Multifunctional City Smart Card
based on M/Chip Advance Technology

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Abstract: In recent years the usage of smart card technologies has increased considerably which triggers new business and technical opportunities especially in transportation and payment service fields. There are several smart card solutions for transportation services of cities with different technical infrastructures and business models which restricts citizens to use the card only in that city. In order to create a unique system, we present a leading smart card study to be used in all cities that provides transportation and loyalty services based on the M/Chip Advance standards. The proposed city smart card provides a unique solution for transportation services of large cities over the world, aiming to answer all transportation needs of citizens. Also, city card can additionally be used by third party companies such as gasoline companies and supermarkets for promoting loyalty services. In this paper, advantages and generic usage models of the multifunctional city smart card are briefly described and illustrated. The system requirements, usage of data slots on cards, and personalization issues are also discussed.

Keywords: Smart Card; M/Chip Advance Standard; City Transportation; Loyalty; Generic Usage Model

1 Introduction

Today smart cards are utilized in a wide range of service domains including finance, health, government, and transportation. Appropriate standardization on interoperability and security of smart cards has an important impact in this development. The use of smart cards as an alternative mean for public transportation services has become a viable option for many countries.

Up to now, several smart card solutions have been proposed and implemented in public transportation with different technical requirements and business models. One of the most popular implementation is the Oyster smart card by Transport for London [1, 2] which is a contactless smart card and can be used on buses, trams, tubes, London Overground, riverboats, and national rail within London. Similar to Oyster Card, some other cities also performed their own public transportation solution such as Nottinghamshire Card [3], YOR-Card [4] for West Yorkshire Region, Istanbulkart [5] for Istanbul, and so on. Also it is possible to see different smart card systems and models in one city.

However, it is seen that payment cards of banks are not efficiently used in supporting transportation services due to some technical and business challenges (e.g., requirement of a citizen who uses that public transportation smart card as a customer of a bank to deposit his/her card, or credit card verification and authorization problems in offline transactions, applying discount problems).

One of the reasons behind this is that the existing standards provided by EMV (Europay/Mastercard/Visa) are mainly focusing on payment and financial standards. They do not support the transportation, loyalty or other type of services on the same smart card.

In this paper, we present a multifunctional city smart card model and its implementation. The proposed city smart card's most challenging feature is that it is based on a new emerging technology; M/Chip Advance introduced by MasterCard. M/Chip Advance standard aims to improve existing transportation and loyalty services significantly by adding payment services on the same smart card. The presented city smart card model is one of the leading implementations that takes advantage of the M/Chip Advance standards and creates a multi-application debit card by integrating transportation and loyalty services to the payment services.

According to the city smart card, users obtain their personalized city smart cards easily from card issuers (i.e., transportation authority, authorized vendors and other distribution channels), and can simply deposit their debit cards using authorized POS and kiosk machines or other appropriate loading systems. Hence, the debit card with enough deposit is ready to be used in transportation, loyalty as well as contact and contactless payment services. The card securely stores transportation information such as latest balance data, vehicle usage information, subscriptions, and discount information, as well as loyalty/membership data of the citizen on relevant slots

on M/Chip Advance compatible smart cards. Major features of the city smart card are listed below:

- Compatibility with global specifications so that it can be used all over the world,
- Consisting of data slots for loyalty services, not only for public transportation and debit card services,
- Balance record and other valuable data can be stored on it,
- Have contact and contactless interfaces to support all type transactions,
- High speed and high security,
- Can be personalized easily by the card issuer.

2 System Requirements

To enable the city smart card model, the requirements for the system need to be carried out. These are briefly described hereunder:

- *Preparation of Personalization Data:* The personalization data is redesigned and prepared for the M/Chip Advance compatible smart cards since M/Chip Advance is a new standard that requires new data elements and production of new keys and certificates.
- *Creating Advanced Algorithms for Reading and Writing on Data Slots*: Since EMV standards are mainly focused on payment operations, these standards become insufficient for carrying large amount of data on the smart card chip for supporting services like transportation and loyalty. M/Chip Advance technology enables carrying large data (i.e., 160 bytes for data storage fields) on the smart card chip. With advanced and optimized algorithms, the data can be read from/written on these data slots of the smart card which are created during personalization of the card phase.
- *Creating and Activating Data Slots:* All of the smart card's all slots are created during the card's personalization process and each slot is protected by a key. The issuer of the city smart card which is generally the transportation authority in the city reserves one or more slots on the card for its own usage. The transportation authority tracks all the transactions on its own validators that are performed by the users. All transaction and balance information is stored the chip of the card.

- *Assigning Data Slots*: Remaining data slots of the smart card can be assigned to other companies such as gasoline companies or supermarkets for promoting loyalty/membership services. The card issuer can make business agreements with other companies and providing the data slot(s) key to the company. Hence companies do not need to produce and create loyalty smart cards by themselves. The loyalty information is also stored on the card and the company updates the information on the corresponding slot through proprietary terminal software.
- *Preparation of M/Chip Advance Compatible Validators:* The transportation authority also needs to develop proprietary software and terminals for enabling the transportation service. These validators need to read/write and update information on the city smart cards.

3 Multifunctional City Smart Card

In this section, we explain the usage of the city smart card.

- *Distributing City Smart Card:* There are several options for obtaining the M/Chip Advance compatible smart cards. The users can obtain their own personalized city smart cards directly from transportation authority in that city, authorized vendors or other distribution channels.
- *Depositing City Smart Card:* There are also many alternatives for depositing M/Chip Advance based debit cards. Users can deposit their smart cards by cash or with their other payment cards through proprietary software POS machines which are located in certain places of the city such as transportation authority's ticket offices and kiosk machines. Users can also deposit their card using remote loading techniques such as money order from banks, EFT, the virtual POS and automatic payment orders. Another way is to perform online depositing transactions from ATM or contact/contactless POS machines of banks. Since the balance is stored on the

chip, the balance information needs to be transferred to the issuing system in online ATM and POS transactions. In this case, verification of the balance information and some cryptology operations and advanced systems is built on the back end of the card system (Figure 1).
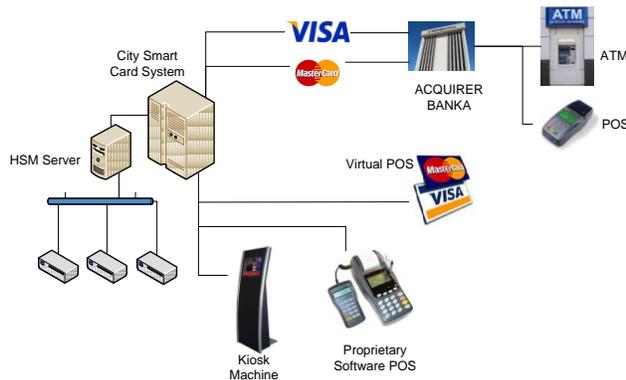

Figure 1.Depositing City Smart Card

- *Using City Smart Card*: The smart card which has enough deposit amount can be used for public transportation and debit payment services. If it includes loyalty services on other slots, it can be used for the loyalty and membership services of the companies as well.

4 Generic Usage Models

Generic usage models help us to understand the characteristics that the system performs mandatorily along with the usage principle of the technology [5]. In this section, we have described and illustrated generic usage model of the city smart card system.

Step 1: Since transportation authority is the card issuer, user buys a personalized city smart card from the transportation authority (Figure 2) .

Step 2: She deposits her smart card from an authorized POS machine of a vendor and enters the amount.

Step 3: POS system starts the transaction process and sends online operation message to the card system on the backend.
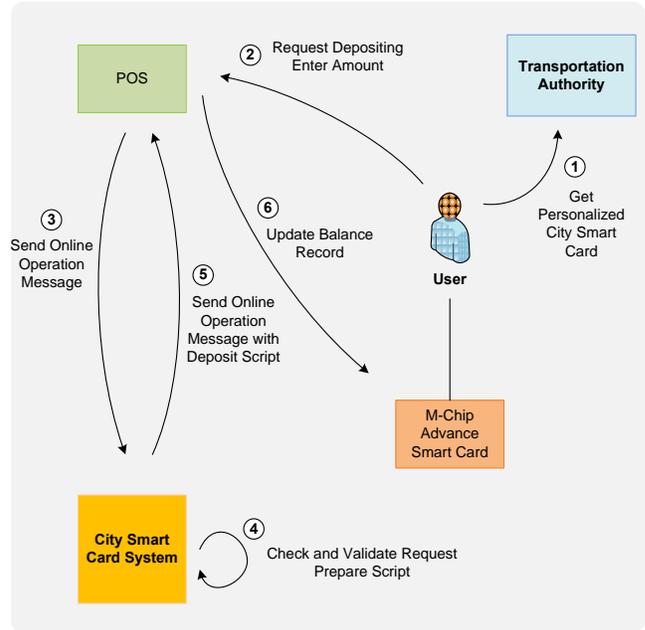

Figure 2. Generic Usage Model for Transportation Service-1

Step 4: The card system checks and validates the request, then prepares script for POS system.

Step 5: The card system sends the online operation message with deposit script to the POS system.

Step 6: The POS updates the M/Chip Advance smart card's balance information according to the online operation message.

Step 7: After completion of the depositing process, the user is ready to use her smart card on the M/Chip Advance compatible validators' of the transportation authority (Figure 3).

Step 8: The validator reads the latest transaction and balance information on the smart card.

Step 9: Then it prepares the transaction amount which will be deducted from the smart card.

Step 10: The validator updates the balance information and transaction information on the data slot of smart card.
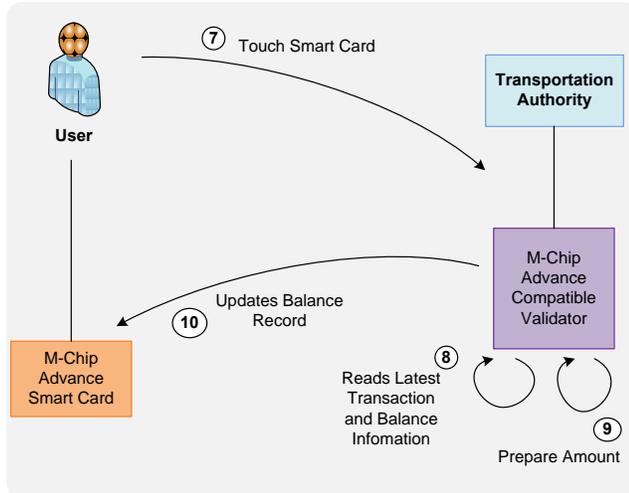
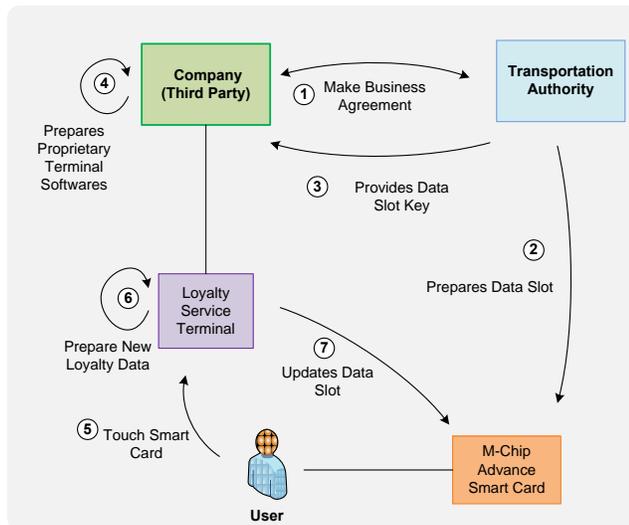**Figure 3. Generic Usage Model for Transportation Service-2**

Figure 4. Generic Usage Model for Loyalty Services

Also, third parties or companies can provide valuable services to the users by taking advantage of the city smart card in following ways (Figure 4):

Step 1: The company who wants to provide a loyalty service on city smart card first needs to make a business agreement with the card issuer who is generally transportation authority of that city.

Step 2: The card issuer prepares the data slot with that company's information.

Step 3: Then the card issuer provides the data slot key to the company. Hence the company has an ultimate responsibility on the relevant data slot of the city smart card.

Step 4: At the same time, the company needs to prepare proprietary terminal softwares for its loyalty service.

Step 5: The user of the city smart card can use that company's loyalty service by touching her smart card to the loyalty service terminal.

Step 6: The loyalty service terminal reads the latest loyalty data (e.g., free miles, coupons, points) on the data slot, and prepares the new loyalty data for the data slot.

Step 7: Then, the terminal updates the relevant data slot.

5 Conclusion

City smart card is one of the first transportation smart card implementations over the world which uses the new emerging standard; M/Chip Advance technology. M/Chip Advance enables to use transportation and loyalty services on the same smart card concurrently and also enable to use all MasterCard based payment cards in transportation and loyalty transactions. Moreover the city smart card is not restricted to a region, a city or even a country on the contrary to the existing business solutions. Since the city smart card is based on global standards (i.e., EMV and M/Chip Advance), it can be used on all POS and ATM systems over the world which provides a global and unique business solution. Another important improvement is that the card provides large data storage slots on its chip. The number of the data slots depends on the capacity of the chip. After personalization, the card issuer can distribute these data slots later to third parties for loyalty services which pave the way for new business opportunities.

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