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Design and Implementation of In-house Mobile Electronic Cash in Universities

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Abstract

The proliferation of information technology (IT) and of the Internet has become the main resource enabling the advance of electronic commerce. Futurologists predict that the future society will be a cashless society, one without the circulation of physical cash. In particular, IT utilization in the finance and industrial sectors and the proliferation of e-commerce have accelerated the emergence of electronic cash. The use of electronic cash in the SNSs (Social Network Services) has become greatly appealing to the younger generation. In Korea, the variety of implementations of electronic cash has been increasing steadily since 2000. For example, the T-Money transport card, which is prepaid or postpaid electronic cash, is a popular transport card widely used throughout Korea, and its use will be expanded as it becomes integrated T-Money starting in 2016. The postpaid T-Money transport card has developed into a mobile payment system in recent years and has become increasingly popular in Korea. In this paper, the design and implementation of an in-house mobile payment system of electronic cash is presented. The mobile electronic cash for in-house use is an electronic cash system that is exclusively used within a single organization; the system was implemented by using mobile payment as the payment method.

Keywords*: NFC, Mobile Electronic Cash, In-house, e-Cash, Mobile e-money*

1. Introduction

With the rapid advances in IT, modern society requires means of electronic payment. Experts expect that the future society would become a so-called cashless society where cash is not required. In particular, IT utilization and e-commerce vitalization in the financial/industrial sector demand transparency and reliability in the use of money, and the expansion of mobile devices needs simplification for this purpose. This trend has accelerated the emergence of electronic cash, and already, electronic cash for Social Network Services support is being well-received among the young generations. In Korea, electronic cash has shown a steady increase in a variety of applications since 2000. The domestic usage of electronic cash includes tolls, convenience stores, department stores, subways, and parking lots. In addition, prepaid transportation card T-Money and postpaid card embedded in credit card integrated circuit (IC) chips are widely used. The stability of electronic cash, developed and used with digital data, has become more emphasized. As such, the fact that electronic cash is used as a payment method in a virtual area through a network continues to increase the importance and necessity of forming a new business paradigm [1-3].

In this study, an in-house mobile electronic cash that can be utilized via mobile devices is proposed. The electronic cash transacted using the mobile payment system suggested by this study is the in-house type and is to be used around university campuses. The use of in-house electronic cash has so far mostly consisted of card-type electronic cash. The users of the in-house mobile electronic cash proposed in this study can use the electronic

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cash via personal smartphones. The in-house mobile electronic cash is an electronic cash system that is exclusively used in a single organization, and it enables activities such as recharging, bill payment, account balancing, and refunding within the organization. Furthermore, payments can be performed via near field communication (NFC) installed in a smartphone, and cash recharges can be done by selecting the mobile option during smart card recharging. Moreover, since in-house mobile electronic cash is operated within a single organization, it can be expected to be developed into a new business model in the electronic cash market as well as making a profit through fee-based income in the electronic cash. This study was conducted on a university campus. At universities, a variety of shops can be found, including coffee shops, stationery shops, school cafeterias, and university school buses; thus, a university campus is a good setting in which to apply the proposed model.

2. Related Work

2.1. Electronic Cash

2.1.1. Overview of electronic Cash: In general, electronic cash is used on the concept of parameters of "performing the function of money using an electronic device" [4]. Further, it is defined as "value information expressed by digital signal signed by the bank to guarantee its face value" [5]. Electronic cash is defined as "money where a certain monetary value is stored as an electronic signal on an IC chip embedded in a plastic card or a computer communication network, and it can be used in information communication network" [6, 7].

2.1.2. Type of Electronic Cash: Electronic cash used in Korea can be classified into IC chips, networks, online and offline, open and, close, advanced payment, and credit cards [4, 6]. Electronic cash with a smartcard IC chip is mostly used in the financial sector. Recently, the spotlight has been focused particularly on T-Money, which is used in the credit card/prepaid card form in connection to PAYCO, a mobile electronic cash. T-Money, which is used in the form of a prepaid card, is associated with credit cards and is already universally used.

2.1.3. Advantage of Electronic Cash: Electronic cash that provides monetary value with electronic symbols reduces social cost and is portable and comfortable [2]. The following are the advantages of the electronic cash. First, it minimizes the need to possess paper notes. Second, it saves various fees incurred from financial transactions, and the transaction fee can be reduced through direct transaction with the seller. Further, the simplification of the possession of money reduces the risk of theft or loss [8].

2.1.4. Domestic of Electronic Cash Usage: Led by Moneta, Bankon, and K-Merrce domestic mobile carriers in the 2000s, K-cash, MYbi, Visacash, and similar forms, which are jointly issued by banks, have been in use since 2008. Among such forms, the MYbi transportation card that originated from Busan is one of the biggest success cases. However, MYbi did not grow much larger because of compatibility issues, and it is currently widely in use in connection with the financial sector that centers on T-Money. In 2016, T-Money will become compatible in entire Korea and be nationally used. In addition, domestic mobile electronic cash is being changed for availability in simple payment service and expanding the business areas. Currently, the simple payment services in Korea include Kakaopay, UBpay, PayPin, SmilePay, PayNow, KPAY, Yelopay, Mobile T-Money, ApplePay, PAYCO, Samsung Pay, and so on. The PAYCO mobile simple payment, released in May this year, is now growing with a gradual increase in the market share [9].

2.1.5. Current Status of Mobile Terminal Payment Services: A mobile terminal payment service is a service by which financial services such as credit cards and T-money can be used with mobile phone terminals. A number of credit cards can also be integrated into a single universal subscriber identity module (USIM) chip in a mobile phone. The convenience of the mobile terminal payment service frees the user from additionally holding cash or credit cards. The outlook for the mobile market in Korea shows that mobile terminal payments totaled USD 145 billion in 2015. It is also noted that NFC-supported terminal sales have increased steadily and in 2015 represented 47% of all mobile phone sales. From the Gartner research in Table 2, it is evident that the volume of NFC transaction has increased 11.3 times, from 316 million in 2010 3570 million in 2014. Japan is one of the most advanced countries with regard to services and technological infrastructures relating to the mobile payment sector, whereas the US has shown slow growth rates in the mobile market generally. This is because the US has less need for mobile payment than Japan because of differences in the means of public transportation [10]. According to the study performed by Nomura Research Institute in Japan, the penetration rate of electronic cash in metropolitan areas has almost reached 80% and its usage continues to increase despite the economic downturn in Japan [11].

Table 1. NFC Device Sell Variation

	2011	2012	2013	2014	2015
Device Sales	1,425	1,513	1,588	1,663	1,738
NFC Device	128	318	460	632	817
Ratio(%)	9	21	29	38	47

<source: Visiongain, NFC 2010-2015, 2010.> unit: million

Table 2. Mobile Trading Volume in Accordance with the Payment Method

	2010	2011	2012	2013	2014
SMS	1,209	1,998	3,226	4,967	7,324
WAP/Web	43	90	191	366	607
USSD	67	106	167	266	440
NFC	316	679	1,270	2,201	3,570
Total	1,634	2,873	4,854	7,799	11,942

<source: Gartner, The Outlook on Mobile Payment, 2010.> unit: USD mn

2.2. Application Technologies in Electronic Cash

2.2.1. Definition of NFC(Neat Field Communication): NFC is an abbreviation for "near field communication," which uses 10-cm short-range communication at the 13.56-MHz frequency band. It is a non-contact short-range wireless communication technology in which data communication is done in a fast communication setup within 0.1 s [12]. NFC is a short-distance wireless communication standard formed in 2004, which centers on Sony and Nokia. The non-contact protocol for NFC is the international standard ISO/IEC 14443A, 14443B, and FELIC for RF ID and RF IC cards [13, 14]. NFC has been implemente in many areas; typical examples include subways, access checkpoints, worker time-and-attendance management, credit cards, cinemas, and ticketing [15].

2.2.2. NFC Operation and Storage Location: NFC operations are divided into the following three modes: card emulation mode, read/write mode, and P2P mode. Card emulation mode functions in the same manner as RFID-based smart cards, in which data can be exchanged with an external reader. Passive mode is the basic NFC communication mode of card emulation; it is free from power consumption issues and can operate

regardless of the terminal status. Read/Write mode refers to communication between two NFC devices in which surrounding RF-IC (Radio Frequency Integrated Circuit) cards are searched continuously during operation in an active mode; to operate in this mode, a source of power is mandatory. P2P mode is a mode in which a mobile device mounts NFC and recognizes NFC tag information [16]. The P2P mode is a unique function of the NFC, which operates in an active format. NFC operates a storage location in a Secure Element (SE) to safely store the financial information of an individual. The SE used in the NFC includes USIM, Micro SD, and Embedded SE [13].

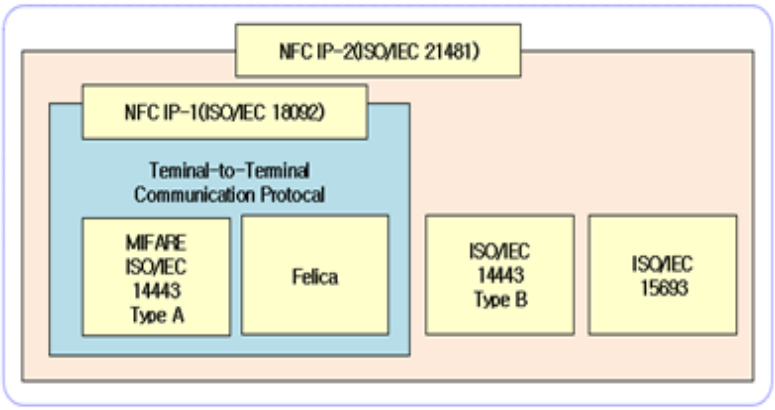

Figure 1. NFC Standard

2.2.3. NFC Communication: NFC communication can be divided into active mode and passive mode. In active mode, the initiator and target create their own RF fields to communicate. To enable this, power must be provided, which is used for bidirectional communication between NFC devices. That is, communication between reader and tag is done by using RF fields created via their own power. In passive mode, the initiator creates RF fields, and the target responds to the initiator's command to communicate. That is, a magnetic field of RF fields generated by an external device is used by an antenna, and the power created thereby is employed to respond to the command of the corresponding equipment to communicate. Accordingly, it can run without power, which is advantageous [17].

2.2.4. NDEF(NFC Data Exchange Format): NDEF (NFC Data Exchange Format) is a standardized data format defined for NFC data exchange by the NFC Forum. NDEF is used when the NFC device fetches data from NFC tags or data are transmitted via P2P between NFC devices. An NDEF message unit is called an "NDEF message"; one NDEF message consists of multiple NDEF records. One NDEF record stores a single piece of data, which is called a "payload." That is, an NDEF record is needed to store data in the payload [18].

2.2.5. NFC Applications: The smartphone is the tool used most frequently in our daily lives that incorporates NFC. Because of the rapid proliferation of smartphones in recent years, NFC-related information services have also been provided in many areas, including the sectors of education, society, and the economy. In educational institutions, NFC-related information services are employed for student time-and-attendance management and for authentication of building access, and a few examples of its use in society can be found in subways, access checking, workplace attendance and punctuality management, credit cards, cinemas, and ticketing. In particular, most Koreans use an NFC-utilizing mobile payment system in their transport card. The following three application areas are those in which NFC is most widely used. The first is data exchange between devices. Data

processing can be done via simple contact between NFC-supported devices; examples are data exchange between smartphones, file sharing between a personal computer and a smartphone, and communication between electronic appliances and a smartphone. The second is service connections. New service connections can be made simply by directly connecting to a related website once the relevant information is obtained by reading an RFID-tagged smart poster. Finally, the third is electronic payment and ticketing. This is the area in which NFC is applied most heavily in Korea; it allows mobile payment by combining non-contact NFC smart card technology and security technology. In addition to the above application areas, NFC has also been applied to various payment means such as transport cards and discount vouchers [19, 20].

Table 3. NDEF Device Record Configuration

Item	Length	Contents
Record header	1byte	Record basic information
Type length	1byte	Data Type Length
Payload length	1byte or 4byte	Payload Length
ID length	1byte	ID Length
Type	Type length: byte	A payload type in the record contains
ID	ID length: byte	Payload ID
Payload	Payload length: byte	The payload which contains the record

Table 4. NDEF 1Byte Record Header

Item	Length	Contents
MB(Message Begin)	1Bit	NDEF message, the first record: 1
ME(Message End)	1Bit	NDEF message, the last record: 1
CF(Chunk Flag)	1Bit	Use for transmission into one of a payload of A number of records
SR(Short Record)	1Bit	Bit is 1, the payload size of the size of 1 byte 0, 4byte
IL(ID Length)	1Bit	If the rwcord ID exist: 1
TNF(Type Name Format)	1Bit	

3. Design and Implementation of In-House Mobile Electronic Cash in Universities

3.1. Overview of the Proposed System

This paper proposes an in-house mobile electronic cash system that is operated on a university campus using the NFC mode. The main functions of the NFC mode in-house mobile electronic cash service are divided into recharging, bill payment, and account balancing. Electronic cash offers the characteristics of physical money as it is used in the same manner. Therefore, electronic cash must be highly difficult to forge. The NFC mode in-house mobile electronic cash proposed in this study is circulated only within a single organization. We employed a university campus to apply the in-house electronic cash. Since a university has a variety of shops and other small businesses including school cafeterias, bookstores, and campus school buses, it is a good setting for applying the in-house electronic cash system.

3.2. Disadvantages of Existing In-House Electronic Cash in a University

Our model deployed at the university is for an existing smart card electronic cash system. A smart card electronic cash system requires smart cards issued by banks. To enable electronic payments at the university, a card authentication process is required during the initial card-issuing process. In addition, when errors occur while using the smart card, the card must be re-issued, and the card must always be held for use, which is inconvenient. In other words, without the smart card, the use of all convenience facilities inside the university will be restricted. In this study, the proposed system was designed to enable independent electronic payments within the university campus via data exchange between devices using the popular NFC technology.

3.3. Design of the In-House Electronic Cash Using Mobile Devices inside the University

This paper has been implemented using the NFC-based technology Card Emulation Mode. USIM (Universal Subscriber Identity Module) in the NFC device is a built-in IC chip to the NFC tag function performs non-contact NFC function. The following Figure 2 shows the flow of electronic cash services for in-house by the university Mobile payment proposed in this study. Electronic cash services within the University of flow in Figure 2 is as follows. ① The user is issued a smart card complete with the authentication of user identity for use in mobile payment. Card registration is complete when card validation is authenticated through electronic cash information verification. ② The issued smart card can be recharged using a charger. ③ At this time, the user transacts on the unattended charging machine, e.g., whether perform mobile payment, and charges the mobile electronic cash to be used in advance to enable mobile payment. ④ The user who wishes to use the mobile payment downloads the mobile application and completes the identity authentication by entering his/her personal ID and password. The user then confirms the pre-charged mobile payment history. ⑤ Once the charged amount is verified, the user can use the electronic cash using mobile methods similar to how smart card-type electronic cash is used at a location where a mobile payment device is installed. In addition, when the service in Fig. 2 is used via a mobile device, NFC in the personal smartphone requires activation to use the service.

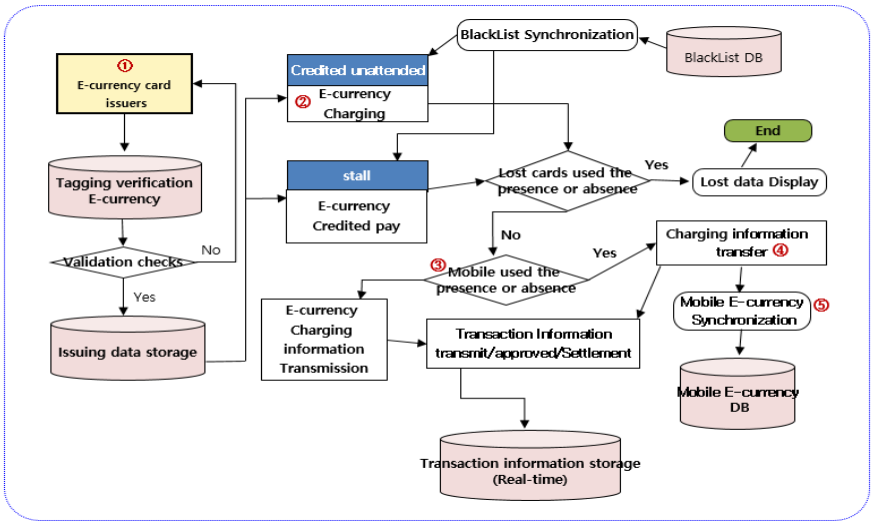

Figure 2. Proposed System Service Flow

3.4. Implementation of the In-House Electronic Cash Using Mobile Devices inside the University

The in-house mobile electronic cash operated in the university is run on a web system and Android applications. From the web system, details of electronic cash usage can be checked. In the Android application, details of the current balance and electronic cash usage can be checked.

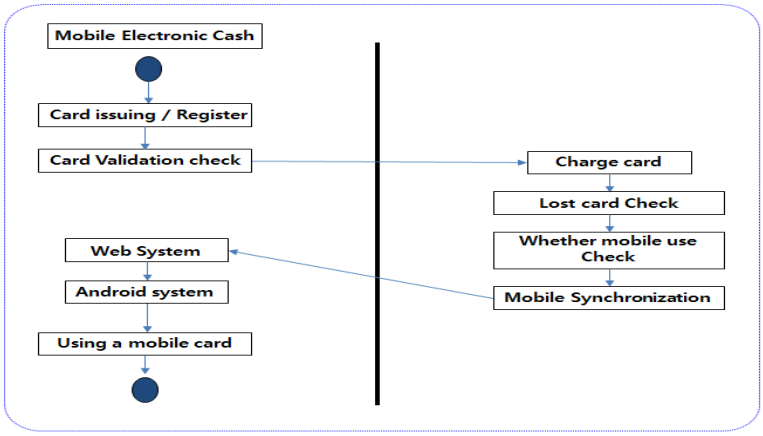

Figure 3. The Proposed System Activity Diagram

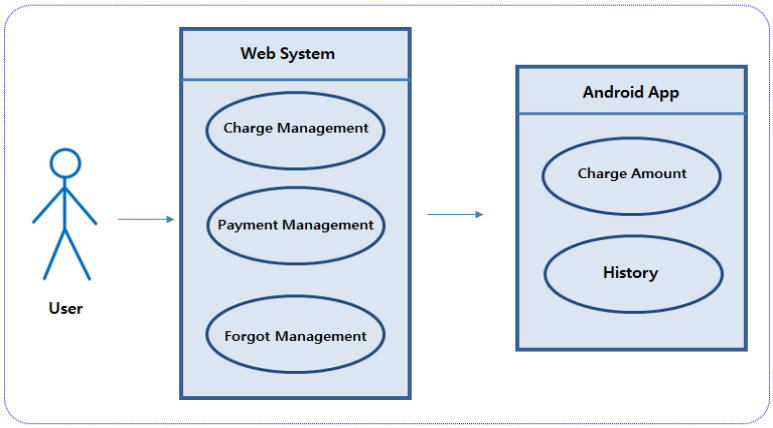

Figure 4. The Proposed System Use Case Diagram

The mobile electronic cash system demonstrated in this study mainly uses an application executed in Android environment. Figure 5 displays the layout of the Android application demonstrating the main screen of the in-house type mobile electronic cash, the screenshot of checking the balance menu and the purchase details and mobile phone-based checking of recharge details. Since the mobile electronic cash demonstrated in this research is only for the campus use, a wide variety of user-friendly services are not included. In other words, it does not support various commercial services where commercialized electronic cash can be applicable but focuses on using mobile electronic cash on university campuses. The use of mobile electronic cash is shown in Figure 5 and is as follows: ① The university student number and password are entered to complete the user authentication. ② Once the electronic cash main screen is displayed, a smartphone is tagged to the NFC reader to use the electronic cash. ③ In addition, the user's electronic cash recharge details and electronic cash usage can be checked by clicking the lower

button on the main screen. Other service details can be checked by connecting to the web system.

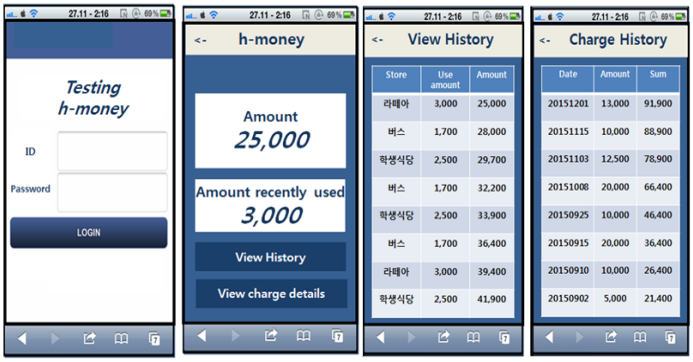

Figure 5. The Proposed System Mobile App Screen

4. Conclusion

The propagation of NFC mobile phones has paved the way to vitalization of mobile payment. In Korea, electronic cash has been introduced since the early 2000 and has been used in various applications in which the most successful case is the T-Money. T-Money supports compatibility of devices and financial payment connections, thus making it convenient for its users.

The electronic cash using mobile payment proposed in this paper is an in-house electronic cash system that is circulated in a specific organization, e.g., a university campus. The existing in-house electronic cash is smart card-based; thus, the user must carry the card-type electronic cash at all times to use it. In addition, the user can enjoy increased convenience and simplicity in terms of mobility. Accordingly, this proposed system requires the design of an in-house mobile electronic cash using NFC on a personal smartphone, which is able to provide user convenience and simplicity in mobility.

The in-house electronic cash in this study is operated independently by the university campus, which can earn additional value-added revenue through fee income. Accordingly, if this electronic cash is utilized in a small or medium-sized organization, not only can it improve convenience for members of the organization but it can also generate income for the organization. However, the startup cost of running the system independently in a small organization needs to be considered. Therefore, if a large operating company provides a packaged electronic cash system for small and medium-sized organizations, it can be beneficial for both parties. This is because the use areas of the in-house electronic cash can be classified into companies, public schools, and private educational institutes. Thus, if the number of internal members in an organization is greater than 1,000, that organization is eligible to receive its own benefit by operating electronic cash.

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