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An Integrated Mobile Phone Payment System Based on 3G Network

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Abstract—Along with globally approaching of the 3G era, the progress of mobile communication technology and the development of mobile terminal devices will rapidly promote the mobilization development of traditional Ecommerce. In order to ensure it to achieve further development, secure, flexible and reliable mobile payment system is becoming more and more important. Compared with the payment pattern of ordinary commerce, there will be profound changes in the mobile payment, such as special payment channel, payment carrier and etc. After deep studying about previous payment methods and future 3G communication technology, this paper introduces a new mobile payment model by combining with IC chip, mobile phone and mobile internet, and then gives some improvement measures for current settlement mechanisms in the network transaction, which is entirely around payment channel, payment carrier, security authentication and other key issues in 3G environment. The real time processing of information flow, capital flow and logistics in mobile environment can be easily achieved, forming a complete and reliable business operation for mobile users, which can bring some great conveniences and profound influences for mobile payment industry.

Index Terms—mobile payment, mobile phone, 3G, integrated payment system

I. INTRODUCTION

With the increase in the quantities of mobile communication users and the improvement of mobile communication rate, mobile phones already not merely limited in providing communication channels and entertainment services, and high bandwidth wireless data channel and mobile payment technologies can assist them to play an important role in mobile commerce. Certainly, the wide range

implementation of 3G era will promote the further development of mobile commerce. In this situation, the mobile payment may become more and more critical and commendably highlight the characteristics and trends of the mobile mode of

internet technology. As the core of mobile commerce, mobile payment is a new payment method, which is coincident with the characteristic of mobile commerce, developing with the progress of mobile communication technologies and the performance improvement of mobile devices.

Researches about mobile commerce and mobile payment have increased significantly with the emphasis on identifying new applications, designing frameworks, and engineering network solutions. Mobile payment is a natural successor to traditional internet payment, which has emerged as one of the sub domains of mobile commerce applications. Referring to the definition in the mobile payment forum, the mobile payment is the payment activity through mobile terminals between buyers and sellers in the mobile commerce. Nowadays, it has achieved significant development in many countries.

For instance, according to the research report of ADLittle Agency, mobile payment services have won a very good development in Japan and Korea, most of banks in the Korea has offered mobile bank services, and the number of mobile payment transactions has been increasing day by day. In the Japan, NTT DoCoMo is one of the more successful operators for developing mobile payment services, which carried out a bold taste in the realization methods and value joint models, having achieved lots of good results. The most important is that non-contact communication technology has become increasingly popular in Japan from 2005, which was regarded as a dominant technology in the mobile payment services.

In China, the mobile payment service was launched in 1999, when the China Mobile Communication Corporation and Commercial bank worked together to launch mobile payment services in 17 provinces, including Beijing, Shanghai, etc. So far, mobile

payment services have been made use of in most provinces. Furthermore, the huge number of mobile users and bank card users in China provides attractive application base for the development of mobile payment. In other word, there will be a huge market space with full potential and a well-behaved development prospects in mobile payment service in China. Since from the end of 2004, there has been an obvious growth trend in mobile payment services of some major third-party mobile operators, which promoted the coverage area of mobile payment to become wider and wider, other sectors of the industry chain also have been more and more active to seek opportunities for cooperation. In particular, it has been regarded as one best business to increase user stickiness and improve user satisfaction. The emergence of 3G era can improve the communication rate in mobile environment, which is also a booster for the further application of mobile payment.

As an integration product of electronic currency and mobile communication, mobile payment has many advantages, first, it is more convenient and easy-to-use than traditional payment manners, secondly, its compatibility is also better by reason of there are only two mobile operators in China, consisting of China Mobile and China Unicom. Moreover, the payment cost of mobile payment is lower. The development space of mobile payment market is large and with rapid growth, the applications of mobile payment services have not reached the desired level. It is because these are some urgent problems, such as encrypted problem during transmission process, lack of identify certify, lack of authentication system. Therefore, strengthen technical support and ensure transaction securities are very necessary to promote the mobile payment service. In this paper, we introduce a new mobile payment model by combining with IC chip, mobile phone and mobile internet, and then make some improvement for current settlement mechanism, around payment channel, payment carrier, security authentication and other key issues in the 3G environment.

The rest of the paper is organized as follows: research related to mobile payment application requirement and constraints is first introduced in section 2. In section 3, we briefly describe the existing mobile payment pattern and the pattern designed in this paper, and then analyzes its characteristics and advantage. And then we discuss how to design mobile payment system with the mobile payment method in section 4. Technology implementation scheme of mobile payment system is analyzed in section 5. Finally, we conclude this paper with future work.

II. RELATED WORK

A. Mobile Payment

According to the definition of mobile payment in mobile payment forum, mobile payment is the financial transactions for some services and products between the trading parties through mobile terminals, which can be mobile phone, PDA, mobile computer or mobile POS machine. That's to say, businessmen or service providers offer commodities or services for consumers, who then transfer the regulated electronic money from their own mobile-phone-bound account to the account of the businessmen or service providers through mobile phones, with the assistance of mobile payment environment providers. Compared with online payment, the mobile payment involves with one more roles, namely mobile payment environment provider, which occupies an important position in the whole payment process since the trading could only be completed with the vigorous cooperation of mobile communication operators mainly due to the insecurity of mobile payment and its immaturity. Mobile payment makes it available to conduct trading anytime and anywhere, which is the biggest advantage of this mode of payment, and it is characterized by mobilization and individualization. But just by this account, the security of trading is weakened, and the relatively late practical application is one of the reasons for insufficient security. Relative to traditional online payment measures, mobile payment is not very mature yet, which is to be perfected in terms of mobile communication techniques and mobile service delivery modes.

B. Existing Modes of Mobile Payment

In general, there are two usual forms of mobile payment in China, namely fee account mobile payment and bank card mobile payment. Mobile fee account payment, which is a very common form of payment, is to conduct mobile payment by making use of people's fixed mobile fee accounts. In this mode, mobile consumers, mobile payment environment providers and vendors are the core components. At the same time, Bank card mobile payment is a form of mobile payment relying on bank card, which has abundant financing functions, could give full play to the mobilization and individualization characteristics of mobile phone, and provide users with ultra-powerful mobile payment functions. Bank card mobile payment adopts STK technique, which consists of a group of commands for the interaction of mobile phones and SIM cards, and could operate java applets inside the card through mobile phone menus to realize the object of value-added services. What's more, the security of STK card is by far higher than that of traditional SIM card, and many mobile users have been using STK cards in China.

C. Existing Mobile Payment System

With the various forms of mobile payment, there have been many different mobile payment systems, which are based on different strategies. Many scholars have designed lots of mobile payment systems with different realization technologies. For example, Jerry presented an innovative mobile payment system based on 2- Dimensional (2D) barcodes for mobile users to improve mobile user experience in mobile commerce. Unlike other existing mobile payment systems, the proposed payment solution provides distinct advantages to support buy-and-sale products and services based on 2D Barcodes. This system uses one standard 2D Barcode (Data Matrix) as an example to demonstrate how to deal with underlying mobile business workflow, mobile transactions and security issues. Wei Liu put forward a optimization design of the GPRS mobile payment system based on radio frequency identification (RFID) as a transitional solution before the prevalence of the NFC (near field communication) cell phone. By virtue of RFID, the telecom service provider can provide diversified mobile payment services with high privacy.

On the other hand, the framework of the system is simple and takes full advantage of the existing GSM mobile communication network compared with the mobile payment system based on CDMA in Japan and Korea. While Kibris illustrated the use of mobile communication devices as versatile, secure and simple micro-payment tools, which satisfy the related financial, technological, computational and managerial requirements. The versatility and security of the method comes from the use of mobile phone and Variable Transaction Number in each transaction. Additionally, it demonstrated usages and details of technologies such as Service Oriented Architecture (SOA) and Embedded Systems. In fact, all mobile payment systems consist of four parts, including mobile payment platform, mobile consumption system, merchant management system, mobile operation management system and so on.

III. CONSTRAINTS IN MOBILE PAYMENTS

In general, there are some constraints in current mobile payment industry, mainly reflecting in the payment channel, payment carrier limitation, liquidation process restrictions and the lack of payment security authentication technology, in addition to industry constraints and some enterprise system support effectiveness.

A. Payment Channel

Before the advent of the 3G era, mobile payment is limited to SMS (short message service), WAP

(wireless application protocol) and some other limited technologies, which seriously hampered the development of mobile payment. It is attributed to the insufficient bandwidth in mobile network, for example, the effective bandwidth of GSM (global system for mobile communications) is only 9.6KBPS, which is insufficient to support the advanced payment technology in mobile network. However, the emergence of 3G mobile network can greatly improve the speed of information transmission. It can provide a better development space for mobile payment.

B. Payment Carrier

In the recent years, most of bank cards issued by the banks in china are magnetic stripes, whose storing information is very limited, and their safety measures are not very comprehensive. The variety defects in magnetic stripe cards are also severely limiting the business development of mobile payment. The popular IC cards at abroad, especially non-contact IC card are used with many constraints by various factors, which is also not conducive to carry out new business with mobile payment.

C. Liquidation Process Restrictions

Another constraint for the development of mobile payment in china is the liquidation process very unitary, which is difficult to meet some industry requirements. It only can calculate the fees between issuing bank and acquiring bank, it is sufficient to provide effective services for other trading entities. However, there are some professional liquidation organizations to provide abundant and characteristic liquidation services for enterprises.

D. Security Authentication Limitations

In addition to the above limitations, there are some limitations in the security certification of payment service in mobile environment. Because current mobile payment implementation technologies are mainly based on SMS, WAP and other ordinary technologies, whose security measure are not very comprehensive. For instance, the real time and data integrity of SMS cannot be guaranteed, moreover, the SMS message is transmitted through the public network without encryption, mobile phone number and payment password maybe easily cracked. Therefore, these security restrictions make mobile payment to be confined to micropayment. Certainly, there are some other obstacles to overcome before the rapid development of mobile payment. Such as changing and improving user consumer awareness, enhancing the user trust and dependence for mobile payment. How to provide simple and reliable payment services for mobile terminal users is a problem worthy of study. In order to well meet the industry requirement of mobile payment, this paper introduces a new mobile payment model by

combining with IC chip, mobile phone and mobile internet, and then makes some improvement for current settlement mechanisms, around payment channel, payment carrier, security authentication and other key issues in the 3G environment. The later sections will introduce how to solve the above issues with the integration solution model in this paper, and analyze its advantages and features.

IV. INTEGRATED MOBILE PAYMENT SOLUTION SCHEME

A. IC Card Payment

As the development of market economy and financial modernization, cash and various certificates have gradually being replaced by a variety of cards. IC card is regarded as the most promising product. Statistics show that payment services with IC cards are growing day by day, and presenting a favorable development trend. In the future, with the mature development of card technology and the application of non-contact IC card, more and more people will use IC cards to participate in payment services.

B. Mobile Phone Payment

Mobile phone payment was applied very early, but it is limited to micro-payment. SMS payment, WAP payment and BREW payment are the typical kinds of mobile phone payment. In the mobile phone payment service, there are two kind methods for consumers to achieve payment. One kind is to deduce fees from user mobile phone fare, and then it is transferred to mobile service provider by mobile operator. SMS, MMS (multimedia message service) are some typical applications. In another way, mobile users can build a corresponding relation between SIM cards in their phones with their own bank accounts. The mobile service fare will be deduced from bank accounts. Herein, the mobile phones are only simple information channels. However, there are some disadvantages in mobile phone payment, first, it is inconvenient to use because of its multiple interaction process. Secondly, its application space is very limiting, only being used in micro-payment. Besides, its safety and timeliness are not very ideal.

C. Internet Payment

After many years' development, internet has gradually become a worldwide network with millions of hosts in more than 200 countries, which is developing with an alarming rate. It has been the second major payment channel beyond the POS payment by right of its open, fast, convenience. So far, there are two popular kinds of payment methods with internet payment. One is to use the internet banking system of banks, and the other is to utilize the third-party payment gateway. The cost of merchants and banks are lower because of the

convenience and safety of the third-party payment platform, whose process is shown in Fig. 1:

1. Mobile users send purchase request to the merchant after obtaining product information.
2. Merchants send the user information and product information to the third-party mobile payment platform.
3. The third-party payment system returns the purchase request response.
4. After receiving response, users will send a payment request to the third-party mobile payment platform, which is responsible for communicating with network operators and bank gateway.
5. Bank takes charge of deducting funds from users' bank account to payment platform, which temporarily keeps the funds.
6. The third-party payment platform notices merchants to deliver products to mobile users after confirming users' payment.
7. Merchants send the produce delivery notification to the end users, waiting for user's confirmation.
8. Users ask the third-party payment platform to transfer the funds to the merchant account. Then, both consumers and merchants will receive corresponding notification.
9. Finally, a trading based on third-party payment platform is finished.

D. Integrated Mobile Payment Mode

After analyzing the features and the limitations of the above payment modes, this paper constructs an integrated mobile payment mode by combining IC card, mobile phone payment and internet payment technology. In this mode, some limitations of mobile payment can be well overcome and provide a secure and flexible mobile commerce transaction for mobile users, and then broaden the application domains of mobile payment. In this trade process, mobile users can easily carry out payment behaviors in mobile environment with their mobile communication devices, according to the operation indication of payment gateway.

At the same time, the delivery network can provide more flexible and convenient liquidation mode, being beneficial for mobile users. Fig. 2 shows the main entities of mobile payment and the payment process and Fig. 3 shows the network topology of mobile payment in 3G networks

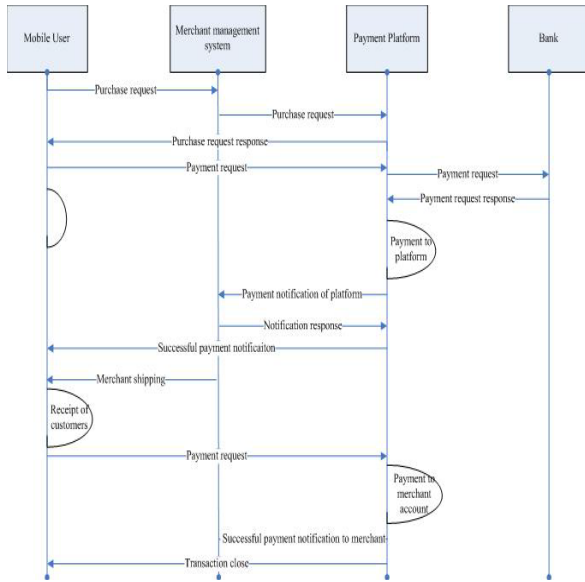


Figure 1. Typical flow-chart of third-party payment system

In addition, another important payment mode of mobile application service is mobile phone payment, which can assist mobile users and merchants to participate in the trading activities. Close non-contact payment will be a popular way, which utilizes NFC mobile phone instead of traditional POS machine. Be similar with RFID technology, mobile phones can make communications with signal processors with wireless channels. Enterprises directly send electronic payment orders to the cardholder's mobile phone in the 3G network, NFC chips will decode the order and store it in the electronic order IC card, the NFC phones' waving the POS machine can achieve payment business. If the cardholders demand higher security, "finger vein authentication" identification technology can be integrated in mobile phones, suggesting that a personal identity card holders. Moreover, mobile phones can complete the payment for mobile services with their own mobile terminal devices according to the prompt of payment gateway. Certainly, these IC chips in mobile phone have stored some secret keys in advance. In this way, hardware investment and maintenance cost will be reduced. As for liquidation, one special agency should be built to deal with liquidation services, in order to provide more flexible liquidation measure and improve clearing efficiency.

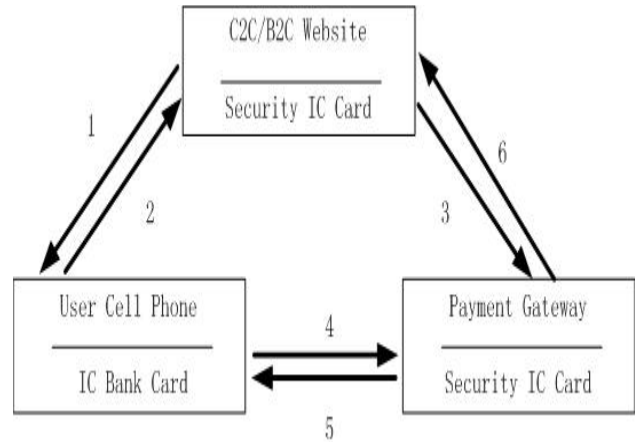


Figure 2. Online payment process.

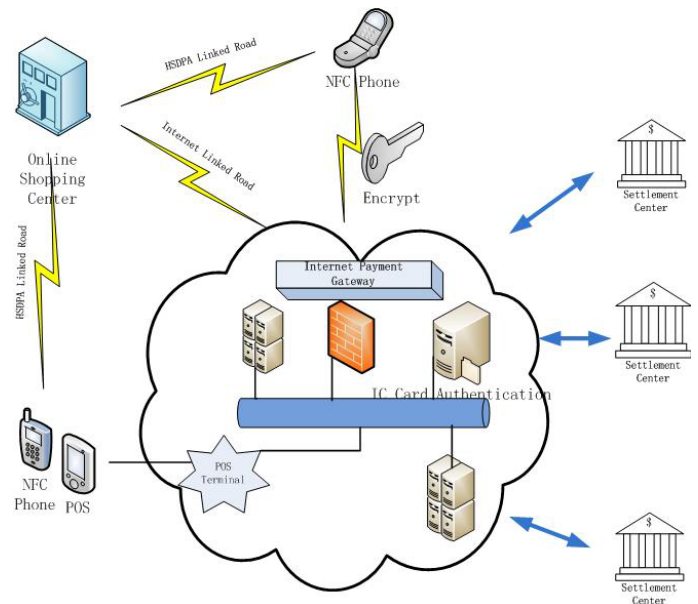


Figure 3. Mobile payment network topology.

V. TECHNOLOGY IMPLEMENT SCHEME OF INTEGRATED MOBILE PAYMENT SYSTEM

The achievement of the integrated mobile phone payment system should be supported by some advanced technology. The following content will introduce the key technology for the integrated mobile phone payment system, mainly focusing on payment channel, payment carrier and payment account.

A. Payment Channel

The direct relevance of 3G wireless communication technology is that the data transmission rate is higher. Mobile payment is requiring higher rate of data communication, because its data amount is bigger than traditional mobile service and the security requirement is higher. However, supporting high-

speed mobile packet data services is an important feature and advantage of 3G network. For example, WCDMA can offer 384 Kbit/s data rate, which is much higher than ordinary communication network, offering a smoother way to carry out data transmission. As a non-symmetric solution, it allows downstream capacity far exceed upstream capacity, in order to enhance the spectral efficiency.

Many key technologies in this scheme can meet the mobile payment requirements, such as adaptive modulation coding, hybrid automatic repeat request and focusing scheduling techniques. These technologies can be efficiently to be utilized in an integrated mobile payment system.

B. Payment Carrier

In the integrated mobile phone payment system based on 3G network, the near field communication technology will be used to as wireless communication method, which was developed by SONY and PHILIPS Company. Its communication distance is only some centimeters, but it can help mobile terminal devices make wireless communication with other devices. Besides, the communication rate in this wireless can be high, which can reach about 1Mb. In the mobile payment, the mobile phones supporting NFC communication can be regarded as data transmission terminal, which takes charge of producing mobile payment order and acquiring order response. Its security is also favorable because of its integrating encryption method. For instance, the private key can be stored in the IC card.

C. Security Authentication

As for the mobile payment industry, security authentication is another key factor, which plays an important role in mobile payment services. In this integrated mobile payment scheme, lots of security authentications are used to ensure the reliability of mobile payment. Herein, the security of mobile user account is the most important. First, mobile phone identification policy is indispensable, which has been applied in many provinces. Furthermore, the security authentication of IC cards should also be improved. For example, some advanced technology can be utilized to prevent cards to be imitated. In addition, software firewall, encryption and decryption algorithm can be used to enhance the security of IC card software system. Certainly, some advanced technology will replace the traditional way to further protect the personal account security of certificate holder, such as finger vein authentication. This technology has three main advantages. First, there is no imitation or theft risk, and the convenience and cleanliness is better than other authentication methods. Fig. 4 shows the whole technology scheme of the integrated mobile payment system. In the

middle area of Fig. 4, it shows a multi-application IC card, which can support many personalized applications. It can utilize virtual machine technology to make some alteration for traditional IC cards. Different applications communicate with each other through firewall measure, in order to ensure the data integrity and system safety. Public key infrastructure also can improve the security of mobile payment, whose private key will be stored in IC cards, preventing cracking and theft. Because of rapider communication technology, NFC technology will be combined with mobile phone to construct the favorable mobile payment carrier. And there is only 0.04 seconds to identify users with finger vein technology. by combining with IC chip, mobile phone and mobile internet, and then makes some improvement for current settlement mechanism, around payment channel, payment carrier, security authentication and other key issues in the 3G environment. In this way, the real time processing of information flow, capital flow and logistics in mobile environment can be easily achieved, forming a complete business operation, which can bring some great convenience and profound influence for mobile payment industry. Certainly, there are some other obstacles to overcome before the rapid development of mobile payment. Such as changing and improving user consumer awareness, enhancing the user trust and dependence for mobile payment. How to provide simple and reliable payment services for mobile terminal users is worthy of study.

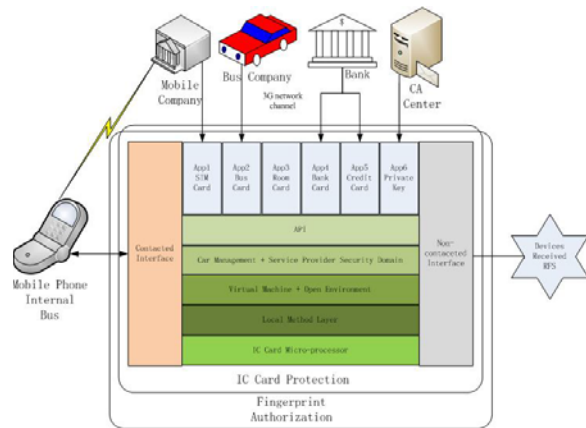


Figure 4. Technology scheme of the integrated mobile payment system.

VI. CONCLUSION

So far, mobile payment has played a great significance role in the process of mobile e-commerce. And it will have a great room to acquire

further development. In this paper, we bring forward a new form of mobile payment by referring to the advantages of the existing two forms of mobile payment and aiming at their disadvantages at the same time. But in practical operations, it is possible to confront with some problems. The development of the forms of mobile payment mainly depends on the influences of policies and industries. Mobile payment is a problem relevant to financial field, and financial industry hopes to occupy the leading position in the mobile e-commerce field with great prospects; meanwhile, mobile e-commerce needs the supports and participation of mobile communication industry, and mobile communication operators just don't want to act as channel providers without profits like traditional cable network providers. Therefore, the development of mobile payment in mobile e-commerce is a game between mobile communication industry and banking industry. Keeping away from these uncontrollable macrocosmic factors, the research has practical significances at present, and brand-new and high-efficiency form of mobile payment is very important for the development of Chinese mobile e-commerce. Using the integrated mobile payment way in this paper, the real time processing of information flow, capital flow and logistics in mobile environment can be easily achieved, forming a complete business operation, which can bring some great convenience and profound influence for mobile payment industry. Certainly, there are some other obstacles to overcome before the rapid development of mobile payment. Such as changing and improving user consumer awareness, enhancing the user trust and dependence for mobile payment. How to provide simple and reliable payment services for mobile terminal users is worthy of study.

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