

## A Secure Off-Line Micro-Payment System

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### **ABSTRACT:**

*Credit and debit card data theft is one of the earliest forms of cybercrime. Still, it is one of the most common nowadays. Attackers often aim at stealing such customer data by targeting the Point of Sale (for short, PoS) system, i.e. the point at which a retailer first acquires customer data. Modern PoS systems are powerful computers equipped with a card reader and running specialized software. Increasingly often, user devices are leveraged as input to the PoS. In these scenarios, malware that can steal card data as soon as they are read by the device has flourished. As such, in cases where customer and vendor are persistently or intermittently disconnected from the network, no secure on-line payment is possible. This paper describes FRoDO, a secure off-line micro-payment solution that is resilient to PoS data breaches. Our solution improves over up to date approaches in terms of flexibility and security. To the best of our knowledge, FRoDO is the first solution that can provide secure fully off-line payments while being resilient to all currently known PoS breaches. In particular, we detail FRoDO architecture, components, and protocols. Further, a thorough analysis of FRoDO functional and security properties is provided, showing its effectiveness and viability.*

### **INTRODUCTION**

MARKET analysts have predicted that mobile payments will overtake the traditional marketplace, thus providing greater convenience to consumers and new sources of revenue to many companies [1]. This scenario produces a shift in purchase methods from classic credit cards to new approaches such as mobile-based payments, giving new market entrants novel business chances.

Widely supported by recent hardware, mobile payment technology is still at its early stages of evolution but it is expected to rise in the near future as demonstrated by the growing interest in crypto-currencies. The first pioneering micro-payment scheme, was proposed by Rivest (see Payword [2]) back in 1996. Nowadays, crypto-currencies and decentralized payment systems (e.g., Bitcoin [3]) are increasingly popular, fostering a shift from physical to digital currencies. However, such payment techniques are not yet commonplace, due to several unresolved issues, including a lack of widely-accepted standards, limited interoperability among systems and, most importantly, security.

Over the last years, several retail organizations have been victims of information security breaches and payment data theft targeting consumer payment card data and personally identifiable information (PII) [4], [5].

Although PoS breaches are declining [4], they still remain an extremely lucrative endeavor for criminals [6]. Customer data can be used by cybercriminals for fraudulent operations, and this led the payment card industry security standards council to establish data security standards for all those organizations that handle credit, debit, and ATM cardholder information.

Regardless of the structure of the electronic payment system, PoS systems always handle critical information and, oftentimes, they also require remote management [7].

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**EXISTING SYSTEM:**

- ❖ PoS systems act as gateways and require some sort of network connection in order to contact external credit card processors. This is mandatory to validate transactions.
- ❖ To reduce cost and simplify administration and maintenance, PoS devices may be remotely managed over these internal networks.
- ❖ Mobile payment solutions proposed so far can be classified as fully on-line, semi off-line, weak off-line or fully off-line.
- ❖ The previous work called FORCE that, similarly to FRoDO, was built using a PUF based architecture. FORCE provided a weak prevention strategy based on data obfuscation and did not address the most relevant attacks aimed at threatening customer sensitive data, thus being vulnerable to many advanced attack techniques

**DISADVANTAGES OF EXISTING SYSTEM:**

- ❖ Off-line scenarios are harder to protect, customer data is kept within the PoS for much longer time, thus being more exposed to attackers.
- ❖ Skimmers: in this attack, the customer input device that belongs to the PoS system is replaced with a fake one in order to capture customer's card data.
- ❖ The main issue with a fully off-line approach is the difficulty of checking the trustworthiness of a transaction without a trusted third party. In fact, keeping track of past transactions with no available connection to external parties or shared databases can be quite difficult, as it is difficult for a vendor to check if some digital coins have already been spent. This is the main reason why during last few years, many different approaches have been proposed to provide a reliable off-line payment scheme.
- ❖ Although many works have been published, they all focused on transaction anonymity and coin unforgeability. However, previous solutions lack a thorough security analysis. While they focus on theoretical attacks, discussion on real world attacks such as skimmers, scrapers and data vulnerabilities is missing.

**PROPOSED SYSTEM:**

- ❖ In this paper, FRoDO is the first solution that neither requires trusted third parties, nor bank accounts, nor trusted devices to provide resiliency against frauds based on data breaches in a fully off-line electronic payment systems. Furthermore, by allowing FRoDO customers to be free from having a bank account, makes it also particularly interesting as regards to privacy.
- ❖ In fact, digital coins used in FRoDO are just a digital version of real cash and, as such, they are not linked to anybody else than the holder of both the identity and the coin element.
- ❖ Differently from other payment solutions based on tamper-proof hardware, FRoDO assumes that only the chips built upon PUFs can take advantage from the tamper evidence feature. As a consequence, our assumptions are much less restrictive than other approaches.
- ❖ This paper introduces and discusses FRoDO, a secure off-line micro-payment approach using multiple physical unclonable functions (PUFs).
- ❖ FRoDO features an identity element to authenticate the customer, and a coin element where coins are not locally stored, but are computed on-the fly when needed.
- ❖ The communication protocol used for the payment transaction does not directly read customer coins. Instead, the vendor only communicates with the identity element in order to identify the user. This simplification alleviates the communication burden with the coin element that affected previous approach.
- ❖ The main benefit is a simpler, faster, and more secure interaction between the involved actors/entities. Among other properties, this two-steps protocol allows the bank or the coin element issuer to design digital coins to be read only by a certain identity element, i.e., by a specific user. Furthermore, the identity element used to improve the security of the users can also be used to thwart malicious users.

- ❖ To the best of our knowledge, this is the first solution that can provide secure fully off-line payments while being resilient to all currently known PoS breaches.

#### **ADVANTAGES OF PROPOSED SYSTEM:**

- ❖ FRoDO has been designed to be a secure and reliable encapsulation scheme of digital coins.
- ❖ FRoDO also applicable to multiple-bank scenarios. Indeed, as for credit and debit cards where trusted third parties (for short, TTPs) such as card issuers guarantee the validity of the cards, some common standard convention can be used in FRoDO to make banks able to produce and sell their own coin element.
- ❖ The identity and the coin element can be considered tamper-proof devices with a secure storage and execution environment for sensitive data.

#### **IMPLEMENTATION**

##### **MODULES:**

- ❖ System Construction Module
- ❖ Identity Element
- ❖ Coin Element
- ❖ Attack Mitigation

##### **MODULES DESCRIPTION:**

###### **System Construction Module**

- ❖ In the first module, we develop the System Construction module with the various entities: Vendor, User, FRoDO, PUF, Attacker. This process is developed completely on Offline Transaction process.
- ❖ We develop the system with user entity initially. The options are available for a new user to register first and then login for authentication process. Then we develop the option of making the Vendor Registration, such that, the new vendor should register first and then login the system for authentication process.
- ❖ FRoDO is the first solution that neither requires trusted third parties, nor bank accounts, nor trusted devices to provide resiliency against frauds based on

data breaches in a fully off-line electronic payment systems. Furthermore, by allowing FRoDO customers to be free from having a bank account, makes it also particularly interesting as regards to privacy. In fact, digital coins used in FRoDO are just a digital version of real cash and, as such, they are not linked to anybody else than the holder of both the identity and the coin element.

- ❖ Differently from other payment solutions based on tamper-proof hardware, FRoDO assumes that only the chips built upon PUFs can take advantage from the tamper evidence feature. As a consequence, our assumptions are much less restrictive than other approaches.

##### **Identity Element**

- ❖ In this module, we develop the Identity Element module functionalities. FRoDO does not require any special hardware component apart from the identity and the coin element that can be either plugged into the customer device or directly embedded into the device.
- ❖ Similarly to secure elements, both the identity and the coin element can be considered tamperproof devices with a secure storage and execution environment for sensitive data. Thus, as defined in the ISO7816-4 standard, both of them can be accessed via some APIs while maintaining the desired security and privacy level. Such software components (i.e., APIs) are not central to the security of our solution and can be easily and constantly updated. This renders infrastructure maintenance easier.

##### **Coin Element**

- ❖ In this module, we develop Coin Element. In this coin Element we develop Key Generator and Cryptographic Element. The Key Generator is used to compute on-the-fly the private key of the coin element. The Cryptographic Element used for symmetric and asymmetric cryptographic algorithms applied to data received in input and send as output by the coin element;

- ❖ The Coin Selector is responsible for the selection of the right registers used together with the output value computed by the coin element PUF in order to obtain the final coin value;
- ❖ The Coin Registers used to store both PUF input and output values required to reconstruct original coin values. Coin registers contain coin seed and coin helper data. Coin seeds are used as input to the PUF whilst coin helpers are used in order to reconstruct stable coin values when the PUF is challenged

### Attack Mitigation

- ❖ In this module we develop the Attack Mitigation process. The read-once property of the erasable PUF used in this solution prevents an attacker from computing the same coin twice. Even if a malicious customer creates a fake vendor device and reads all the coins, it will not be able to spend any of these coins due to the inability to decrypt the request of other vendors.
- ❖ The private keys of both the identity and coin elements are needed to decrypt the request of the vendor and can be computed only within the customer device. The fake vendor could then try to forge a new emulated identity/coin element with private/ public key pair. However, identity/coin element public keys are valid only if signed by the bank. As such, any message received by an unconfirmed identity/coin element will be immediately rejected;
- ❖ Each coin is encrypted by either the bank or the coin element issuer and thus it is not possible for an attacker to forge new coins

### SCREENSHOTS:

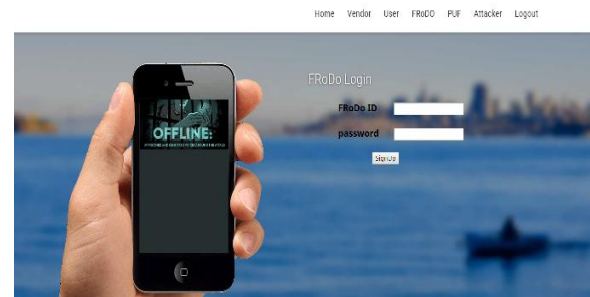


Fig: FRoDO Login



Fig: FRoDO Home



Fig: Binary Conversion:

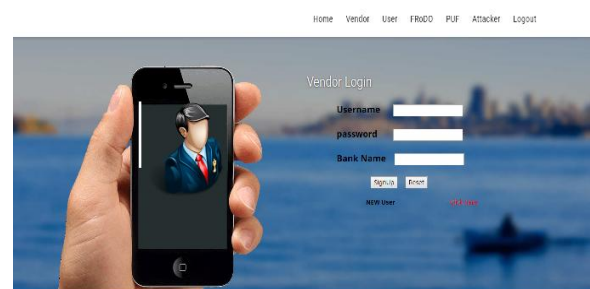


Fig: Vendor Login Page



Fig: Home Page



Fig: Vendor Home Page

## CONCLUSION

In this paper we have introduced FRoDO that is, to the best of our knowledge, the first data-breach-resilient fully offline micro-payment approach. The security analysis shows that FRoDO does not impose trustworthiness assumptions. Further, FRoDO is also the first solution in the literature where no customer device data attacks can be exploited to compromise the system. This has been achieved mainly by leveraging a novel erasable PUF architecture and a novel protocol design. Furthermore, our proposal has been thoroughly discussed and compared against the state of the art. Our analysis shows that FRoDO is the only proposal that enjoys all the properties required to a secure micro-payment solution, while also introducing flexibility when considering the payment medium (types of digital coins). Finally, some open issues have been identified that are left as future work. In particular, we are investigating the possibility to allow digital change to be spent over multiple off-line transactions while maintaining the same level of security and usability.

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