ENHANCING SECURITY AND ACCESSIBILITY IN ATM CARDLESS CASH WITHDRAWAL TRANSACTIONS WITH SMART CONTRACTS

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ABSTRACT
The widespread adoption of mobile banking and internet banking has led to a need for enhanced security measures in universal banking applications to protect customer credentials. Despite the trend towards cashless transactions, cash withdrawals from ATMs remain a necessary component of banking services. In the cash withdrawal process, there are three key stakeholders: the customer, the payment gateway, and the bank. While national and international payment gateways facilitate transactions between customers and banks, they introduce a centralized third-party that increases the risk of data breaches and other security threats. The aim of this research is to propose a solution that eliminates the ATM card, centralized third-party and instead utilizes a decentralized digital ledger through the use of smart contracts to safeguard customer credentials. A survey was conducted to assess the level of adaptability of the new Smart Contract-based, cardless ATM cash withdrawal system.
Keywords: Cash withdrawal, Data breach, Smart contract, Smart Mobile Banking Application (SMBA).

Introduction

Automated Teller Machines (ATMs) have become an essential aspect of the banking industry, providing millions of people with convenient access to cash globally. However, ATMs are vulnerable to various security threats such as fraud, skimming, data theft, and cybercrime, similar to any financial system. The process of cash withdrawal, when a customer initiates a cash withdrawal transaction, they insert their debit or credit card into the ATM, which verifies the card's validity and the status of the customer's account. Once the customer enters their PIN, the ATM checks the availability of sufficient funds in the customer's bank account, and if available, the cash withdrawal is processed through the payment gateway network. The payment gateway system verifies the transaction credentials and then dispenses the requested amount while updating the account balance to reflect the transaction.

To obtain a credit or debit card, a customer requests one from their bank, which then sends a request to a third-party. The third-party then issues the card to the customer, and it is linked to the payment gateway system. The payment gateway, also known as the third-party, acts as a link between the customer and the bank, processing the transaction securely by communicating the data to the individual bank. This payment processing infrastructure is cost-effective for banks as they do not have to form their payment processing systems. This third-party payment network enables customers to withdraw money from any part of the world, providing one of the primary benefits of including a third-party payment network in the banking system.

Blockchain, the advent of blockchain technology gained traction with the introduction of blockchain 2.0 by Ethereum. While it first gained recognition through the implementation of cryptocurrency systems, such as Bitcoin in 2008, a blockchain is essentially a digital ledger that is distributed and decentralized, enabling transactions to be recorded across a network of computers. This eliminates the need for a central authority and allows multiple parties to reach consensus on the state of a database. Transactions on a blockchain are recorded as "blocks" that are connected together to form a permanent and unalterable chain. This provides a high degree of security and trust in the system. Blockchains have various potential uses beyond cryptocurrencies, including tracking the movement of goods, verifying the authenticity of documents, and facilitating secure voting systems. As noted by Wood (2020), blockchain technology operates as a distributed transaction ledger that is shared between nodes on a peer-to-peer network. Angelo and Salzer (2019) further emphasize that the data stored on a blockchain is shared among nodes on the network. Smart contract code analysis tools also vary with advances in technology. Overall, the implementation of blockchain technology has the potential to transform the way we store and exchange information, conduct business, and interact with one another.

Smart contract, the introduction of smart contracts has significantly expanded the capabilities and applications of blockchain technology. Smart contracts offer a promising future for security in various fields. Essentially, a smart contract is a self-executing agreement that is directly written into a piece of code, and stored on a blockchain network. By allowing for the automation of contract execution, smart contracts can facilitate, verify, and enforce the negotiation or performance of an agreement, especially on blockchain-based platforms.

Pierro and Rocha (2019), ethereum is a decentralized and open-source blockchain platform that was specifically designed to run smart contracts. Transactions on the Ethereum network are completed by miners, who charge gas fees for each transaction.

Li. (2020) further explained that the gas fees charged to customers can determine the speed of a transaction, with the option to choose between fast, medium, or slow. Miners then verify and include these transactions in Ethereum blocks, with the urgency of the work determined by the gas price value associated with each transaction. However, miners are limited by the maximum gas limit per block and can only comprise a certain number of transactions in each block.

Objective of the study

1. To explore the feasibility of using smart contracts in eliminating payment gateways from ATM cash withdrawal.
2. To identify the feasibility and adaptability of the proposed smart contract-based ATM cash withdrawal.

Literature review

Hughes (2019), the impact of decentralized ledger technology has been tremendous across various domains. It has revolutionized the architecture of the internet, introducing new perspectives, techniques, and tools.

Lacity (2018), Erceg (2020), Joo (2021), Rejeb and Bell (2019), Khatoon (2020), Kamilaris (2019), Shah (2022), and Buyukbaskin (2020), have also noted the profound social impact of decentralized ledgers on various fields, including computer science, economics, law, business, tourism, commerce, landing systems, healthcare, supply chain management, finance, government voting systems, e-voting, and many more. This raises the question of how blockchain implementation affects functionality, benefits, and impact across different domains. Moreover, Kemmoe (2020) classifies the advancement work in smart contracts between 2017 and 2020 into four categories: cryptography, access management, social applications, and smart contract structures. This paper aims to discuss the current developments in smart contracts and their widespread utilization.

Yang (2019), a combination of blockchain and smart contracts was implemented into lending systems. This proposed system provides several benefits, including increased security and ease of loan processing, as well as improved supervision and standardization of management behavior. Pustisek (2020) employed a blockchain-based multi-tenant 5G application prototype for a smart grid system. Backman (2017) proposed a blockchain-based 5G network slice broker system aimed at reducing service time and enabling engineering equipment to autonomously and dynamically acquire the necessary slice for more efficient operation. The 5G network lease is executed on a network operator who maintains a record of each transaction in a slice ledger.

Reyna (2018) combining IoT and blockchain can enhance data security across various networks. By utilizing this combination, the scalability of the decentralized system can be improved while ensuring more security. This integration can also facilitate effective device authentication and management. Additionally, the blockchain technology can enhance data integrity, enable micropayments, foster sharing services, facilitate data monetization, enable autonomous device operations, and improve the security of various types of transactions.

Kim (2017) the use of blockchain technology to enable mobile charging of electric vehicles. Meanwhile, Kang (2017) has developed a blockchain-based petaelectronvolt (PEV) charging system that enables energy transfer between electric vehicles in peer-to-peer (P2P) mode.

Zhang (2021) developed an Attribute-Based Access Control (ABAC) framework for smart cities. By utilizing Ethereum and smart contracts, the model is capable of managing ABAC policies, attributes of subjects and objects, and access control.

McCorry (2017) created an ethereum-based Open Vote Network that has been tested on the official Ethereum test network with a cost of $0.73 per voter. The model was able to support up to forty simultaneous voters. Patient data is a valuable asset in the healthcare sector. Duong-Trung (2020) have developed and tested a patient-centered healthcare system that utilizes blockchain and smart contract technology. The system effectively coordinates between doctors, patients, nurses, medical staff, insurance providers, and more, using six different algorithms to synchronize data between system components.

Yang (2021) developed ring signature algorithms. This algorithm helps in securing IoT device data transmission on blockchain networks and performing smart contract transactions while maintaining the anonymity of the initiator. The algorithm hides the unique device and its address on the blockchain network, ensuring the overall security of the process.

Liu (2020) proposes a novel supply chain model based on blockchain and smart contracts to tackle issues in the Supply Chain Matrix (SCM) system. The benefits of using smart contracts in SCM include cost reduction, value enhancement, quicker turnover, easier financing, stronger risk management, and seamless integration with advanced technology.

Buterin (2014) smart contracts and their ongoing implementations have proven to be useful in all domains.
Malavolta (2017) focused on enhancing privacy and concurrency in payments channel networks. Smart contracts have become an essential tool in various domains due to their ability to store data, process inputs, check conditions, and generate outputs. These contracts can be easily implemented on the Ethereum network, providing a convenient platform for their execution. Bogner (2016) developed a decentralized application on the Ethereum blockchain to facilitate the sharing of everyday objects without requiring a trusted third party. Through the use of smart contracts, tool owners could register and retrieve their objects, while renters could rent out the objects of their choice.

Rejeb, Keogh (2021) conducted a SWOT analysis on centralized and decentralized ledger systems for the money supply process. The authors concluded that centralized ledger systems are ideal for recording financial transactions, while decentralized ledger systems are expected to become increasingly significant in the future of finance and may disrupt financial transactions.

Rahmadika (2018) discovered that financial records are currently centralized and are produced, regulated, and maintained by a central authority. On the other hand, Morgan JS (2017) found that decentralized ledgers with smart contracts could help banks maintain secure transaction ledgers.

Xu (2020) found that decentralized ledgers are specific data structures maintained by numerous parties through a consensus protocol, and each party has a copy of the ledger.

Smart contracts have distinct characteristics such as verifiability, distributed nature, and self-enforcing capabilities, which enable them to encode and execute business rules in a peer-to-peer network. With the absence of a trusted central authority, each node in the network has equal power. These features are likely to transform many traditional businesses. In this regard, we propose a model that uses smart contracts for the ATM cash withdrawal process.

Research methodology

1. Analyze the problem: Identify the problems associated with the ATM cash withdrawal process.
2. Understand the new system requirements to address the existing problems.
3. Design new system: Design a system architecture for the smart contract-based ATM cash withdrawal using Smart Mobile Banking Application (SMBA). The design should cover the components, their interactions, and utilizing security features of smart contracts.
4. Smart contract development: Develop smart contracts using a suitable programming language such as Solidity. The smart contracts should include the business logic, security features, and transaction details.
5. Integrating new system with ATM network: Integrate the smart contract-based system with the ATM network. This may involve setting up APIs, network protocols, and other necessary components.
6. Testing and deployment: Test the system extensively to ensure that it is secure, reliable, and efficient. Deploy the system on the ATM network after successful testing.
7. Customer education and training: Educate customers about the new system and train them on how to use it. This step is crucial to ensure that customers can use the system with ease and without errors.
8. To assess the feasibility of a smart contract-based system for cash withdrawal from ATM, our research designed and administered an online questionnaire. The study utilized a random sampling method, where a sample of 150 individuals was selected to participate in the survey. The use of a random sampling method enhances the external validity of the study by ensuring that the sample is representative of the population of interest and increases the generalizability of the study findings.

The current cash withdrawal process requires customers to have an ATM card provided by the bank. These cards are associated with payment gateway networks such as Visa, Mastercard, RuPay, etc. which enable customers to withdraw money from other bank ATMs or third-party ATMs. Our proposed system utilizes a smart contract to share customer data from the ATM to the bank server at a specified timestamp, eliminating the need for a Trusted Third Party or payment gateway. All cash withdrawal credentials are recorded on the public Ethereum blockchain and are implemented as indicated. Both the bank and the customer establish the cash withdrawal terms and conditions. Our goal is to increase transparency and eliminate the need for a payment gateway in the process.

Implementation details

The key difference between a centralized and decentralized ledger is that the latter involves a network of interconnected nodes that simultaneously create and store all data on the ledger. The distributed consensus protocol is crucial in the creation of a decentralized ledger, as it ensures that all nodes on the network agree on a unified transaction ledger without the need for a third party.

To implement a novel smart contract-based cash withdrawal system from ATMs, the following steps are taken:

Step 1: Customers install the Smart Mobile Banking Application (SMBA) on their smartphones, as suggested by Pote (2022).

Step 2: Customers initiate cash withdrawals by answering security questions, reach the nearest ATM, scan the QR code generated by SMBA on the ATM, and receive cash from the nearest ATM, as suggested by Pote (2022).

Step 3: A consensus protocol, such as Proof of Stake (PoS), can be used to generate a smart contract for the cash withdrawal transaction, including all credentials and logic.

Step 4: The data is securely communicated over the network using the AES algorithm.

Step 5: The smart contract is created based on the customer's transaction and stored on the blockchain.

The smart contract is written in Solidity, JavaScript is used in combination to interact with and test the smart contract. Ethereum Virtual Machine (EVM) executes smart contracts on the Ethereum blockchain, and JavaScript is used to create the web-based user interface to interact with the smart contract via web3.js.
Using a consensus protocol prevents a single entity from controlling a blockchain or altering the truth of what should be recorded. To make the data more robust, we are securing it with the AES algorithm, as suggested by Lin (2022). To encrypt data during transmission, AES is used to generate a secret key, which is then used with an AES library to encrypt the data. When decrypting data, the authorized party would need access to the secret key and the same AES library to decrypt the data. It's worth noting that AES provides a high level of data security.

Data analysis

In the realm of cash withdrawal, there exist multiple approaches, including physically visiting a bank, using an ATM, or creating an account with N26, which offers fee-free cash withdrawal without transaction limits and an international bank account number for all transactions, including cash withdrawal through CASH26. Each of these methods has its own set of advantages and disadvantages. Our focus is specifically on withdrawing physical money from an ATM, which currently utilizes a payment gateway system. To address this, we propose an alternative method that employs SMBA for cash withdrawal. Our approach eliminates ATM cards, instead we suggest using SMBA. Before customers can proceed to the nearby ATM and scan the generated QR code to withdraw cash, our proposed model performs thorough customer authentication through security questions. The utilization of smart contracts is a crucial aspect of this method, as it replaces the centralized payment gateway system with a more secure and decentralized solution.

Smart contracts are deployed on a blockchain, which is a distributed ledger that records all transactions in a transparent and secure manner. The blockchain uses cryptographic algorithms to ensure that transactions are encrypted and cannot be altered or tampered with once they are added to the ledger. This provides a high level of security, as it is virtually impossible to hack or manipulate the blockchain without the consensus of the majority of nodes on the network.

The complete logic and complex rules related to ATM cash withdrawal transactions via SMBA are implemented in smart contracts. Smart contracts are transparent and cannot be altered once deployed on the blockchain. This ensures that transactions are executed automatically and without any human intervention, reducing the likelihood of errors or fraud. The decentralized nature of the blockchain also ensures that there is no single point of failure, as the ledger is maintained by a network of nodes rather than a central authority.

The security of smart contract-based ATM cash withdrawal transactions can be validated with the help of, encryption, immutability, and automation. It provides a high level of security that is difficult to achieve with traditional banking systems. The table below shows a comparison of Smart contract-based ATM cash withdrawal transaction and Normal ATM cash withdrawal transaction.

Comparison	Smart Contract-based ATM Cash Withdrawal Transaction	Normal ATM Cash Withdrawal Transaction
Security	More secure due to the decentralized nature of smart contracts	Less secure due to the centralized nature of the banking system
Speed	Faster due to the automatic execution of smart contracts	Slower, especially during peak hours
Fees	Potentially lower due to the lack of intermediaries	May be higher due to fees charged by banks or ATM owners
Accessibility	Less accessible due to the need for a cryptocurrency wallet and blockchain knowledge	More accessible with just a bank account and ATM card
Limits	Potentially higher due to the programmable nature of smart contracts	Limited by predefined withdrawal limits set by banks or ATM owners

Table No. 1: Comparison of Smart contract-based ATM cash withdrawal transaction and Normal ATM cash withdrawal transaction.

After implementing smart contract on blockchain, it became evident that raising customer awareness about the importance of smart contract security is of utmost significance. To explore the feasibility of smart contract-based ATM cash withdrawal, we conducted a survey to investigate customers' attitudes towards withdrawing cash from ATMs. The survey aimed to assess the potential shift from the traditional method of ATM cash withdrawal, which involves the use of ATM cards, to a proposed new method of cardless cash withdrawal.

The survey questions were designed to gauge customers' understanding of ATM cash withdrawal processes and related technological concepts such as smart contracts. The survey aimed to identify the extent of the general public's awareness of these concepts and their perceptions of the security of the current ATM cash withdrawal process. To ensure a comprehensive understanding of customer attitudes, the survey questions were framed in a general manner. The below table shows responses of customers of mixed age and gender.

Questions	Yes	May be	No
Are you satisfied with current ATM cash withdrawal process?	30 %	30 %	40 %
Do you think the current ATM cash withdrawal process is secure enough?	30%	10%	60%
Would you like to have a better secure ATM cash withdrawal process?	90%	10%	Nil
Would you prefer cardless cash withdrawal from an ATM?	97.2%	1.8%	1%
Are you aware of Smart Contracts?	64.5%	5.5%	30.0%
Are you aware about the risk of using Smart Contracts?	53.8%	19.5%	26.7%
Are you aware of the benefits of using Smart Contracts?	62.6%	7.5%	29.9%
Are you willing to adopt Smart Contract-based service for ATM cash withdrawal?	63.7%	12.1%	24.2%

Table No. 2: Customers feedback towards change in ATM cash withdrawal process.

The Table No. 2 presents the responses of a survey conducted among ATM users regarding their satisfaction with the current ATM cash withdrawal process, their perception of its security, their willingness to adopt a more secure process, their preference for cardless cash withdrawal, and their awareness, understanding, and willingness to adopt smart contract-based services for ATM cash withdrawal.

The survey results show that 30% of the respondents are satisfied with the current ATM cash withdrawal process, while 30% are unsure, and 40% are not satisfied. Additionally, only 30% of the respondents consider the current process to be secure enough, while 10% are unsure, and 60% do not consider it to be secure enough. Furthermore, a significant majority (90%) of respondents expressed their desire for a more secure ATM cash withdrawal process, while 10% are unsure and none of the respondents are not interested.

The survey also indicates that "The majority of respondents (97.2%) prefer cardless cash withdrawal from ATMs", while only 1.8% are unsure and 1% do not prefer it. Moreover, the survey shows that while a significant portion of respondents (64.5%) are aware of smart contracts, a considerable proportion (30%) are not aware, and 5.5% are unsure. Similarly, while a majority of respondents (62.6%) are aware of the benefits of using smart contracts, a smaller proportion (7.5%) are not aware, and 29.9% are unsure. Furthermore, the survey reveals that while a significant portion of respondents (53.8%) are aware of the risks associated with smart contracts, a smaller proportion (19.5%) are not aware, and 26.7% are unsure. Finally, the survey results show that 63.7% of the respondents are willing to adopt smart contract-based services for ATM cash withdrawal, while 12.1% are not willing, and 24.2% are unsure.

The results of the survey suggest that," A significant proportion of the general public lacks a clear understanding of how ATM cash withdrawal works and are not familiar with Smart Contracts". It also suggested that customer awareness and education about smart contracts are essential to promote their adoption and trust in smart contract-based services, particularly in the context of ATM cash withdrawal. Additionally, addressing customers' concerns about security and errors is crucial to promote the adoption of smart contract-based services. The findings of this study can inform the development of strategies to promote the adoption and use of smart contract-based services in the financial sector.

Limitations

Smart contracts have a significant drawback in that they are challenging to modify and practically impossible to do so. If an error occurs while developing a smart contract, it can be time-consuming and costly to correct. Moreover, due to the limited number of transactions that a blockchain can process at a given time, it may be necessary to conduct an audit of the smart contract, which can be expensive. While using AES can be helpful, incorporating other security measures such as secure key management and access control will enhance the system's overall robustness.

Although the proposed approach provides a broad overview, implementing a secure smart contract-based cash withdrawal from an ATM may present several technical and non-technical obstacles.

Conclusion

Smart contract-based ATM cash withdrawal transactions offer a more secure, transparent, and cardless alternative to traditional banking systems. The decentralized nature of smart contracts ensures that transactions are tamper-proof and not susceptible to fraud or manipulation. Customers have complete control over their transactions, reducing their dependence on banks or ATM owners. The absence of intermediaries, such as payment gateways, in smart contract-based transactions creates the potential for lower fees, making them an attractive option. Despite the potential benefits, accessibility remains a challenge, and further research is necessary to fully explore the potential of smart contracts in facilitating secure and easily accessible financial transactions. The survey results indicate that the majority of respondents desire a more secure ATM cash withdrawal process, and most of them prefer cardless cash withdrawal from ATMs. However, a significant proportion of the general public lacks a clear understanding of how ATM cash withdrawal works and is not familiar with smart contracts. This underscores the importance of educating the public on the advantages and features of smart contract-based cash withdrawal systems to increase their adoption and overall security. Financial institutions and policymakers can leverage smart contracts to design and implement a more secure and efficient ATM cash withdrawal system that meets the needs and preferences of the general public.

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