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# Review and Comparison of Mobile Payment Protocol

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**Abstract.** Mobile phones are getting smarter and people have been using them for many different proposes. Recently, more and more people have begun using their mobile phones as a method of payment for online shopping and banking. Mobile payments have become easier than ever. Present security issues of mobile payments, however, still require improvement. This paper aims to summarize the idea of mobile payments and analyze the research of existing secure mobile payment protocols by using MPPS (Mobile Payment Protocol Security) framework. As a result, this paper will give researchers tools to standardize current protocol and share new developments.

**Keywords:** Mobile Payment; Payment Protocol; Secure Mobile Payment Protocol

## 1 Introduction

Mobile devices have become a popular method for businesses in the digital world because of their convenience for payments of goods and services. The payers can access the payment system via web browsers or applications on mobile devices. More people nowadays are willing to pay for goods or services using their mobile devices. Gartner Inc., the world's leading information technology, reports that the market worth of worldwide mobile payment transactions grew to \$235 billion in 2013 and will reach \$721 billion by 2017 [1]. Thrive Analytics surveyed the consumers in Asia-Pacific region and the results showed that there are about 800 million people who have used mobile phones as of June 2014 [2]. Thrive Analytics also found that 46% haven't used a mobile phone to pay for goods and services because they concern about security and privacy [2]. Thus, the study concluded that the mobile payments have both advantages and disadvantages. The researchers are trying to find ways to deal with privacy and security issues by designing a protocol for mobile payments to be more effective and secure.

This paper analyzed the mobile payment protocols dating back ten years in three aspects: methodology, security and performance. The structure of the paper is organized as follows. Section II provides an overview and the background of mobile payments. Section III classifies the technology of mobile payment systems. Section IV presents the properties of security and cryptographic concept. Section V analyzes the existing secure mobile payment protocols. Section VI concludes the paper.

## 2 Background and Related Work

This section provides the background and related works of the mobile payment.

### 2.1 Primitive payment transaction

In concept, the primitive mobile payment is composed of three basic steps [4, 5].

*Payment:* Client makes a payment to the merchant. *Value Subtraction:* Client requests to the payment gateway for his debit. *Value Claim:* Merchant requests to the payment gateway to credit transaction amount into his account.

### 2.2 Components of Mobile Payment

We analyze the components of mobile payments from the existing researches related to mobile payment protocols. Fun, Beng and Razali stated that the components of mobile payment scheme consist of seven main actors: Financial Service Providers (FSPs), Payment Service providers (PSPs), Payee, Payer, Mobile Network Operator (MNOs), Device Manufacturers, and Regulators [3]. However, Fun, Beng, Roslan and Habeeb stated that mobile payment protocols are composed of five principals which include client, merchant, issuer (client's financial institution), acquirer (merchant's financial institution) and payment gateway (PG) [4]. Kungpisdan, Srinivasan and Le also defined that five parties on mobile payment protocols are client, merchant, payment gateway, issuer and acquirer [5, 6]. Singh and Shahazad stated that the components of mobile payment protocol consist of three participants: payee, payer and financial institution [7]. McKitterick and Dowling stated that the components of mobile payment protocols are composed of four parts: customer, merchant, payment service provider and trust third party (TTP) [8].

The number of components mentioned above by researchers is different due to the design of payment protocols. However, we conclude that the components of mobile payment protocols, in general, consist of only three main parts: buyer, payment channel and seller.

### 2.3 Mobile Payment Procedure

The long-term goal of mobile payments is to integrate with all legacy payments and to provide an alternative payment option that uses different payment channels in homogeneous way. Therefore, it targets a wide range of payments depending on location, value, charging method and validation of the token. In this section, different groupings are introduced based on different attributes in mobile payments [11].

#### 2.3.1 Type of payments based on location

- **Remote Transactions:** These transactions are conducted regardless of the user's location. Location distances don't limit the users.
- **Proximity/Local Transactions:** These transactions are where the device communicates locally to perform close proximity payments. This involves the use of short range messaging protocol such as Bluetooth infrared, RFID and contactless chips to pay for goods and services in short distances.

#### 2.3.2 Type of payments based on value

- **Micro-Payments:** These are low value payments less than US\$1 [3].
- **Macro-Payments:** These are large value payments more than US\$10 [3].

### 2.3.3 Type of payments based on charging method

**Post-paid:** This is the most common payment method used in e-commerce transactions today. This consists of account-based and token-based method. Account-based is used by banks, and the credit card industry. Consumers with a bank account or credit card can pay using the account-based method [7] and token-based is the charge method for goods and service such as e-money, e-wallet by mobile network operator [9, 10].

**Pre-paid:** This is the most common charging method used by mobile network operators as well as third-party service providers. This method can only be used by consumers capable of paying immediately.

## 3 Technology of Mobile Payment

We studied and assessed technologies in mobile payment systems from the existing researches as described below [14].

- **SMS:** Short Messaging Service is a text messaging service used to send and receive short text messages. The maximum length of messages is less than 160 alphanumeric characters, to and from mobile phones.
- **WAP:** Wireless Application Protocol is a technology which provides a mechanism for displaying internet information on a mobile phone.
- **NFC:** Near Field Communication is the communication between contactless smart cards and mobile phones.
- **RFID:** Radio Frequency Identification is a method of identifying an item wirelessly using radio waves
- **Smart Card:** Smart cards and plastic cards normally appear in the same shape as credit cards are embedded with a chip or microprocessor that can handle and store 10 to 100 times more information than traditional magnetic-stripe cards [13].
- **Internet:** The internet is a publicly accessible, globally interconnected network. It uses the internet protocol to enable the exchanging and sharing of data among computers in the network
- **USSD:** Unstructured Supplementary Services Data is a mechanism of transmitting information via a GSM network. Unlike SMS, it offers a real-time connection during a session
- **IVR:** Interactive Voice Response is a telephony technology where the users can interact with the database of a system without any human interaction
- **Magnetic:** Data is stored in a magnetic stripe on a plastic card. It is read by swiping the card in a magnetic card reader.

## 4 Security of Mobile Payment

This section presents security properties, and cryptographic techniques.

#### 4.1 Security Properties

A secure mobile payment system must have the following properties [16].

- **Confidentiality:** The system must ensure that private or confidential information will not be made available or disclosed to unauthorized individuals.
- **Integrity:** The system must ensure that only authorized parties are able to modify computer system assets and transmitted information.
- **Authentication:** The system must ensure that the origin of a message is correctly identified, with an assurance that the identity is not false.
- **Non-repudiation:** The system must ensure that the user cannot deny that he/she has performed a transaction and he/she must provide proof if such a situation occurs.
- **Availability:** The system must be accessible for authorized users at any time.
- **Authorization:** The system must verify if the user is allowed to make the requested transaction.

#### 4.2 Cryptography Concept

Cryptography is a technique used to secure data protection from the hacker, which can be classified into the following three groups:

- **Symmetric Key Cryptography:** It is the encryption methods in which both the sender and receiver share the same key. The algorithms, in general, consist of DES (Data Encryption Standard), 3DES (Triple DES) and AES (Advance Encryption Standard)
- **Asymmetric Key Cryptography:** It is also known as public key cryptography, a class of cryptographic algorithms which requires two separate keys. One key is secret and the other key is public. The algorithms are RSA (Rivest, Shamir and Adleman) and ECC (Elliptic Curve Cryptography).
- **Hash Function:** It is a public one-way function that maps a message of any length into a fixed-length, which serves as the authenticator. A variety of ways of a hash code can be used to provide message authentication.

### 5 Analysis of Existing Secure Mobile Payment Protocols

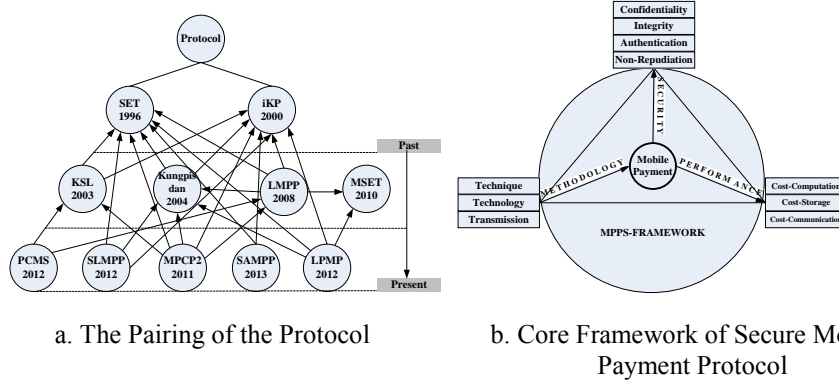
We analyzed the existing researches on 11 secure mobile payment protocols that focus on lightweight protocol and high level of security. Bellare and Wang [17] designed the SET protocol (Secure Electronic Transfer Protocol) in 1996. This protocol is using a cryptographic technique by using public key and digital signature to protect information on mobile payment via a credit card that gives three important properties of information security: Confidentiality, Integrity and Authorization. Bellare and Garay [18] designed the iKP protocol (i-Key-Protocol) in 2000 that is adjusted from the SET protocol by using pair “i”. If it is high, it shows a high level of security. This protocol provided the properties of security similar to the SET protocol. Kungpisdan and Srinivasan [19] designed the KSL protocol (Kungpisdan Logic) in 2003 which focuses on client processing for decreasing the computational cost on the mobile wireless network. The protocol applied a symmetric key cryptography. The comparison shows that it has better performance over the SET and

iKP protocols and also provides the non-repudiation property. Kungpisdan et al. [5] developed the Kungpisdan Protocol (Account-based Mobile Payment) in 2004 that is improved from KSL protocol by using symmetric key for all the parties. This protocol creates a secret shared key between two parties which support high level of four security properties: confidentiality, integrity, authentication and non-repudiation. The performance, when compared with the SET and iKP protocol, showed that the computation time at the client is relatively faster.

Fun et al. [20] designed the LMPP protocol (Lightweight Mobile Payment Protocol) in 2008. This protocol is using only the symmetric key but the performance is better than the SET, iKP and Kungpisdan [19] protocols. Shedid [21] adjusted the MSET Protocol (Modified SET Protocol) in 2010 by decreasing the number of operational cryptographic for increasing the performance. Dizaj et al. [22] designed the MPCP2 Protocol (Mobile Pay Center Protocol 2) in 2011 for decreasing the number of cryptographic operations between all engaging parties. By using symmetric cryptography all parties exchange key offline by Diffie-Hellman method. When compared with the SET, iKP, KSL and Kungpisdan protocols, the performance showed that the number of operation at the client is less than the number of operation of the other protocols. Isaac and Zeadally [24] designed PCMS Protocol (Payment Centric Model Using Symmetric Cryptography) in 2012. The protocol focuses on Payment gateway centric model. All parties must connect via the payment gateway for authorization.

Sekhar and Sarvabhatla [23] designed the SLMPP Protocol (Secure Lightweight Mobile Payment Protocol) in 2012. This protocol focuses on end-to-end encryption by using symmetric key cryptography in order to decrease the number of operation at the client side. The comparison with the SET, iKP and Kungpisdan protocols found that this protocol has less number of operations. The authors concluded that this protocol is suitable for mobile wireless network. Tripathai [25] designed the LPMP Protocol (Lightweight Protocol For Mobile Payment) in 2012 focusing on the number of cryptographic operations. It is compared with the SET, iKP, KSL and MSET protocols, and found that the LPMP use only the cryptographic operations on the client side which all processes are less than the others. Auala and Arora [26] designed the SAMPP Protocol (Secure Account-based Mobile Payment Protocol) in 2013 by using asymmetric key and digital signature. The authentication technique is using a multifactor authentication with a biometric and private key. The performance is better when compared with the SET and iKP protocols.

The analyses of the relationship between all secure mobile payment protocols from the past to present showed that almost all protocols are compared in performance with SET and iKP. Subordinates of SET and iKP are Kungpisdan, KSL, LMPP and MSET. The relationship of the secure mobile payments protocols from the past ten years is depicted in Fig. 1.(a). The original protocol, SET, was formed in 1996 and the latest protocol, SAMPP, was formed in 2013. Security protocols can be divided into three aspects: methodology, security and performance. These three aspects are key factors to the success of secure mobile payment protocol and are the core of research on mobile payment security. The concept of MPPS framework is depicted in Fig. 1.(b).



**Fig. 1.** The concept of secure mobile payment

The detailed analysis of secure mobile payment protocol is as follows:

#### Methodology Aspect

Secure mobile payment protocols such as SET, iKP, KSL and SAMPP use the asymmetric key cryptography technique to support security. The others use symmetric key cryptography. The processes of encryption have the following objectives:

- **Encryption/Decryption:** Assure that the data is confidential and is encrypted secretly and privately.
- **Hash Function:** Assure that the data is sent correctly and the sent data matches the original data. HMAC (Hash Message Authentication Code): provides an easy mechanism for verifying both user authenticity and that a message hasn't been tampered with of message; it protects the integrity and the authenticity of the message.
- **Key generation:** Assure the non-repudiation property by confirming the corresponding data before beginning a transaction order to prevent disclaimers.

#### Security Aspect

After analyzing the 11 protocols of mobile payments, we found that almost all protocols support features of security in four key areas: confidentiality, integrity, authentication and non-repudiation. But, two protocols SET and iKP do not support non-repudiation. Moreover, the protocols KSL, LMPP, MSET, MPCP2, SLMPP, LPMP and SAMPP provided all privacy properties that the others could not. The security properties and features of the different protocols are summarized in Table 1.

#### Performance Aspect

Protocol's performance is analyzed by counting the number of operations needed for encoding and decoding. This includes operations related to data transmission between three parts. Table 2 summarizes the number of cryptographic operations which consist of public encryption- decryption, signature verifications, symmetric key encryption-decryption, a hash function, keyed-hash function and key generations. The researchers presented secure mobile payment protocols providing a high level of security and low computation, cost and power.

**Table 1.** Security Properties of Protocols

Number of Ref	[17]	[18]	[19]	[5]	[20]	[21]	[22]	[24]	[23]	[25]	[26]
Confidentiality	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Integrity	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Authentication	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Non-repudiation	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Id Protect from payee	N	N	Y	Y	Y	Y	Y	Y	Y	Y	Y
Id Protection from Eavesdropper	N	N	N	N	Y	Y	Y	-	Y	Y	Y
Transaction privacy protection from Eavesdropper	Y	Y	Y	Y	Y	Y	Y	-	Y	Y	Y
Transaction privacy protection from TTP or related financial	N	N	N	N	Y	Y	Y	-	Y	Y	Y

**Table 2.** Number of Cryptographic Operation of Protocol

Number of Ref	[17]	[18]	[19]	[5]	[20]	[21]	[22]	[24]	[23]	[25]	[26]
Public Encryption	C	1	1								1
	M	1		1							
	PG	1		1							
Public Decryption	C										
	M	1									1
	PG	2	1	1							
Signature Generations	C	1	1								
	M	3	3	1							
	PG	1	1	1							
Signature Verifications	C	2	3								
	M	2	2	1							
	PG	1	2	1							
Symmetric Encrypt	C	2		3	4	5	11	4	3	4	6
	M			4	5	6		4	4	4	6
	PG	1			2			3	3	3	2
Hash Function	C	3	2	3	2		6	1	2	1	5
	M	2	4	3		2		3		3	
	PG		1			1					
Key Hash	C			2	2			1	2	1	
	M		1		2			1	2	1	
	PG				1				1		
Key Generation	C			2	2			2	2	2	1
	M			1	1			1	1	1	2
	PG				1			1	1	1	1
Total		24	22	26	22	14	17	21	21	21	12

## 6 Conclusion

This paper gives an overview of mobile payments and analyzes the existing secure mobile payment protocol over the past ten years. All protocol schemes focus on reducing the use of resources in the mobile process by cryptographic concept. Each researcher tried to design and modify the process of the protocol so the message is short and lightweight. All protocols provided four main security properties: confidentiality, integrity, authentication, and non-repudiation. As a conclusion, to discover the best secure mobile payment protocol, the protocol standard must be the



same all over the world and the communities and industries must be adopting the standard.

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