMET card is a deposit. Railway operators are interested in the deposit, because it is the money at zero interest. They can determine the right to use it in either of the following ways. The first way is to give the right to the operator who issued the recharged TRAMET card. As a result, operators will be eager to issue their original TRAMET card. The second way is to give the right to the operator who installed the equipment which gets the deposit. If, at the time to recharge, some values remains in the card, this operator has the right to use them all in exchange for approving the equivalent debt to the last operator.

How does the operator exchange the value for money?
For each transport operator, the value accepted at the gate machine in the station or the fare box on the bus is credit and the value remaining in the card is debt. Operators participating in the common use system need to clear regularly the debt and credit among them. Some operators would like to clear the debt in traditional face to face way rather than through a clearing a house. After evaluating the cost for each clearing method, they will discuss this issue and select the best for them.

5.2 Backyard system for TRAMET card

The forgery or alteration, fault or damage and lost or stolen are the security related problems in TRAMET card. One of the important role of a backyard system is to support how to resolve these problems. Comparing with magnetic card, the latest security related technology can make TRAMET card very strong in forgery and alteration. And, in principle, passengers themselves should be responsible for their lost and stolen TRAMET card.

On the contrary, transport operators or card issue organizations should be responsible for the fault and damage of their card. They will be required to secure the stored value remaining in it. Because the remaining value in the magnetic card is always printed out on the card face, the fault or damage card can secure the value by itself. Unfortunately, TRAMET card can not secure the stored value without the backup data preserved in the backyard system. How to resolve this problem depends on the reliability of TRAMET card. If the reliability is sufficiently high, it would be reasonable to estimate the remaining value from the card holder's declaration. However, if it is low, the remaining value should be preserved in the backyard system.
It is an important customer service to prevent invalid use of lost or stolen card and reissue a new one. If we can work on this subject in cooperation with customer, a large scale backyard system may be unnecessary. For example, customer could control the expiration of TRAMET card for himself or herself. In that case, the backyard system will be released from preventing improper use.

6 Concluding remarks

Although TRAMET card is transport oriented, it can be used in areas other than transportation. The connection with bank card or credit card is an important subject to study. We can imagine two ways of TRAMET card usage. Firstly, big railway business will take the initiative in TRAMET card usage. In this case, the memory of TRAMET card is divided into three: commuter ticket, stored value in common and the original application of each railway. In a large city like Tokyo, the practical use of TRAMET card will, we believe, go in this direction. In the second way, local government may issue TRAMET card for its residents. In this case, most of the memory will be allocated to the information about administrative service. However, we may secure memory for stored value, which will be used in small payment to public facilities. If transport operators agree to accept the fare from this stored value, they will reduce the fare related work with small investment.

References

Section 11:

Multi Train Simulators