A. AHMED

DESIGN AND DEVELOPMENT OF AN AUTOMATED USSD-BASED MOBILE PAYMENT SYSTEM FOR MONEY TRANSFER COMPANIES

THE GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES
OF
ATILIM UNIVERSITY

ABDIRAHMAN ABDI AHMED

A MASTER OF SCIENCE THESIS
IN
INFORMATION SYSTEM ENGINEERING

JANUARY 2024

ATILIM UNIVERSITY 2024

DESIGN AND DEVELOPMENT OF AN AUTOMATED USSD-BASED MOBILE PAYMENT SYSTEM FOR MONEY TRANSFER COMPANIES

A THESIS SUBMITTED TO
THE GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES
OF
ATILIM UNIVERSITY

BY

ABDIRAHMAN ABDI AHMED

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR
THE DEGREE OF MASTER OF SCIENCE
IN
INFORMATION SYSTEM ENGINEERING

JANUARY 2024

Approval of the Graduate School of Natural and Applied Sciences, Atilim University.

_____

Prof. Dr. Ender KESKİNKILIÇ
Director

I certify that this thesis satisfies all the requirements as a thesis for the degree of **Master of Science in Information Technology, Atılım University**.

_____

Prof. Dr. Murat KOYUNCU
Head of Department

This is to certify that we have read the thesis DESIGN AND DEVELOPMENT OF AN AUTOMATED USSD-BASED MOBILE PAYMENT SYSTEM FOR MONEY TRANSFER COMPANIES submitted by ABDIRAHMAN ABDI AHMED and that in our opinion it is fully adequate, in scope and quality, as a thesis for the degree of Master of Science.

_____	_____
Assist. Prof. Dr. Kerem AY Co-Supervisor	Prof. Dr. Murat KOYUNCU Supervisor

Examining Committee Members:

Assoc. Prof. Dr. Sacip TOKER Information Systems Engineering, Atılım University	_____
Prof. Dr. Murat KOYUNCU Information Systems Engineering, Atılım University	_____
Assoc. Prof. Dr. Gökhan Dağhan Educational Sciences , Hacettepe University	_____

Date: *23 January 2024*

I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

Name, Last Name: Abdirahman Abdi, Ahmed

Signature:

ABSTRACT

DESIGN AND DEVELOPMENT OF AUTOMATED USSD-BASED MOBILE PAYMENTS FOR MONEY TRANSFER COMPANIES

Ahmed, Abdirahman Abdi
M.Sc., Information Technology
Supervisor: Prof. Dr. Murat KOYUNCU
Co-Supervisor: Assist. Prof. Dr. Kerem AY

January 2024, 88 pages

In this study, an automated USSD-based mobile payment system for money transfer companies was designed and developed and it was aimed to examine the effects of this system. Within the scope of the study, the efficiency, accuracy, user experience and overall impact of the automatic USSD-based mobile payment system on financial transactions were examined. In this study, which used a quantitative research approach, data was collected from 16 authentic participants. A form developed within the scope of this study was used as a data collection tool. The findings revealed that the processing speed and accuracy of the current system was higher compared to traditional systems and that users were highly satisfied with this system. The research also addresses the challenges and opportunities in implementing these technologies and offers recommendations on how they can contribute to broader financial inclusion and economic development. The results of the study provide a model for developing financial systems using technology, especially for countries with similar economic and infrastructural contexts.

Keywords: Mobile Payment Systems, USSD Technology, Automated Financial Transactions, USSD-Based Payment, Financial Technology.

ÖZ

PARA TRANSFER ŞİRKETLERİNE YÖNELİK OTOMATİK USSD TABANLI MOBİL ÖDEMELERİN TASARIMI VE GELİŞTİRİLMESİ

Ahmed, Abdirahman Abdi
Yüksek Lisans, Bilgi Teknolojileri
Tez Yöneticisi : Prof. Dr. Murat KOYUNCU
Ortak Tez Yöneticisi : Dr. Öğr. Üyesi Kerem AY

Ocak 2024, 88 sayfa

Bu çalışmada para transfer şirketlerine yönelik otomatik bir USSD tabanlı mobil ödeme sistemi tasarlanmış ve geliştirilmiş ve bu sistemin etkilerinin incelenmesi amaçlanmıştır. Çalışma kapsamında otomatik USSD tabanlı mobil ödeme sisteminin finansal işlemler üzerindeki verimliliği, doğruluğu, kullanıcı deneyimi ve genel etkisi incelenmiştir. Nicel bir araştırma yaklaşımı kullanılan bu araştırmada 16 otantik katılımcıdan veri toplanmıştır. Veri toplama aracı olarak bu çalışma kapsamında geliştirilen bir form kullanılmıştır. Elde edilen bulgular, geleneksel sistemlerle karşılaştırıldığında mevcut sistemin işlem hızı ve doğruluğunun daha yüksek olduğunu ve kullanıcıların bu sistemden yüksek düzeyde memnuniyet duyduklarını ortaya koymaktadır. Araştırma aynı zamanda bu teknolojilerin uygulanmasındaki zorluklara ve fırsatlara da değinmekte ve bunların daha geniş finansal katılıma ve ekonomik kalkınmaya nasıl katkıda bulunabileceğine dair öneriler sunmaktadır. Çalışmanın sonuçları özellikle benzer ekonomik ve altyapısal bağlamlara sahip ülkeler için teknolojiden yararlanarak finansal sistemleri geliştirmeye yönelik bir model sunmaktadır.

Anahtar Kelimeler: Mobil Ödeme Sistemleri, USSD Teknolojisi, Otomatik Finansal İşlemler, USSD Tabanlı Ödeme, Finansal Teknoloji.

To my beloved parents, for their unending prayers and love, shaping the person I am today.

To my cherished wife, whose support and encouragement have been my constant source of strength.

To my brother and sister, whose unwavering support has been a pillar in my life.

To my friends, for always being there and encouraging me in my journey.

To my homeland, Somalia, a constant inspiration in my heart.

And to all those who have paved the way in the realms of science and knowledge, guiding my path.

ACKNOWLEDGMENTS

In the Name of Allah, the Most Gracious, the Most Merciful, from Whom all knowledge and success emanate, and without Whose will nothing can be accomplished.

I express my deepest gratitude to advisor Prof. Dr. Murat Koyuncu and co-advisor Assist Prof. Dr. Kerem Ay for their invaluable guidance, support, and patience throughout this research. Their insightful critiques and continuous encouragement have been pivotal, and for that, I owe them profound thanks. Appreciation is also due to the academic staff in the Departments of Information Systems Engineering, Computer Engineering, and Software Engineering at Atılım University, as well as the staff of the Graduate School of Natural and Applied Sciences.

My heartfelt thanks to my parents for their love, unending prayers, sacrifices, and unwavering belief in me. Their encouragement has been a guiding light in my journey, and without Allah's blessing through them, I could not have persevered.

To my loving wife, whose support, understanding, and encouragement have been a source of strength and inspiration. Her presence in my life has been a blessing from Allah, guiding me through challenges and celebrating every success.

And to my daughter, the joy of my life, who has brought immeasurable happiness and motivation into my world. Her laughter and love are constant reminders of Allah's graciousness.

Finally, my brothers and sister deserve special thanks for their unwavering support, love, and kindness, which have brightened my path and given me the strength and motivation to succeed.

This thesis is dedicated to these extraordinary individuals. Without their support, and the grace of Allah guiding and sustaining me, this dissertation would not have been possible.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS/ABBREVIATIONS

CDMA	Code-division multiple access
EVC	Electronic Voucher Cards
GSM	Global System for Mobile Communications
SIM	Subscriber Identity Module
SMS	Short Message/Messaging Service
SMSC	Short Message Service Center
USSD	Unstructured Supplementary Service Data

CHAPTER 1

INTRODUCTION

1.1 Background

In a broad sense, mobile money encompasses various services conducted and finalized through a mobile device, like a cell phone. Terms like "mobile wallet," "mobile money transfer," and "mobile payment" exist under this category. Mobile money essentially represents the convergence of telecommunications and banking services [1]. It involves a diverse range of stakeholders, including financial service providers and mobile network operators.

Mobile money services refer to electronic money accounts that can be accessed via a mobile phone [1]. These services give users of mobile phones easy and safe ways to send and receive money anytime, anywhere in the entire country using their phones, whether or not they have bank accounts. These services come with various features, such as mobile banking, mobile wallets, airtime transfers, and mobile transfers.

With a mobile wallet, users may send, receive, save, and make payments effortlessly from anywhere at any time. Money transfer capabilities mean that individuals can send funds from their mobile money account to another user no matter where they are, mirroring the simplicity of airtime transfers, where one can buy and send airtime to another user on the same network [2]. Mobile banking collaborates closely with traditional banks to deliver banking services to mobile money users.

Mobile phone payments are a crucial and preferred means of sending and receiving money within and between African countries. The significance of this lies in the fact that a large proportion of the African population lacks information about banking services and that many of them reside in urban areas with restricted access to traditional banking services [3]. Initially, the concept of mobile money transfers was more prominent in Asia and Europe. Nonetheless, most parts of the world, especially

North America, have seen a notable increase in mobile money transfers in recent decades [3]. Over time, the telecommunications and banking industries have collaborated to facilitate the provision of mobile money services [3].

As a result of the civil war that broke out in Somalia, important institutions collapsed. The nation's infrastructure was destroyed by the anarchy, which also destroyed banking and communication networks. The populace has been largely dependent on remittances from overseas since the fall of the central authority in 1991. However, due to the destruction of banking services and communication systems, transferring money became a significant challenge. As a result, the need to develop a substitute method of carrying out financial transactions emerged [4]. Gradually, the telecommunications industry emerged as a potential alternative for both entrepreneurs and civil society [5].

A recent study conducted by the World Bank in 2018 [6] found that in Somalia, mobile money usage was more widespread than the use of physical cash. Approximately 73 percent of adult Somalis regularly made use of mobile money services, according to the report, and in only one month, over $2.7 billion worth of mobile money transactions occur in Somalia. Presently, Somalia stands out as one of the countries with substantial investments in the global mobile money market, and the sector offers some of the most competitive telecommunication rates in Africa [2], [5]. As per information from the World Bank, EVC-plus services are the prevailing and widely preferred mobile money services in the southern and central regions of Somalia [2]. A variety of options are available for users to select from an interactive menu through the EVC Plus service. Users can use this service to top up airtime for their own mobile phone or for their friends, request refunds, and convert their balance into cash. Customers can first register for the service for free, fund their accounts, then utilize the money they have to trade and spend. EVC Plus has now become an integral part of daily transactions for people in southern and central Somalia. It is extensively used for a variety of payment purposes, such as paying utility and water bills, and the majority of financial transactions inside the family are done via this service. Additionally, EVC Plus offers a low-cost or commission option for international money transfers. It becomes a comprehensive tool for various financial demands with this additional capability.

Hormuud is a prominent telecommunications company in Somalia, providing a range of services such as mobile and internet connectivity. It began operating in the Horn of Africa nation in 2002, played a crucial role in the development and expansion of communication infrastructure in Somalia [7]. In this study, EVC Plus, Hormuud Telecom's digital payment service, has been utilized to automate the process of money transfer. Hormuud's Electronic Voucher Cards, known as EVC Plus, enable customers to send and receive money, settle bills, make purchases of various goods and services, and buy airtime through their mobile phones. Since its preferred mobile money services, over 83% of Hormuud Telecom's 3.6 million mobile phone subscribers now rely on the EVC Plus service for their everyday financial transactions [7].

In Somalia, using mobile money services doesn't necessitate having a bank account. All that's required is purchasing a mobile phone, a SIM card, and registering the service with the assistance of a representative from telecommunications agents. It's important to note that EVC Plus collaborates with Salaam Somali Bank and money transfer companies like Taaj Money Transfer and Tawakal Express. Thanks to this partnership, EVC Plus customers who have accounts with Salaam Somali Bank can access their bank accounts through EVC Plus and make large cash withdrawals and deposits at any time. Moreover, they can also send or receive money internationally directly through this service [4].

Importantly, EVC Plus uses USSD technology to enable these various mobile money and banking services, providing customers with an easy-to-use method to manage money via their phone. USSD is a feature found in mobile devices that activates a service by sending a message to the Short Message Service Center (SMSC), similar to SMS but without storing data. Information can only be accessed when logged in. USSD technology relies on plain text input and operates in a text-based format [8]. USSD technology is mainly used in areas with limited access to banking services, where mobile phones serve as an essential tool for various transactions such as money transfers, bill payments applications, top up prepaid cards and manage account funds. It's worth noting that USSD remains the favored communication channel for creating and expanding service offerings [9].

1.2 Problem Statement

The existing market of money transfer companies faces significant challenges due to the absence of APIs provided by Hormuud's EVC Plus service, a dominant player in the industry [2]. As a result, customers are reluctant to visit multiple offices to collect cash and then deposit it into their mobile wallets for usage. In response, these companies have resorted to manual, person-to-person transfers using EVC (Electronic Voucher Card), which is free of charge [5]. However, this manual process introduces a range of issues, including:

Additional time: Transactions take longer to complete, impacting efficiency.

Increased staffing needs: Handling a high volume of transactions, often exceeding 200, necessitates more personnel.

Higher probability of errors: Manual processes increase the likelihood of mistakes.

Increased labor costs: More users require additional staff, increasing operational costs.

Complex error rectification: When mistakes occur, rectifying them consumes time and resources, incurring additional expenses.

These challenges collectively hinder the efficiency and cost-effectiveness of money transfer companies, underscoring the need for a more streamlined and automated solution in the absence of EVC Plus APIs.

1.3 Suggested Solution

The goal of the suggested automated system is to smoothly interface with Hormuud's Simcard, offering a more effective and convenient way to transfer money while lowering the necessity for human participation. Here's a more detailed elaboration:

Integration with Hormuud's Simcard: The proposed automated system is designed to work in harmony with Hormuud's Simcard infrastructure, ensuring

a smooth and hassle-free experience for companies. The system and the mobile network may now interact more directly and securely thanks to this integration, which speeds up and improves the dependability of transactions.

Elimination of manual data entry: One of the key features of this proposed automated system is its ability to eliminate the need for manual data input during money transfer transactions. Currently, companies often have to enter transaction details manually, which can be time-consuming and prone to errors. With the automated system, this process becomes streamlined and error-free.

Reduced transaction time: By automating the data entry process, the proposed system significantly reduces transaction times. As a result, businesses may send money more swiftly and effectively. The entire money transfer procedure thus becomes more practical and easier to utilize.

Enhanced money transfer efficiency: Automation is the key to improving the overall efficiency of money transfer services. With manual processes, there's often a need for human intervention at multiple stages, leading to delays and potential errors. The automated method ensures that transactions are finished promptly and without incurring any further delays by eliminating these inefficiencies.

Cost savings: Automating money transfer procedures not only increases productivity but also lowers costs. Money transfer firms can run more profitably with shorter transaction times, fewer errors, and less manual work required.

The proposed automated system not only integrates seamlessly with Hormuud's Simcard but also offers significant advantages by eliminating manual data entry, reducing transaction times, enhancing overall efficiency, and generating cost savings for both money transfer companies and their customers.

1.4 Research Questions

Determining the right research questions is a crucial step in any investigative study. The research questions of this study are as follows:

1) How do employees perceive the impact of adopting automated money transfer system on the efficiency and accuracy of transactions, as compared to manual processes?
2) What challenges and barriers do employees perceive as significant in the transition from manual to automated money transfer system?
3) How do users perceive the benefits, security, and ease of use of automated money transfer system, and how satisfied are they with the system compared to manual processes?

1.5 Organization of the Thesis

This thesis is systematically organized into six comprehensive chapters to ensure a coherent flow of ideas and information. In-depth reviews of relevant research on mobile money and its worldwide ramifications are covered in Chapter 2. In-depth discussion of the methodology employed throughout the research is provided in Chapter 3 (the methodology section). In Chapter 4, the system's actual implementation is shown, along with an analysis of its practical features and obstacles. In Chapter 5, the key findings are summed up. Finally, discussions, conclusion and future directions for mobile money service research and developments are outlined in chapter 6.

CHAPTER 2

LITERATURE REVIEW

In 2019, out of a global population of approximately 7.7 billion, 5.1 billion individuals possessed a mobile device while 4.4 billion were active Internet users, equating to a penetration rate of 57%. Despite the universal surge in Internet usage rates, a pronounced digital divide persists, especially in less developed nations where countless individuals lack online access [10].

Furthermore, the Global Bank's 2017 Global Findex database sheds light on another pertinent issue: the state of financial inclusivity. Over 1.7 billion people globally do not maintain an affiliation with any banking institution, hence being termed "unbanked" '*Individuals who lack an account with a formal financial institution*'. The situation is especially stark in Africa, where approximately 90% of the population falls into this category [11]. In sub-Saharan African nations, the prevalence of banking services stands at a mere 10%, a stark contrast to developed nations such as the USA where this rate escalates to 90% [9].

In actuality, financial transactions that are secure and quick to conduct are essential for any business activity to thrive and expand in Somalia. The country faces challenges with a weak internet connection, leading to subpar online services, including online payment. Hormuud, the industry leader in mobile, started offering mobile money payments in 2012 [6], [12].

2.1 Mobile Money

Mobile money can be defined in various ways; it refers to the utilization of mobile phones to access financial services, as described by GSMA. Mobile money applications are often concise software programs either integrated into a SIM card or accessible via a mobile network. Even with a basic mobile device, a user can transmit

value to another individual. To convert this digital value into physical cash, the user can approach a retail agent who, after confirming the user's identity, facilitates the conversion [12]. For instance, consider a young individual from Tanzania who has relocated to Dar es Salaam for employment opportunities. Thanks to mobile money, he can regularly send modest amounts to his family in their rural hometown without relying on, or paying for, traditional couriers or delivering it in person. His family can then easily convert this digital credit into tangible cash through a nearby agent.

In Somalia, mobile payment systems ensure secure transactions. However, there's some uncertainty among customers regarding cash management credit analysis. An example of mobile money is MPESA in Kenya, which is paralleled with a bank guarantee. Safaricom, a mobile network operator in Kenya, manages MPESA funds, which are securely deposited in commercial banks. This setup allows customers to claim in case of transactional issues. In Somalia, mobile services such as EVC-plus function similarly to MPESA in Kenya. Due to the devaluation of Somalia's currency, both businesses and individual consumers have turned to mobile money for efficient trading. Consequently, mobile money has become an essential financial tool in Somalia, reducing the reliance on physical cash [2].

2.2 The Evolution of Mobile Financial Services

During World War II, mobile banking emerged when field cash offices provided local currency to various units, facilitating financial transactions for the army and post offices. These cash offices, often situated in tents or mobile trucks, catered to army units, especially in remote areas [13]. Furthermore, mobile banking's roots can be traced back to 1946 in Kirkintilloch, Scotland [14]. Here, Royal Bank of Scotland, initiated the first commercial mobile services. This early form of mobile banking was conducted using vans, offering bank facilities on the move [15].

Schofield and Kubin [16] note that banking services initially targeted rural regions such as the highlands and eastern Scotland. This banking model quickly expanded from Scotland to global regions including Africa, the Americas, Arabic nations, and Europe. The concept of mobile banks took a modern turn in 1999 when European

banks began offering services through WAP-enabled smartphones, marking a significant step in the evolution of bank account access.

The Suoranta [17] suggests that Finland led the way in mobile banking, attributed to its strong growth in mobile industries. Pelkonen and Dholakia [18] believe that the 19th-century advancements in telecommunications paved the way for financial institutions to see the potential in mobile-based financial services. Lonie [19] emphasizes that the rise of smartphones revolutionized the business landscape, introducing a new model that ensures constant accessibility for users.

In 2009, Standard Chartered Bank introduced mobile banking in seven African markets, utilizing unstructured data based on GSM, enabling customers to access banking services via mobile devices. However, Okiro and Ndungu [20] argue that these services, while providing convenience, come at certain fees and charges for the users.

In Somalia, Hormuud Telecom initiated its mobile money service, EVC Plus, in 2011, marking it as the first mobile money platform within Somalia. The launch of EVC Plus significantly contributed to transforming the financial landscape in the country, offering a widely used payment method that was distinctive for being entirely free at the point of use. The service has continued to evolve and impact various sectors within Somalia, including the performance of local firms and the broader financial inclusion narrative in the country [4].

2.3 USSD

Unstructured Supplementary Service Data is a long-standing communication method in mobile phones, particularly within the GSM technology. It's more commonly adopted worldwide compared to another system known as CDMA (Code-division multiple access) [8]. USSD allows mobile phones to communicate with network servers. This system is not tied to a specific device or SIM card and offers a more affordable and quicker alternative to traditional SMS. A notable feature of USSD is its capability to support interactive applications with menus. It can manage both voice and data communications simultaneously [21], [22].

USSD is a versatile tool that has enabled various mobile services like chatting, m-commerce, checking prepaid balances, requesting callbacks, updating software, and mobile banking [22]. Users can 'pull' information on-demand, such as news, weather forecasts, movie details, sports scores, currency rates, stock market updates, and directories. On the other hand, 'push' services deliver data directly to users, like voting results, polls, and emergency alerts. Businesses utilize USSD as an advertising platform by listing themselves on USSD menus to showcase their offerings [21].

USSD offers several benefits for users and network operators. It's quick, with responses typically coming in just 2 seconds. It's universal, working on all GSM phones, and doesn't rely on a specific phone or SIM card. Users enjoy the convenience of not having to type messages or remember codes to access services. Its menu-driven design supports applications that enhance user experience, like Value Added Services (VAS). For network operators, USSD can boost the Average Revenue Per User (ARPU) and remains functional even if the user is roaming. However, there's a downside: USSD occupies resources for the entire duration of a transaction. This can increase the traffic between the mobile network's Message Control Centers (MSC) and the Home Location Register (HLR) [22].

USSD is a distinctive feature of GSM technology. Embedded within the GSM framework, it's designed to transmit data across the network's signaling channels. Unlike SMS, which operates on a store-and-forward basis, USSD is session-based, making it more transactional. This ensures faster response times for interactive apps when using USSD compared to SMS. Another intriguing aspect of GSM is its flexibility in security. GSM Network operators have the freedom to select the specific algorithm they want, ensuring robust authentication and security [8].

USSD technology is integrated into the GSM standard, making it accessible on all GSM mobile devices, including what are termed "feature phones." These feature phones, also known as "low-level phones," stand in contrast to smartphones due to their limited functionalities [23]. They range from early 2G models to more recent ones, but typically lack features like cameras, internet access, or significant storage space. Some might possess these features but in a very limited capacity compared to

modern smartphones. Despite these limitations, feature phones can perform USSD financial operations, such as banking. However, they either have subpar or entirely lack features like cameras, primary biometric tools, and extensive memory space, which many authentication models require [23]. Given that USSD technology operates through text and accepts plain text inputs, any authentication system designed for the USSD platform must be text-based [8]. USSD boasts several significant advantages:

Speedy data transmission: USSD sets up and sustains a direct session between the sender and recipient, facilitating rapid data transfer. According to [24] the response time for USSD is just 2 seconds, regardless of the outcome (successful or failed).

Security: There's no storage of sensitive information on the mobile device, making it a secure choice [24].

User-friendly interface: Its easy-to-use, menu-driven system, which comes with menu option timeouts, is ideal for developing mobile payment apps.

Multifunctionality: USSD allows for simultaneous voice calls and service use without the need for internet connectivity.

Enhanced security over SMS: User inputs through USSD are not stored on the mobile device, unlike SMS.

Cost-effective for service providers: USSD employs SS7, which can also be utilized to send notifications about new services.

Platform independence: USSD isn't tied to any specific phone or SIM, making it universally compatible with all GSM mobiles.

Roaming capabilities: USSD messages are channeled through the user's home network. This ensures that all services available on the home network remain accessible even when roaming [24].

2.4 Related Works

In the realm of mobile payment solutions, Dayang and Hamza [9] delved into the challenges posed by regions with limited internet connectivity. Recognizing the ubiquity of mobile payment accounts like orange money or MTN mobile money in certain African countries, they identified prevalent issues such as ergonomic challenges and the need for tangible proof of payment. To address these challenges, they proposed a novel USSD-based mobile payment model that operates seamlessly both online and offline. This model, inspired by the operational framework of orange money outlets, employs a dual SIM card system—one for the seller and another for the buyer. Transactions are initiated through a USSD code, ensuring the transfer of funds upon the buyer's confirmation. A salient feature of this model is its commitment to user security; it refrains from storing any confidential data of either party involved in the transaction. The paper underscores the potential of USSD as a pivotal tool in regions grappling with inadequate banking services and internet infrastructure.

In their exploration of authentication models suitable for the USSD channel, Binitie, et al. [8] highlight the inherent vulnerabilities of the Direct PIN entry method, which is notably susceptible to shoulder surfing attacks. Given that USSD technology is predominantly text-based, it restricts the implementation of many existing authentication models that rely on graphical or biometric inputs. The authors emphasize the increasing significance of user authentication models due to the surge in mobile-based services and the associated security risks. The paper critically examines various existing authentication models against shoulder surfing attacks, including those based on graphical, textual, and biometric techniques. Some of these models utilize pass-matrix, cued click points, PIN-based methods, session passwords, OTPs, and more. However, many of these models are not feasible for USSD channels due to their reliance on graphical displays, large memory requirements, or specialized hardware.

They underscore the challenge of implementing robust authentication models on the USSD channel, especially given the limitations of feature phones, which are prevalent in many regions. These phones often lack the capabilities to display colored images or

store large applications. The paper's primary objective is to discern why, despite the existence of robust authentication models against shoulder surfing attacks, the USSD channel predominantly employs the vulnerable direct PIN entry method.

In the domain of health informatics and mobile-based solutions, a significant contribution was made by researchers Mosweunyane et al. [25]. With one of the highest reported rates of tuberculosis cases globally, Botswana, the writers tackled the pressing issue of the disease's outbreak. This alarming rate is attributed to the rising HIV prevalence in the region. The paper underscores the importance of tracing and monitoring close contacts of diagnosed TB patients, given that these individuals are at a heightened risk of contracting the disease. The current methodology in Botswana, which is predominantly manual and paper-based, is riddled with challenges such as inadequate human resources, time-consuming travel, poor data record management, and difficulties in data analysis. To address these challenges, the authors propose a novel USSD-based system for TB contact tracing. This system leverages the high mobile phone penetration in Botswana and offers real-time data collection to a centralized store. The proposed solution aims to streamline the TB contact tracing process, facilitate decision-making, and enhance report generation for health personnel. The paper provides a comprehensive overview of the USSD technology, its advantages over SMS, and its potential applications in health systems, particularly in patient monitoring.

In the sphere of health informatics and multiculturalism, Osae-Larbi [26] delves into the challenges posed by language barriers in accessing vital health information, particularly in multicultural societies. Using Ghana as a case study, the paper highlights the increasing diversity due to domestic and international migration and the associated linguistic challenges in healthcare. The author underscores the significance of bridging language barriers to ensure equitable participation in healthcare, especially for new migrants and linguistically diverse groups. Medical interpreters are one example of a traditional method; however helpful, their availability and accessibility are restricted. To address this, author proposes an innovative mobile phone-based solution using USSD codes. This intervention, leveraging the widespread use of mobile phones in Ghana, aims to provide health information in multiple languages,

ensuring that diverse populations can access pertinent preventive health information. The USSD protocol facilitates two-way communication between mobile phones and service providers without the need for internet access. By dialing specific USSD codes, users can receive health information in their preferred language. The paper emphasizes the potential of this intervention to enhance access to health information, promote public health, and foster multicultural relationships in Ghana.

In the paper [10], Agbezoutsi et al. present an innovative approach to enhance mobile money transactions by integrating USSD with blockchain technology. The process begins with a user initiating a transaction using a specific USSD code, signaling that the transaction data is intended for the Blockchain. This data is then transported via USSD to the Blockchain, ensuring all necessary transaction details are accessible. Once transported, the transaction undergoes verification and is subsequently recorded in the Blockchain. This integration not only ensures the traceability of transactions across the mobile money ecosystem but also leverages the inherent security and transparency features of blockchain technology.

In the evolving landscape of mobile-based services, Lakshmi et al. [24] present a comprehensive analysis of the USSD technology, its architecture, and its potential security threats. USSD, a real-time session-oriented technology, has gained prominence for offering mobile network and banking services without the need for internet connectivity. The paper underscores the advantages of USSD over SMS, highlighting its cost-effectiveness, platform independence, and enhanced security features. However, the authors also draw attention to various security threats inherent in USSD, including the susceptibility to tampering, replay attacks, and the potential misuse of confidential information displayed during transactions. The paper further delves into the GSM-specific limitations and proposes security enhancements to bolster the USSD-based mobile banking application's information security. Among the proposed solutions are the obfuscation of confidential information during balance inquiries and fund transfers, ensuring that only masked data is displayed to the user. The authors emphasize the need for these enhancements to ensure the secure and efficient use of USSD for banking and other services.

In the study [27], Ochoa et al. address the challenges faced by Paraguay's General Office of Health Surveillance in timely data collection and dissemination. The traditional method, which primarily involves manual processing of printed notification forms, results in significant delays in information dissemination. To tackle this, the researchers propose a model that employs USSD mobile technology to optimize the collection of geographically-referenced data on suspected or confirmed disease occurrences. Using the Mobicents platform, the model facilitates real-time USSD dialogues between users and a centralized system, logging each interaction in a georeferenced database. After that, a Geographic Information System (GIS) module processes and displays this data, making it possible to identify and visualize possible epidemiological risk zones in real time. This innovative approach not only streamlines data collection but also enhances decision-making processes in public health.

In the research [28], Mallik et al. shed light on the global challenge of financial exclusion, with over 2 billion individuals lacking access to traditional banking or digital financial services. Recognizing the barriers such as distrust in banking systems, technological illiteracy, and high banking fees, the study introduces a solution leveraging USSD technology. They propose a USSD-based digital wallet, designed to be accessible even on basic feature phones, eliminating the need for internet connectivity. This wallet offers an array of banking services, from bill payments to loan applications, catering to both the unbanked and those with existing bank accounts. By bridging the technological and banking divide, this research underscores the potential of USSD in promoting financial inclusion, especially in underdeveloped regions.

In Somalia, the telecommunication sector is dominated by four primary private companies: Hormuud, Telesom, Golis Telecom, and Somtel. These entities have introduced various mobile money services, catering to different regions and customer needs. Telesom offers the ZAAD service in Somaliland, Golis Telecom provides the SAHAL service in the east northern regions, Somtel delivers the e-Dahab service in both northern and southern regions, and Hormuud offers the EVC-plus service in the

south and central regions. Notably, EVC-plus, introduced by Hormuud, stands as the pioneer in mobile money services in the country. It has garnered significant adoption, with functionalities allowing users to pay bills, transfer funds, purchase goods, and recharge airtime.

This service has become integral to daily transactions in south and central Somalia, with a vast majority of Hormuud's mobile phone customers relying on EVC-plus for their financial needs [14]. Customers can use EVC-plus to transfer and receive money, pay bills, and make purchases using mobile devices. Depending on the daily transaction, the people in south and central Somalia start using EVC-plus services extensively. Mobile payment methods are widely used by businesses when billing for services like energy and water [5]. Approximately 3 million individuals, accounting for over 82% of the 3.6 million total, are Hormuud mobile phone users and presently utilize EVC plus service for daily transactions [7].

2.5 Gap in Existing Literature

While several studies have delved into the potential of mobile money services in developing countries, there remains a significant gap in addressing the challenges faced by money transfer companies due to the absence of APIs, especially in the context of dominant services like Hormuud's EVC Plus [2]. Existing literature has explored the landscape of mobile money services, their adoption rates, and their impact on financial inclusion. For instance, the widespread adoption of EVC-plus in Somalia and its role in daily transactions has been highlighted [7]. However, the specific challenges faced by money transfer companies, such as the need for manual transfers, increased transaction times, higher error rates, and the associated operational costs, have not been comprehensively addressed. Moreover, while some papers have proposed USSD-based solutions for financial inclusion, the unique challenges posed by the lack of APIs in dominant services like EVC Plus remain largely unexplored. The manual processes adopted by companies in the absence of these APIs introduce inefficiencies that have not been the primary focus of previous research.

2.6 Importance of the Study

This study aims to bridge the identified gap by proposing an automated system that seamlessly integrates with Hormuud's Simcard, addressing the challenges posed by the absence of EVC Plus APIs. Unlike previous research that primarily focused on the broader landscape of mobile money services, this study delves deep into the operational challenges faced by money transfer companies and offers a tangible solution.

The proposed system not only promises efficiency and user-friendliness but also aims to significantly reduce operational costs, transaction times, and error rates. By eliminating manual data entry and leveraging the infrastructure of Hormuud's Simcard, this research introduces a novel approach to money transfers in the context of Somalia's unique challenges.

In essence, this study contributes to the existing body of knowledge by offering a targeted solution to a specific problem that has been overlooked in previous research. The findings and solutions proposed herein have the potential to revolutionize the money transfer industry in Somalia and provide a blueprint for similar challenges in other developing countries.

2.7 Comparative Synthesis of USSD-based Systems in Existing Literature

Table 2. 1 Comparative synthesis of the related studies

Papers	**Domain**	**Security**	**Reporting**	**Auto Transfer**
Design of a USSD system for tb contact tracing [25].	Health	NO	YES	NO
Bridging the language barrier gap in the health of multicultural societies [26]	Health	NO	NO	NO
Using USSD-based mobile payment in context of low internet connection [9].	Finance	YES	NO	NO

Table 2.1 (continues)

Towards blockchain services for mobile money traceability and federation [10]	Finance	YES	NO	NO
USSD Digital Wallet [28].	Finance	YES	NO	NO
Design and development of automated USSD-based mobile payments for money transfer companies (current study)	Finance	YES	YES	YES

The Table 2.1 presents a comparison of various papers focusing on the application of USSD technology across two primary domains: health and finance. The table evaluates each system based on the presence of three critical features: Security, Reporting, and Auto Transfer capabilities.

- Design of a USSD System for TB Contact Tracing (Health Domain)
    - Focuses on health, specifically tuberculosis contact tracing.
    - Features Reporting capability, but lacks Security and Auto Transfer. This system aids in data collection and monitoring but does not prioritize transaction security or automation.
- Bridging the Language Barrier Gap in Health of Multicultural Societies (Health Domain)
    - Addresses language barriers in healthcare for diverse populations.
    - Lacks Security, Reporting, and Auto Transfer features, indicating its primary role may be in communication facilitation rather than data management or transactional efficiency.
- Using USSD-Based Mobile Payment in Context of Low Internet Connection (Finance Domain)
    - Targets financial transactions in areas with poor internet connectivity.
    - Incorporates Security but lacks Reporting and Auto Transfer, focusing on secure transactions while potentially missing out on advanced data handling and automation.

- Towards Blockchain Services for Mobile Money Traceability and Federation (Finance Domain)
    - Integrates blockchain for enhancing mobile money services.
    - Offers Security but does not provide Reporting or Auto Transfer, indicating a focus on secure and traceable transactions without additional data management or automation features.
- USSD Digital Wallet (Finance Domain)
    - A digital wallet utilizing USSD technology.
    - Includes Security but lacks Reporting and Auto Transfer, ensuring secure transactions but without the added benefits of data reporting or transaction automation.
- Design and Development of Automated USSD-Based Mobile Payments for Money Transfer Companies (Finance Domain)
    - Stands out with all three features: Security, Reporting, and Auto Transfer. This holistic approach signifies a comprehensive solution in mobile payment technology. The focus on Security ensures safe transactions, vital in the financial domain. Reporting capability allows for better data management and analysis, important for both operational transparency and strategic decision-making. Auto Transfer functionality enhances user experience and operational efficiency by automating repetitive tasks and reducing manual errors.

This study represents a significant leap in the application of USSD technology within the financial sector. Unlike the other systems listed, the study encompasses a complete range of features necessary for a robust, efficient, and user-friendly mobile payment system. This comprehensive approach addresses the critical needs of modern financial transactions: ensuring security, facilitating detailed reporting, and automating the transfer process.

CHAPTER 3

METHODOLOGY

It is crucial to have a stable or efficient methodological overview in order to complete any research without a defined direction or technique to evaluate or identify all the vital measures associated with the identified or evaluated study here [29]. This thesis' approach is essential since it provides the framework for comprehending the ideation, design, and implementation of the suggested system. It provides insights into the reasoning behind the choice of particular tools and technologies in addition to acting as a guide for the procedures involved in system development. This thorough explanation guarantees the transparency and reproducibility of the research, facilitating a clear comprehension of the project's parameters. Developing a workable research technique is the first step towards doing productive research [29].

3.1 Research Design

Research design is a comprehensive blueprint that outlines the specific techniques and procedures for gathering and evaluating the required information. It refers to the deliberate arrangement, organization, and approach taken in a study to get information that addresses research inquiries and manages variability [29]. This study involved observing and analyzing factors in order to acquire information on variables within a sample group. A research design incorporating quantitative approaches implemented using online survey questionnaires was employed. According to Fraenkel et al. [30], a survey is described as a method of gathering information from a sample of individuals. This is typically done through asking questions to understand their abilities, opinions, attitudes, beliefs, or knowledge to conclude the larger population to which they belong.

3.2 Survey

In this study, an online survey containing 26 questions was developed and used as a primary tool for data collection. To ensure the quality and effectiveness of the survey instrument, an expert from the field of Information Technologies was invited to provide feedback on the clarity and relevance of the questions. This collaborative revision process resulted in the refinement of several questions, strengthening the overall quality and accuracy of the data collection tool. At the final stage, there were 16 multiple-choice questions, 1 multiple-select question, 4 Likert scale questions, 4 short-answer questions, and 1 open-ended question in the questionarre.

3.3 Participants

In this study, the participants, or respondents, are defined as individuals who are currently employed in money transfer companies in Somalia, and directly involved in manual transfer processes. These respondents are integral to the research as they provide firsthand insights into the practical challenges and issues faced in manual money transfer operations. Their experiences and perspectives are crucial for understanding the real-world implications of manual processes and the potential benefits of automating these systems. A total of 16 people participated in this research. Table 3.1 highlights the demographic characteristics of the 16 respondents in the study.

Table 3. 1 Demographic characteristics of the respondents

Item	Category	Frequency	Percentage
Gender	**Male**	**10**	**62.50%**
	Female	6	37.50%
	Total	16	100.00%

Table 3.1 (Continued)

Age	16 years	1	6.3%
	18 years	1	6.3%
	19 years	1	6.3%
	20 years	**2**	**12.5%**
	21 years	1	6.3%
	22 years	**2**	**12.5%**
	23 years	**2**	**12.5%**
	24 years	**2**	**12.5%**
	27 years	**2**	**12.5%**
	30 years	**2**	**12.5%**
	Total	16	100.00%
Education	High School	6	37.5%
	Bachelor	**10**	**62.5%**
	Total	16	100.00%
Experience	6 months	1	6.25%
	1 year	**7**	**43.75%**
	2 years	5	31.25%
	3 years	3	18.75%
	Total	16	100.00%

Table 3.1 shows a distribution of 16 individuals based on gender, with 10 males (62.5%) and 6 females (37.5%). This indicates a higher representation of males in the participants. The second background characteristics was age. The age range in the data spans from 16 to 30 years, with each age group varying in representation. The ages 20, 22, 23, 24, 27, and 30 years have an equal frequency of 2 individuals each, accounting for 12.5% of the total sample for each age group, and the average of these ages are 24 years. The ages 16, 18, 19, and 21 years are represented by 1 individual each, making

up 6.3% of the participants for each of these ages. This shows a fairly even distribution across the age groups, with a slight emphasis on the higher age groups (20 years and above). Additionally, the study made an effort to determine the respondents' educational background. The participants are divided into two groups: those with High School education (6 individuals or 37.5%) and those with Bachelor degree (10 individuals or 62.5%). This indicates a higher prevalence of degree level education among the participants. Last but not least, the study attempted to find the experience level of the participants involved in the survey. Level of experience was one of the essential criteria utilized to select and identify the respondents for the study. The experience mentioned here relates to the duration for which individuals have been working in their current manual transfer role. This period ranges from 6 months to 3 years. The rationale behind assessing their experience is based on the assumption that the longer someone has been in this role, the more skilled and efficient they are likely to become. Generally, with more experience in a job, an employee's error rate is expected to decrease due to increased familiarity and proficiency with the tasks. One individual (6.3%) has 6 months of experience, 7 individuals (43.8%) have 1 year of experience, 5 individuals (31.3%) have 2 years of experience, and 3 individuals (18.8%) have 3 years of experience. The most common experience level of the participants is 1 year.

3.4 Data Collection Process

The data-collecting process is an essential component of research methodology since the researcher must determine a specific strategy for gathering information based on the study subject. According to Pandey and Paydey [29], data collection is the process of gathering and measuring data on certain variables in a structured manner, allowing researchers to methodically address research topics. The successful outcome of a certain research project is determined by the efficient handling of data collecting.

To gather relevant insights on user experience with the developed automated transfer system, this research employed a two-pronged approach. First, a curated sample of participants currently engaged in manual money transfer operations within recognized

companies received a Google Form questionnaire. This strategic data collection ensured firsthand perspectives on the specific challenges and processes related to the research topic. The online platform offered convenience for participants and efficient data management.

Furthermore, to directly assess user interaction with the system, the researcher conducted a software testing from the 20th to 23rd survey questions. This involved installing the software on participants' phones and observing their engagement with the automated transfer process while they answered related questions. This approach provided data on user experience and potential areas for improvement within the newly developed system.

In order to gain a more nuanced understanding of the user experience, detailed individual interviews were conducted online. Each interview was meticulously planned and executed on a one-on-one basis to ensure focused attention and a personalized approach. The Google Meet platform was chosen for these interviews due to its reliability and the capability to share and view screens in real-time. This feature was particularly beneficial for observing how participants interacted with the software in their natural setting.

During these sessions, the researcher shared the .apk file of the automated transfer system with the participants through the meeting interface. Instructions for installation were provided, and assistance was available if any technical difficulties were encountered. This process allowed the participants, all of whom were based in Somalia, to install the software directly onto their smartphones. By witnessing the installation process and the participants' initial interactions with the software, the researcher could gather real-time, feedback. This approach not only helped in understanding the user experience but also provided insights into the practical aspects of software deployment and usability in a real-world environment.

3.5 Data Analysis

Data collecting, input, and summarization were performed with Google Forms and Microsoft Office Excel 2021 spreadsheets. Upon completion of the data collecting and

categorization process, the gathered information was condensed and organized into tables, bar, and pie graphs for clarity and ease of interpretation. Descriptive statistics including frequency and percentage were employed to succinctly convey the prevalence and distribution of the responses, thus providing an insightful quantitative overview of the data.

3.6 Software Testing

Software testing is a fundamental aspect of software development, crucial for ensuring the quality and functionality of a software product. Glenford et al. [31] define it as the process of analyzing a software application to detect differences between existing and required conditions. This phase is essential for identifying defects and verifying that the software meets its design specifications. Effective software testing minimizes the risk of failures and ensures the software's reliability in real-world applications.

User testing, a specific branch of software testing, focuses on the user's interaction with the software. Rubin and Chisnell [32] emphasize its significance in assessing how real users perceive and use the software. This type of testing is crucial for understanding the usability and user experience aspects of a software product. It enables developers to tailor the software to better meet user needs and expectations, thereby enhancing the overall user satisfaction and software efficacy.

The user testing phase of the software was designed to evaluate the system's functionality, user interface, and overall user experience. This phase was integral to understanding how end-users, specifically those involved in manual money transfer operations, interacted with the software and perceived its utility. The testing methodology was developed to provide a comprehensive view of the system from the user's perspective.

Participants were carefully selected based on specific criteria: individuals currently employed in money transfer companies and directly engaged in manual transfer operations. This criterion ensured that the feedback was relevant and came from users who could potentially benefit most from the automated transfer system. The testing

process was conducted through one-on-one online interviews using the Google Meet platform. During these interviews, the following steps were taken:

- Installation: participants were guided to install the automated transfer system on their smartphones. An .apk file of the system was shared with each participant through the meeting interface. Assistance was provided as needed during the installation process.
- Walkthrough: once the installation was complete, participants were given a brief walkthrough of the software. This included an overview of its features, how to navigate the interface, and the process of executing a transfer.
- User interaction: participants were then asked to interact with the software by performing a series of tasks that mimicked real-life usage scenarios. This hands-on interaction was crucial for observing how users navigated the system and for identifying any usability issues.
- Feedback collection: throughout the testing session, participants were encouraged to verbalize their thoughts and experiences. Questions were asked regarding the ease of use, interface intuitiveness, and overall satisfaction with the system. The researcher observed the participants' interaction with the system, noting any difficulties or points of confusion.
- Screen sharing: utilizing the screen sharing feature of Google Meet, the researcher was able to observe real-time interaction with the software, providing insights into the user experience.

The data collected from these sessions were analyzed to assess the system's usability and effectiveness. Participant feedback played a crucial role in identifying areas for improvement. Observations made during the screen-sharing sessions helped in understanding how users navigated the system, any challenges they faced, and their overall engagement with the software. The user testing phase was pivotal in refining the system, ensuring it was user-friendly and met the needs of its intended users. It provided a detailed understanding of how the system would perform in real-world scenarios, directly informing further development and enhancements.

3.7 Limitations of the Study

This research, while providing valuable insights into the user experience with the developed automated transfer system, encountered certain limitations that are important to acknowledge.

Firstly, the scope of the study was restricted by the availability of a specific subset of participants. Only 16 individuals were involved in the study, primarily due to the stringent criteria set for participant selection. The research focused on individuals who are currently employed in money transfer companies and specifically those engaged in manual transfer operations. This criterion was essential to ensure that the feedback and data collected were directly relevant and informed by firsthand experience in the domain of manual money transfers. However, the narrow focus on this specific group significantly limited the number of available participants, which may impact the generalizability of the findings.

Additionally, another notable limitation was the system's compatibility. The automated transfer system developed for this study was designed to work with only one operator. This limitation could potentially affect the system's applicability and scalability, as it may not accurately represent or adapt to the varied environments and systems used by other operators in the field. This constraint also means that the study's findings may not be fully representative of the broader context of automated money transfer systems, which often need to interact with multiple operators to be effective in a real-world setting.

These limitations are critical to consider when interpreting the results of this study. They highlight the need for further research that includes a more diverse and larger sample of participants and a system capable of operating across various operators to enhance the generalizability and applicability of the findings.

3.8 Reliability

The degree to which an assessment instrument produces steady and consistent outcomes is known as its reliability. When many researchers do the same study and

provide comparable findings, the study is considered trustworthy [33]. In this study, validity of the study was ensured by concentrating only on pertinent inquiries and a suitable sample size. As such, the outcomes of this study will hold true if it is repeated by another researcher.

3.9 Ethical Considerations

The ethical consideration of this research study involved the consideration of the set of articles that gives effective information about USSD-based systems and the components of the auto payments system that need to be added. The researcher would ensure that all the articles chosen from online databases are accessible to all the readers as an ethical consideration. The availability of information to re-verify all the critical data added by the researcher is considered an equally important ethical consideration. Any kind of academic misconduct has not been allowed in this research study. All the authentic articles and journals that have been selected from verified sources have been properly referenced and cited as per the requirement of the utilization of their information. All the ethical considerations have been maintained by the researcher without any bias.

3.10 Chapter Summary

This chapter outlined the research design, which includes a quantitative survey distributed to 16 participants from money transfer companies, focusing on their experiences with manual transfer processes. The data collection combined an online questionnaire with hands-on software testing by participants, providing both subjective feedback and objective usability data. Analysis was conducted using Excel and Google Forms, ensuring structured data interpretation. The chapter also emphasizes the validity, reliability, and ethical considerations of the study, ensuring the research's integrity and adherence to academic standards.

CHAPTER 4

DESIGN AND IMPLEMENTATION

This chapter explores the detailed requirements, design, and final implementation of the automated mobile payment system based on USSD. It offers a thorough explanation of the system in plain language, making it understandable and approachable to all readers. This strategy is to provide a comprehensive knowledge of the architecture and operation of the system, even for non-technical individuals.

4.1 The Project

The principal aim of this endeavor is to create an automated mobile payment system utilizing USSD technology, with the intention of transforming the money transmission procedure within the realm of mobile payments. This system aims to transform the process of transferring money in the context of mobile payments. This system is specifically designed to cater to the requirements of money transfer providers, providing a solution that automates the process of transferring monies straight to clients' cellphone phones.

The project's importance is emphasized by its potential influence on the mobile payment sector, particularly in areas where conventional banking services are restricted or unavailable.

For this project, a complete system has been created by combining several technologies like Laravel for the online interface, C# for backend services, and Flutter for the mobile application. This connection guarantees a smooth and effective transaction procedure, enabling firms to move payments effortlessly and with dependability. The system's design is a result of the increasing need for automated mobile money transfers that are more efficient, precise, and economical.

The creation of this system is crucial since it signifies a substantial advancement in mobile payment technology. The solution tackles the difficulties encountered by conventional money transfer techniques, which frequently entail labor-intensive procedures that are time-consuming and susceptible to mistakes. Through the automation of these procedures, the system improves both the efficiency and accuracy of transactions, while also increasing the cost-effectiveness of mobile money operations.

4.2 System Design and Architecture

The system's design and architecture are pivotal in understanding how the automated USSD-based mobile payment system functions as a cohesive unit. The system's architecture is intentionally built to be flexible, adaptable, and impervious, guaranteeing simplified management of transactions and customer data. The framework is organized in a multi-level engineering, containing the presentation layer, the business rationale layer, and the information access layer, each filling an unmistakable need and cooperating consistently with each other.

4.2.1 System Requirements

The following are the system requirements essential for implementing the automated USSD-based mobile payment system.

- Hormuud’s Simcard
- Android Phone
- Windows Server
- XAMPP software
- MySQL database.
- Companies’ API to reiterative the transaction transfer to be sent.
- Access to USSD gateway

4.2.2 Modeling

Through a set of clearly defined stages, the system created in this study ensures efficiency and security while streamlining the money transfer process. The automated USSD-based mobile payment system initiates with the company sending transaction data to the server, which then relays this information to the mobile app to dial a USSD payment short code for the transfer. The USSD gateway processes these requests with the mobile network operator, requiring PIN entry for authentication. Upon successful verification, the operator confirms the transaction, and the system communicates the outcome - success or failure - back to the server. This efficient process ensures secure and seamless money transfers, with the server providing final confirmation to the initiating company.

4.2.3 System Architecture

The USSD Payment System Architecture is illustrated in Figure 4.1. This flowchart provides a comprehensive depiction of the operational framework of the system, highlighting the sequence of interactions among the server, mobile app, USSD gateway, and the company's backend. The process begins with data retrieval from the server, followed by transaction initiation and verification through the mobile app. Subsequent steps include the secure USSD payment procedure, PIN authentication, and the final confirmation reporting. Each component's role and the transaction flow's progression are sequentially numbered to facilitate understanding of the system's interconnected functionality.

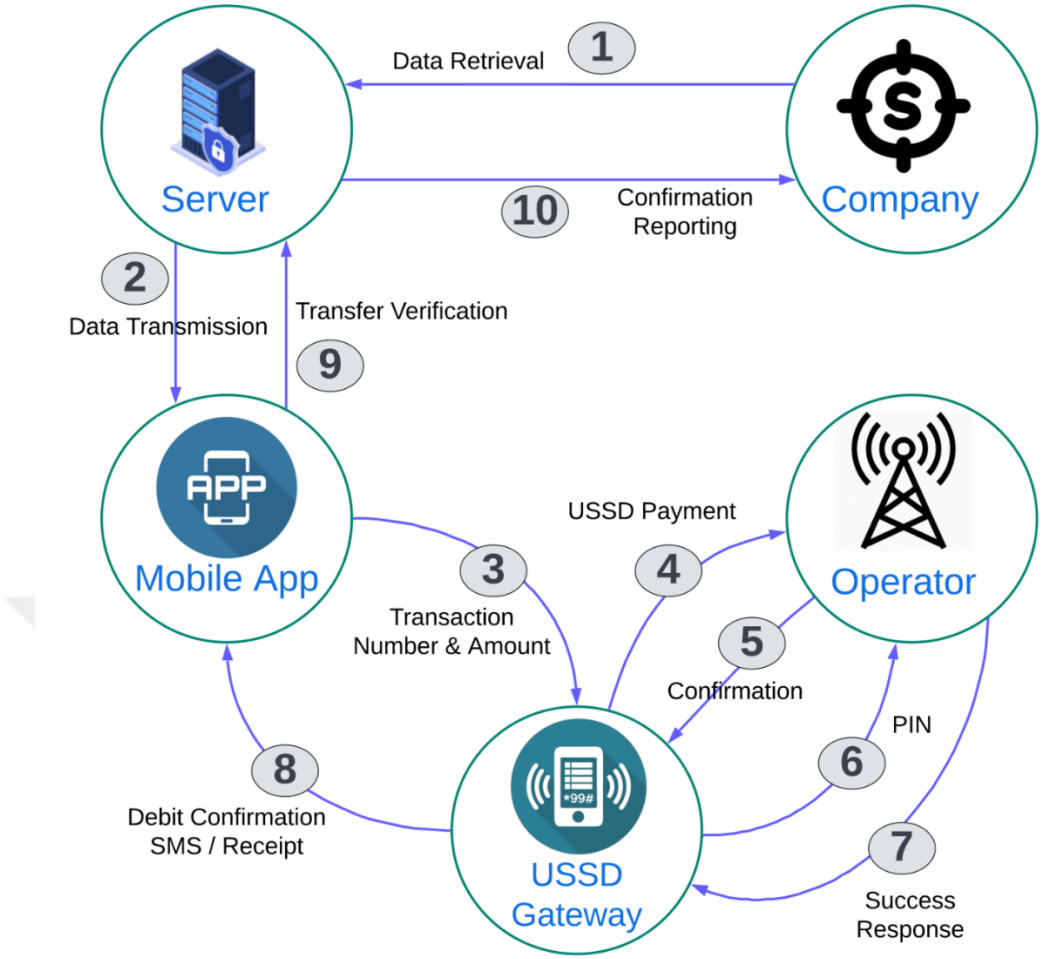

Figure 4. 1 USSD Payment System Architecture Flowchart

Server: acts as the central hub of the system, managing the core processes and ensuring secure data storage and retrieval. It is responsible for initiating transactions with the company upon user requests and handling the back-and-forth communication necessary for transaction validation and completion.

Company: refers to the recipient of the payment and is responsible for initiating the request for funds transfer through the server.

Mobile app: offers an intuitive interface for initiating transactions, entering transaction numbers, amounts, and receiving confirmations. The app communicates with the server to begin the payment process.

Operator: represents the telecommunications service provider that facilitates USSD communication. It plays a pivotal role in transmitting messages and codes between the

user's mobile device and the USSD gateway, ensuring the transaction commands are relayed in real-time.

USSD gateway: serves as the intermediary between the mobile operator and the payment system's server. It processes USSD codes, converts them into actionable requests for the server, and ensures the secure transmission of confirmation messages back to the app.

1) **Data retrieval**: the process begins with the company initiating a money transfer request by sending the transaction data to a secure server. This step is fundamental in establishing the parameters of the transaction and is critical for maintaining the integrity of the data being transferred. The server acts as the gatekeeper, ensuring that all incoming data is accurate and ready for processing, a concept supported by Hassan & Shukur [34] who emphasize the server's role in the initial validation of digital transactions.
2) **Data transmission**: upon validation, the server sends the transaction data to the mobile application. This step is where the robustness of the server's security protocols is tested, as it involves transmitting sensitive financial data over potentially vulnerable networks. Mota, Azam, Shanmugam, & Kannoorpatti [35] discussed the encryption methods and secure transmission protocols that are vital at this stage to prevent data breaches and ensure confidentiality.
3) **Transaction number and amount**: the transaction process is initiated automatically when the mobile app receives transaction data including the number and amount from the server. This data is used by the app to generate and send a USSD payment short-code without requiring manual input from the user. This automation streamlines the transaction process, reducing the potential for user error and enhancing the overall efficiency of the system. The use of USSD short-codes for automated transactions represents a significant advancement in mobile payment technology, offering a swift and secure method for executing transfers. The literature, such as the work by Patri [36], discussed the benefits and challenges of automating financial transactions through mobile applications, emphasizing how it can lead to faster processing

times and improved accuracy by eliminating manual entry steps that could be prone to error.

4) **USSD payment**: the USSD gateway translates the short-code into a request to the mobile operator's system to execute the transfer. This step is a cornerstone of the mobile payment process, as the USSD gateway serves as a bridge between the user and the operator. Dabas & Dabas [37] describe the USSD gateway as a critical component that enables real-time communication for mobile transactions.
5) **Confirmation**: the mobile operator sends a confirmation request back to the user (mobile app), often requiring the entry of a PIN to authenticate the transaction. This step is essential for security, as it verifies the user's intent and protects against unauthorized transactions. The significance of two-factor authentication, including PIN verification, is discussed by Binitie, Innocent, Egbokhare, & Egwali [8] as a standard security practice in mobile payments.
6) **PIN**: the app enters the secret PIN code of the Simcard via the USSD gateway, which is a critical step for authorizing the transaction. The confidentiality and secure handling of the PIN are of utmost importance, as they represent the user's credentials. Mota, Azam, Shanmugam, & Kannoorpatti [35] also examined the security measures that ensure the protection of PINs and other sensitive user information during this phase. In the development of the application, standard GSM network security protocols were relied upon for PIN protection. No additional security measures were implemented specifically for PIN encryption or concealment. However, the application was designed to hide the PIN from the user interface to ensure confidentiality and minimize the risk of unauthorized exposure.
7) **Success or failure response**: the mobile operator processes the transaction and sends a success or failure response to the USSD gateway. This feedback mechanism is crucial as it provides immediate information on the transaction's outcome. Huang, Stankovic, Towsley, & Ramamritham [38] discussed the importance of real-time processing and feedback in digital transactions, which enhances user trust and satisfaction.

8) **Debit confirmation or failure notification**: the user receives a debit confirmation receipt or a failure notification from the system, marking the completion of the transaction process. Providing clear and concise communication at this stage is key to maintaining transparency and user confidence, a point that Masrek, Halim, Khan, & Ramli [39] argued is the essential for the credibility of mobile payment systems.
9) **Transfer verification**: the mobile application communicates the result of the transaction back to the server for verification. This step ensures that there is a record of the transaction's outcome, facilitating auditing and reconciliation processes. Broucek [40] highlighted the need for accurate record-keeping and verification in automated financial systems to ensure accountability and traceability.
10) **Confirmation reporting**: the server reports the final status of the money transfer back to the company. This final step closes the loop on the transaction process, providing the company with the necessary confirmation that the funds have been transferred successfully. Ball, Jayaraman, & Shivakumar [41] emphasized the role of confirmation reporting in providing businesses with the assurance needed to finalize their financial records.

4.3 Development Tools and Technologies

Section 4.3 outlines the suite of development tools and technologies selected for the creation of the USSD Payment System. These tools were carefully chosen to ensure robustness, scalability, and security throughout the development process. The mobile interface, web framework, background services, and data management components each leverage specific technologies designed for optimal performance in their respective domains.

4.3.1 Flutter for Mobile Interface Development

At the heart of the system's architecture, Flutter, an open-source UI software development kit created by Google, is employed for developing the mobile interface

of the system. Due to its extensive library of pre-built elements and capability to compile to native code, Flutter is an ideal framework for developing user-friendly and responsive mobile interfaces. It enables the system to initiate and manage USSD sessions directly from the user's mobile device by facilitating the interaction with the SIM card. Flutter's cross-platform functionality guarantees that the application may be used on various platforms, expanding the system's accessibility and usability [42].

Flutter was chosen for mobile interface development due to its ability to compile to native code, providing a high-performance, visually appealing user experience. Its rich set of pre-designed widgets and cross-platform capabilities allow for the creation of a responsive and intuitive mobile interface, accessible across a diverse range of devices [42]. Flutter's rapid development cycle and hot reload feature significantly reduce the time and effort required for mobile UI development, making it an ideal choice for this project.

In addition to these benefits, a key factor in selecting Flutter was its ease of integration with Laravel's API. This integration capability is crucial for the system, as it allows for seamless data retrieval and response handling between the mobile interface and the server. Seamlessly transferring data between the mobile application and the backend guarantees a streamlined and uniform user experience.

Moreover, Flutter's compatibility with various packages, including those specifically designed for USSD interactions, greatly facilitated the development process. The availability of a USSD package in Flutter was a decisive factor, as it enabled direct integration with the SIM card to send and receive USSD messages or responses. This feature was essential for the core functionality of the system, allowing users to initiate and manage USSD sessions effortlessly. The integration of this package into the Flutter app ensured that the system could reliably handle USSD requests, making it a comprehensive solution for USSD-based mobile payments.

Last but not least, the selection of Flutter was not only due to its technical merits but also because of its practical applicability in meeting the specific needs of the project, particularly in terms of API integration and USSD functionality.

```
// find if there is remittance assign me to send it. getRemittanceAssignedToMe()
Future<Map<String, dynamic>?> findMoneyToSend(int simId) async {
  ApiResponse apiResponse = ApiResponse();

  String token = await getToken();

  final response = await http.get(Uri.parse('$remitAssignedURL/$simId'),
      headers: {
        'Accept': 'application/json',
        'Authorization': 'Bearer $token'
      });

  try {
    if (response.statusCode == 200) {
      apiResponse.data = jsonDecode(response.body)['remittanceAssigned'];

      // direct string
      final Map<String, dynamic> remittanceData =
          apiResponse.data as Map<String, dynamic>;

      return remittanceData;
    } else {
      print(
          'No Money Assigned to Send it with status code ${response.statusCode}');
      return null;
    }
  } catch (e) {
    print(
        'No Money Assigned to Sendit with catch status code ${response.statusCode}');
    return null;
  }
  // return apiResponse;
}
```

Figure 4. 2 Flutter Code for retrieving transaction to send

Figure 4.2 shows the code snippet used to determine if remittance has been assigned for sending via the USSD gateway. This figure illustrates the function ‘findMoneyToSend’, which is invoked to check if there is any remittance assigned to the user to be sent. The function makes an HTTP GET request to the ‘remittanceAssignedURL’ with the user's ‘simID’ and authorization token. If the server responds with a status code of 200, indicating success, the response is parsed to extract the 'remittanceAssigned' data. In case of an error or if no remittance is assigned, the function returns ‘null’, signalling the absence of any remittance to be sent. The

process is wrapped in a try-catch block to handle any exceptions that may occur during the request.

4.3.2 Laravel for Web Framework:

Laravel is a PHP web framework that is recognized for its sophisticated syntax and strong capabilities. Laravel serves as the backbone of the web-based interface, providing a secure and scalable platform for online access and administration. It handles the server-side logic and interacts with the database, ensuring smooth data processing and management. Laravel's MVC (Model-View-Controller) architecture aids in maintaining a clean separation of concerns, making the system more manageable and modular [43].

Laravel was selected as the primary web framework for its elegant syntax and robust features that facilitate rapid development and scalability. Known for its comprehensive ecosystem and a wide array of functionalities, Laravel offers advanced security features, such as CSRF protection and secure routing, which are essential for handling sensitive financial transactions [43]. Its MVC architecture promotes a clean separation of concerns, making the codebase more manageable and modular, a critical aspect in the development of complex systems like mobile payment platforms.

In addition to these advantages, Laravel stands out for its ease of implementing complex payment-related systems. Its framework comes with a range of predefined modules and software, particularly for crucial functionalities like authorization and authentication. This feature significantly reduces development time and effort, allowing for a focus on other critical aspects of the system.

Another compelling reason for choosing Laravel is its capability to create modern systems with aesthetically pleasing interfaces. The framework upholds various tools and libraries that upgrade the UI, making it useful as well as outwardly engaging. This aspect is particularly important in ensuring a positive user experience, encouraging user engagement and satisfaction.

In addition, Laravel offers a secured API that uses token-based authentication, which makes sure that no data is leaked when clients and servers exchange it. This feature is vital for protecting sensitive financial data and maintaining user trust in the system [43].

Lastly, Laravel's seamless integration with MySQL, the chosen database for this project, was a significant factor in its selection. Laravel's ORM (Object-Relational Mapping) makes it straightforward to connect and interact with the MySQL database, facilitating efficient data storage, retrieval, and management. This integration is crucial for maintaining the integrity and performance of the system's database operations [44].

```php
public function RemittanceAssign()
{
    $remittanceAssigning = DB::table('remittance_accounts as r_a')
        ->join('customers as c', 'r_a.customer_id', '=', 'c.id')
        ->select('r_a.*', 'c.name as customer_name')
        ->where('r_a.status', 'Processing')
        ->get();

    $remittanceAssigned = DB::table('remittance_assigned as ra')
        ->join('remittance_accounts as r_a', 'ra.remittance_id', '=', 'r_a.id')
        ->join('simcards as s', 'ra.simcard_id', '=', 's.id')
        ->select('ra.id as id', 'r_a.tx_number as tx_number', 'r_a.amount as amount2send', 'r_a.commission as fee2send', 's.id as sim_id'
        ->where('ra.status', 'Assigned')
        ->get();

    $remittanceSent = DB::table('remittance_assigned as ra')
        ->join('remittance_accounts as r_a', 'ra.remittance_id', '=', 'r_a.id')
        ->join('simcards as s', 'ra.simcard_id', '=', 's.id')
        ->join('devices as d', 's.device_id', '=', 'd.id')
        ->join('providers as p', 'd.provider_id', '=', 'p.id')
        ->select('ra.id as id', 'r_a.tx_number as tx_number', 'r_a.amount as amount2send', 'r_a.receiver_phone as receiver_phone', 'p.id
        ->where('ra.status', 'SentButCheck')
        ->get();

    $remittanceUnpaid = DB::table('remittance_assigned as ra')
        ->join('remittance_accounts as r_a', 'ra.remittance_id', '=', 'r_a.id')
        ->join('simcards as s', 'ra.simcard_id', '=', 's.id')
        ->join('devices as d', 's.device_id', '=', 'd.id')
        ->join('providers as p', 'd.provider_id', '=', 'p.id')
        ->select('ra.id as id', 'r_a.tx_number as tx_number', 'r_a.amount as amount2send', 'r_a.receiver_phone as receiver_phone', 'p.id
        ->where('ra.status', 'UnPaid')
        ->get();

    return view('Remittance.Assign.index2', compact('remittanceAssigning', 'remittanceAssigned', 'remittanceSent', 'remittanceUnpaid'));
}
```

Figure 4. 3 Laravel Code for displaying transactions

As depicted in Figure 4.3, the RemittanceAssign function is integral to the operation of the system, interfacing with the database to retrieve and categorize remittance records. This figure illustrates the ‘RemittanceAssign’ function within the application. The function executes several database queries to fetch and sort remittance records into distinct categories: assigning, assigned, sent, and unpaid. Each query joins multiple tables—such as customers, remittance accounts, service providers, and SIM card details—to compile comprehensive views of each remittance's status. For instance, the ‘remittanceAssigning’ query retrieves all records currently being

processed, while ‘remittanceAssigned’ fetches those that are ready and assigned for remittance. This structured retrieval is crucial for maintaining an organized flow of transactions within the application.

4.3.3 C# for Background Services

C# was chosen for its robust capabilities in developing background services, particularly for a system that needed to be installed and run-on Windows OS PCs. The ability of C# to build services that can operate seamlessly in the background was a key factor in its selection. This capability is particularly crucial for applications that needs uninterrupted functioning without user involvement, such as automated payment processing systems.

In this project, C# played a pivotal role in handling background activities. It was used to develop services that continuously run on the server, performing critical tasks such as retrieving data from companies' APIs, processing this data, and then interfacing with this payment system. This seamless integration and processing are crucial for the efficiency and reliability of the overall system.

One of the main reasons for choosing C# was its native support for Windows environments, allowing for smooth deployment and operation on Windows-based servers. This compatibility is essential for ensuring that the system runs reliably and efficiently, with minimal downtime or performance issues.

The ability of C# to work in the background and handle these functions without requiring constant user interaction ensures that the system remains operational at all times. This is particularly important for a payment system, where timely processing and reliability are paramount [45].

In summary, the selection of C# was driven by its suitability for creating robust and reliable background services, its compatibility with Windows OS, and its comprehensive features that support the development of complex server-side functionalities [45]. These attributes made C# an integral part of the system, ensuring

seamless operation and contributing to the overall effectiveness of the automated USSD-based mobile payment platform.

```
private void GetFirstIdOfRemittance()
{
    try
    {
        string constr = ConfigurationManager.ConnectionStrings["constr"].ConnectionString;
        using (SqlConnection con = new SqlConnection(constr))
        {
            if (con.State == ConnectionState.Closed)
                con.Open();
            string sql = "SELECT id FROM remittance_accounts WHERE status = 'Processing' ORDER BY created_at DESC LIMIT 1";
            using (SqlCommand cmd = new SqlCommand(sql, con))
            {
                using (SqlDataReader dtr = cmd.ExecuteReader())
                {
                    if (dtr.Read()) // Reading the first record
                    {
                        remittanceId = Convert.ToInt32(dtr["id"]);
                    }
                }
            }
            if (remittanceId > 0)
            {
                // Get Simcards
                WriteToFile2("Remittance > ID: " + remittanceId.ToString());
                GetSimcardToAssign();
            }
            ClearVariables();
        }
    }
    catch (SqlException ex)
    {
        WriteToFile2("An error occurred: " + ex.Message);
        ClearVariables();
    }
```

Figure 4. 4 C# Code for the service to assign a transaction to a Simcard

The method for retrieving the first remittance record marked as 'Processing' is presented in Figure 4.4. Figure illustrates the ‘GetFirstIdOfRemittance’ method from the application's codebase. This method is responsible for connecting to the SQL database using the provided connection string and selecting the first 'Processing' remittance record. It orders the records by the ‘created_at’ timestamp in descending order to ensure the most recent record is selected first, but limits the selection to one entry with ‘LIMIT 1’. Once a valid record is found, identified by a non-zero ‘remittanceId’, the system proceeds to retrieve the associated SIM card information for assignment. The method encapsulates error handling to log any exceptions encountered during the process, maintaining robustness in the application's operations.

4.3.4 MySQL Database for Data Management

The decision to utilize MySQL as the database management system for the automated USSD-based mobile payment system was influenced by several key factors that align

with the requirements of a robust financial transaction system. MySQL's reputation for reliability and stability stands at the forefront of these considerations. As a mature and widely-used open-source relational database, it offers the assurance that the data is securely managed and consistently accessible, a non-negotiable requirement for any financial system [46].

Performance is another critical aspect, especially given the real-time nature of financial transactions. MySQL excels in this area, providing fast data processing capabilities essential for handling real-time transaction processing and efficient querying. This performance can be further enhanced through techniques such as indexing and query optimization, ensuring that the system remains responsive even under heavy load [46].

Scalability is a vital feature for the system, which is expected to grow and handle an increasing volume of transactions. MySQL's scalability features are well-suited to meet these demands, allowing for the management of large data volumes and numerous concurrent transactions without significant performance loss.

The compatibility of MySQL with Laravel, the chosen web framework, also played a significant role in its selection. Laravel's Eloquent ORM integrates seamlessly with MySQL, offering an efficient and developer-friendly way to interact with the database using object-oriented models [43]. This integration simplifies the development process and ensures smooth data operations within the system.

Security concerns are paramount in any financial application. MySQL addresses these concerns with robust security features, including encrypted data storage and secure client-server communication protocols [46]. These features are crucial in protecting sensitive financial data from potential security threats and unauthorized access.

4.4 Challenges and Solutions

The development of an automated USSD-based mobile payment system was not without its challenges. Each obstacle presented an opportunity to learn and adapt, each requiring a strategic approach to resolve and ensuring the final product met the desired

standards of quality and functionality. One significant challenge was identifying the most suitable technology for handling USSD commands effectively.

This part frames the huge difficulties that emerged during the advancement cycle and the arrangements that were applied to address them.

Challenge: Finding a Suitable Technology for USSD Command Handling

Initially, various mobile app development platforms, including Android Studio and React Native were explored to implement the USSD command handling functionality. Android Studio, with its native language capabilities, presented a steep learning curve as it required writing extensive custom code for USSD interactions. Despite its robustness, it was found that there was a lack of pre-built libraries specifically designed for handling USSD commands, which significantly increased the complexity and development time.

Similarly, React Native was also considered for its cross-platform benefits. However, the author encountered significant issues with the available USSD packages. Although React Native had some libraries for USSD command handling, they were not up to date and were incompatible with the latest version of React Native 0.72. This lack of recent updates and compatibility issues posed a substantial challenge, as it meant that the libraries could not be reliably used for the project requirements.

Solution: Transition to Flutter

After careful examination, testing, and assessment of these advances, the decision was made to progress to Flutter. This decision was influenced by Flutter's more effective integration with USSD functionalities. Flutter provided a USSD package that was not only up to date but also compatible with its latest version (dark 3), unlike the options available in React Native. This package simplified the process of integrating with the SIM card for sending and receiving USSD messages, significantly reducing development complexity. This package significantly reduced the development complexity and allowed me to focus on other critical aspects of the system.

Challenge: Integration of Different Technologies

One of the primary challenges was integrating various technologies like Laravel, C#, and Flutter to work seamlessly together. Each technology possessed its own distinct collection of libraries, norms, and best practices, occasionally resulting in conflicting approaches.

Solution: To address this, the author established a clear integration strategy early in the development process. This involved creating API and adopting standard data exchange formats like JSON. Regular integration testing was conducted to identify and resolve compatibility issues promptly. Additionally, middleware were utilized to facilitate smooth communication between different layers of the system.

Challenge: Ensuring System Security

Given the financial nature of the system, ensuring robust security to protect against data breaches and fraudulent activities was a significant concern.

Solution: multiple layers of security were implemented, including encryption for data transmission, secure hashing algorithms for storing sensitive data, and rigorous input validation to prevent SQL injection and other common web vulnerabilities. Periodic security audits and penetration testing were performed to detect and rectify potential security vulnerabilities.

4.5 Chapter Summary

This chapter provides a thorough description of the system's architecture, components, and operational flow, including both design and implementation. The system is made to automate money transfers to consumers' mobile phones through the integration of technologies such as Laravel, C#, Flutter, and MySQL. This meets the demand for transactions that are accurate, timely, and affordable. In particular, the chapter highlights how the system might enable safe and easy money transfers by carefully outlining every step of the transaction process, from data retrieval to final confirmation.

CHAPTER 5

RESULTS AND DISCUSSION

In this chapter, the results and discussion of the study on the designing and developing of an automating USSD-based mobile money transfer are presented. These findings are presented according to the research questions discussed throughout the document:

RQ1: How do employees perceive the impact of adopting automated money transfer system on the efficiency and accuracy of transactions, as compared to manual processes?

RQ2: What challenges and barriers do employees perceive as significant in the transition from manual to automated money transfer system?

RQ3: How do users perceive the benefits, security, and ease of use of automated money transfer system, and how satisfied are they with the system compared to manual processes?

5.1 Results

This Results section evaluates the system's transaction handling, gathers user views on automated transfers, assesses satisfaction with the USSD-based payment system, and lists potential improvements identified during the study.

5.1.1 Transaction Handling and Manual Process Evaluation

The questions given in the Table 5.1 delve into the frequency, time taken, error rates, time required to rectify errors, and the number of employees involved in similar tasks in manual money transfers.

Table 5. 1 Transaction handling and manual process

Questions	Frequency	Percentage
1. On average, how many money transfer transactions do you handle manually each day?		
10	1	6.25%
13	1	6.25%
14	2	12.50%
15	**3**	**18.75%**
17	2	12.50%
19	1	6.25%
20	1	6.25%
22	1	6.25%
24	1	6.25%
25	2	12.50%
29	1	6.25%
Total	16	100.00%
2. How much time does it typically take you to complete each transaction?		
2 minutes	**9**	**56.30%**
3 minutes	7	43.70%
Total	16	100.00%
3. How often do you experience errors when conducting manual money transfers?		
Often	5	31.25%
Sometimes	**9**	**56.25%**
Rarely	2	12.5%
Total	16	100.00%

Table 5.1 (continued)

4. If an error occurs during a manual money transfer, how much time takes to rectify that mistake?		
2 minutes	1	6.25%
3 minutes	4	25.00%
4 minutes	2	12.50%
5 minutes	**6**	**37.50%**
6 minutes	3	18.75%
Total	16	100.00%
5. How many employees are there at your workplace who perform similar money transfer tasks as you do?		
Employees	**7**	**43.80%**
Employees	6	37.40%
Employees	3	18.80%
Total	16	100.00%

The data collected on manual money transfer processes encapsulates a detailed look at the frequency of transactions, time taken for each transaction, error rates, the time required to rectify errors, and the number of employees involved in similar tasks, all exhibiting a range of frequencies and their corresponding percentages. The highest reported frequency for handling daily transaction is 15 transactions per day, accounted for by 18.75% of respondents. Following this, 14, 17, and 25 transactions each day are reported by 12.50% of respondents. The least frequent counts, at 6.25%, are for 10, 13, 19, 20, 22, 24, and 29 transactions per day. This data underlines that while a small proportion of individuals manage a high volume of transactions, a significant number of participants handle a moderate number of transactions, with 15 transactions being the most common daily workload.

For transaction completion time, 56.30%, can complete a transaction in 2 minutes. The remaining 43.70% of participants indicate that it takes them 3 minutes to complete a transaction. The result indicating that most manual transactions are completed within 2 to 3 minutes.

The survey data concerning the frequency of errors in manual money transfers indicates that a modest number of respondents, 31.25% often experience errors. The majority 56.25% sometimes encounter errors, while a smaller fraction 12.5% rarely have errors in their transactions. These percentages are based on a total of 16 responses and expose that while errors are not a constant issue for most, a significant portion of the participants still faces them with some regularity in manual money transfers. The time to rectify errors also differs, 6.25% take 2 minutes, 25.00% require 3 minutes, 12.50% need 4 minutes, 37.50% spend 5 minutes, and 18.75% take 6 minutes.

According to the survey data on error rectification in manual money transfers, the time taken to correct a mistake varies among participants. The largest group 37.50% requires 5 minutes to rectify an error. A significant number 25.00% takes to resolve errors within 3 minutes, and 18.75% need 6 minutes for correction. Fewer respondents, 12.50% take 4 minutes, and a minority of 6.25% can amend the error in just 2 minutes. These figures suggest that most errors in manual money transfers can be resolved within a 3 to 6-minute.

The survey data concerning workforce allocation for manual money transfer tasks at participants' workplaces indicates that the most common team size consists of 4 employees, with 43.80% of respondents reporting this number. This suggests that, within this sample, the typical staffing configuration for such tasks tends to be smaller teams, as larger groups of 5 and 6 employees are less common, represented by 37.40% and 18.80% of respondents, respectively. This insight could imply that manual money transfer tasks are most frequently managed by teams of four and above, which could reflect operational or efficiency considerations within these organizations.

5.1.2 Views on Automated Money Transfer System

This section of the survey delves into perspectives on automated money transfer system, contrasting them with the challenges of manual processes and encompasses a range of aspects.

Table 5. 2 Views on automated money transfer system

Questions	Frequency	Percentage
6. What are the main challenges you face with manual fund transfers?		
Time-consuming	**15**	**45.50%**
Error-prone	14	42.40%
Inconvenient	4	12.10%
Total	33	100.00%
7. What benefits do you think an automated money transfer system would bring?		
Increased efficiency	3	18.75%
Improved accuracy	**13**	**81.25%**
Total	16	100.00%
8. What challenges do you foresee in implementing an automated system for money transfers?		
Technical difficulties	**7**	**43.75%**
High initial costs	6	37.50%
Security concerns	3	18.75%
Total	16	100.00%

Table 5.2 (continued)

9. How do you think an automated system would affect the speed of money transfers?		
Significantly faster	**14**	**87.50%**
Somewhat faster	2	12.50%
Total	16	100.00%
10. What level of training do you think would be necessary for users to effectively adopt this automated money transfer system?		
Minimal training	**15**	**93.75%**
No training needed	1	6.25%
Total	16	100.00%

The survey data affecting to the challenges faced with manual fund transfers illustrates that the predominant issues are time consumption and susceptibility to errors. The most frequently cited challenge is that manual transfers are time-consuming as indicated by 45.50% of respondents. Following closely 42.40% of participants find manual transfers to be error-prone. Additionally, 12.10% of respondents report inconvenience as a significant challenge. These findings underscore that the primary difficulties associated with manual money transfers are related to the efficiency and accuracy of the process.

Additionally, the survey data on the anticipated benefits of an automated money transfer system indicated that the majority of respondents 81.25% believed improved accuracy was the key benefit, while 18.75% foresaw increased efficiency as a benefit of implementing such a system. These percentages clearly suggesting that improved accuracy was the primary expected advantage of automation in money transfers, followed by the efficiency it could bring to the process.

On the other hand, technical difficulties are the most anticipated challenge with 43.75% of respondents expressing this concern. High initial costs are also a significant consideration noted by 37.50% of the participants. Security concerns are acknowledged by 18.75% representing the least mentioned but still noteworthy challenge. These insights were crucial in highlighting the primary areas that were addressed during the planning and implementation of the automated money transfer system.

Furthermore, the expectations regarding the speed of money transfers after automation indicated that a majority of the respondents 87.50% thought that an automated system made the transfers significantly faster. Meanwhile, 12.50% of the participants anticipated that the transfers were somewhat faster. These perspectives suggest that most respondents expected a positive impact on the speed of transactions through automation, with a majority foreseeing a moderate increase in speed.

Lastly, the level of training required for adopting an automated money transfer system showed that 93.75% of the participants believed minimal training would be necessary. A small minority of 6.25% considered that no training at all would be needed for effective adoption of the system. These findings indicate that the majority of users expected the transition to an automated system to be relatively straightforward, requiring minimal to moderate training.

5.1.3 Perception and Satisfaction with Automated USSD-based Mobile Payment System

The questions given in the table 5.3 explore various aspects of user perception and satisfaction with an automated USSD-based mobile payment system. They address key factors such as the importance of specific features, confidence in security, ease of integration, perceived benefits versus costs, usability, clarity of instructions, transaction speed, efficiency, overall satisfaction, willingness to recommend the system to others, and a general rating of the system's performance.

Table 5. 3 Preferences and perceptions on automated system

Questions	Frequency	Percentage
11. Which feature would you consider most important in an automated fund transfer system?		
Speed	**10**	**62.50%**
Accuracy	6	37.50%
Total	16	100.00%
12. How confident are you in the security of automated money transfer systems?		
Very confident	**13**	**81.25%**
Somewhat confident	3	18.75%
Total	16	100.00%
13. How easy do you think it would be to integrate this automated money transfer system with existing financial systems?		
Very easy	**14**	**87.50%**
Easy	2	12.50%
Total	16	100.00%

Table 5.3 (continued)

14. Do you believe the benefits of an automated money transfer system outweigh the potential costs and challenges?		
Strongly agree	**10**	**62.50%**
Agree	6	37.50%
Total	16	100.00%
15. How easy was it to navigate and use the automated USSD-based mobile payment system?		
Very easy	**14**	**87.50%**
Easy	2	12.50%
Total	16	100.00%
16. How clear were the instructions and functions within the system?		
Extremely clear	**10**	**62.50%**
Clear	5	31.25%
Moderately clear	1	6.25%
Total	16	100.00%
17. How would you rate the speed of transactions when using this automated system compared to manual system?		
Very fast	**13**	**81.25%**
Fast	3	18.75%
Total	16	100.00%

Table 5.3 (continued)

18. How efficient do you find the transaction process in this automated system compared to manual system?		
Extremely efficient	**13**	**81.25%**
Very efficient	3	18.75%
Total	16	100.00%
19. Overall, how satisfied are you with this automated USSD-based mobile payment system?		
Very satisfied	**14**	**87.50%**
Satisfied	2	12.50%
Total	16	100.00%
20. How likely are you to recommend the automated USSD-based mobile payment system to others?		
Extremely likely	**13**	**81.25%**
Likely	3	18.75%
Total	16	100.00%
21. On a scale from 1 to 10, how would you rate the performance of your system?		
10	**12**	**75.00%**
9	3	18.75%
8	1	6.25%
Total	16	100.00%

This survey data about preferences for features in an automated fund transfer system indicates that speed is the most valued feature with 62.50% of respondents identifying it as the most important, followed by accuracy with 37.50%. None of the respondents considered security as the most important feature, suggesting that while security is important, it is not the top priority among the participants surveyed. These insights suggest that users are primarily concerned with the efficiency and reliability of automated fund transfers.

The result data on the confidence in the security of automated money transfer systems shows that a significant majority of respondents 81.25% are very confident in their security, while 18.75% are somewhat confident. This reflects a high level of trust in the security measures of automated systems.

In addition, the survey results on the ease of integration of an automated money transfer system with existing financial systems show that a large majority of respondents, 87.50%, consider it very easy to integrate, while 12.50% find it easy. This indicates that most users view the integration process as relatively straightforward and user-friendly.

Regarding the perceived value of an automated money transfer system, 62.50% of respondents strongly agree that the benefits outweigh the potential costs and challenges, and 37.50% agree, suggesting a strong overall consensus in favor of implementing such a system.

Concerning the usability of the automated USSD-based mobile payment system, the majority of respondents find it user-friendly, with 87.50% reporting that it was very easy to navigate and use, and 12.50% finding it easy. This indicates a high level of accessibility and a smooth user experience.

As for the clarity of instructions and functions within the system, 62.50% of participants found them extremely clear, 31.25% clear, and 6.25% moderately clear, suggesting that the system is well-designed in terms of user guidance. In terms of the speed of transactions with the automated system 81.25% of respondents rate the transaction speed as very fast, and 18.75% as fast, indicating a noticeable speed

improvement compared to manual processes. Moreover, 81.25% of users find the automated process extremely efficient, and 18.75% very efficient, suggesting a significant enhancement in efficiency over the manual method.

In terms of user satisfaction, 87.50% of users are very satisfied and 12.50% are satisfied with the automated USSD-based mobile payment system, indicating a successful implementation and positive user experience. Furthermore, the willingness to recommend the system is high, with 81.25% of users being extremely likely to recommend it, and 18.75% likely to do so, reflecting a strong endorsement of the system's capabilities and benefits. Lastly, the respondents' ratings are very positive, with 75.00% giving a score of 10, 18.75% a score of 9, and 6.25% a score of 8. This overwhelmingly positive feedback underscores the high level of satisfaction with the system's performance among its users.

5.1.4 Suggested Improvements

This final question gathers feedback from the users on specific areas for improvement in the automated system, providing valuable user insights for system enhancement.

Table 5. 4 Suggested improvements

22. What aspects of this software do you think are open to improvement?
- Let compatible with other operators. - Get receiver's name before sending - Enable real-time data streaming for the assigning and assigned report

In the survey, participants offered specific feedback on areas where they felt the automated system could be improved. One suggestion was to enhance compatibility with other operators, which would likely expand the system's usability and convenience for users interacting with multiple telecommunications networks. Another recommendation was to incorporate a feature that confirms the receiver's name before sending funds. This could serve as an additional layer of accuracy, reducing the risk of sending money to the wrong recipient. Finally, there was a call for

the ability to live stream data for transactions. This could potentially provide real-time updates and transparency for users, allowing them to monitor their transfers as they happen.

CHAPTER 6

DISCUSSION, CONCLUSION AND RECOMMENDATION

6.1 Discussion

The 'Discussion' section critically examines the findings of the study. Subsection 5.2.1 revisits the current manual processes, 5.2.2 explores the benefits and challenges of automated money transfers, and 5.2.3 evaluates the system's effectiveness in terms of usability and efficiency

6.1.1 Current Manual Process

> RQ1: How do employees perceive the impact of adopting automated money transfer system on the efficiency and accuracy of transactions, as compared to manual processes?

The present manual processes in the money transfer market, particularly in the context of Hormuud's EVC Plus service, pose several challenges. The absence of APIs compels a dependence on person-to-person transfers using Electronic Voucher Cards, a situation that has been extensively discussed in the literature by Hefny, Helmy, & Abdelsalam [47]. This reliance contributes to prolonged transaction times, as highlighted by numerous studies in the field [47]. Moreover, the lack of API integration results in increased staffing needs, a finding echoed in the works of experts in financial technology [48]. The higher probability of errors in this manual process has been documented in various articles on money transfer systems [47], [48], leading to elevated labour costs for error rectification. The intricacies of this challenge have been extensively researched and discussed in the literature on financial technology and mobile payment [49], underscoring the need for more streamlined, automated solutions.

Survey data delves into the intricacies of the manual money transfer process, revealing that employees handle varying transaction volumes daily. The time taken per transaction varies, with a significant portion completing each within 2-3 minutes. Concerns about errors are prevalent, with a considerable number of respondents reporting encountering them. The workforce allocation varies among respondents, indicating differing levels of staffing needs. Challenges include time-consuming transactions (45.50%), error-prone processes (42.40%), and inconvenience (12.10%). According to Michailidou [50] in fintech sector, these insights highlight the inefficiencies and challenges of manual money transfers, emphasizing the potential benefits of automation and improved processes.

6.1.2 Benefits and Challenges of Automated Money Transfers

> RQ2: What challenges and barriers do employees perceive as significant in the transition from manual to automated money transfer system?

The anticipated benefits and challenges of implementing automated money transfer systems, as indicated by the survey data, align with several key themes identified in fintech literature.

The survey data revealing that 18.75% of participants anticipate increased efficiency, while a significant 81.25% expect improved accuracy with automation, resonate with the findings in fintech literature. For example, studies like those by Patri [36] have emphasized the role of automation in enhancing operational efficiency and reducing human error in financial transactions. This literature supports the survey's indication that accuracy is a paramount concern and expected benefit in the automation of money transfers.

The survey also highlights anticipated challenges, such as technical difficulties (43.75%), high initial costs (37.50%), and security concerns (18.75%). These concerns are echoed in the work of Suryono et al. [51], who discussed the technical and financial barriers to implementing advanced fintech solutions, particularly in contexts with limited existing technological infrastructure. Moreover, security concerns, as noted by

a smaller proportion of respondents, are a critical topic in fintech, as discussed by Patri [52], who explore the evolving landscape of cybersecurity in financial technology.

The expectation of faster transactions post-automation, with 87.50% of respondents predicting significant speed increases, aligns with findings from Patri [36]. In his research, Patri highlights how automated systems can drastically reduce transaction times in financial operations, underscoring the efficiency gains that come with digital transformation in the finance sector.

Interestingly, a vast majority (93.75%) of respondents believe minimal training is required for adopting automated systems, with only 6.25% suggesting moderate training. This perspective is supported by the work of Nourallah [53], who argue that modern fintech solutions are increasingly user-friendly and designed for easy integration and use, reducing the need for extensive training.

6.1.3 System Effectiveness in Terms of Ease of Use and Transaction Efficiency:

> RQ3: How do users perceive the benefits, security, and ease of use of automated money transfer system, and how satisfied are they with the system compared to manual processes?

Ease of use

The positive responses towards the user interface and clarity of instructions in the automated money transfer system, as highlighted in the survey, align well with key concepts and findings in the fields of human-computer interaction (HCI) and user experience design (UXD).

The fact that 87.50% of survey respondents found the system's interface very easy to navigate and 12.50% rated it as easy resonates with the principles outlined in Nielsen's "Usability Engineering" [54]. Nielsen emphasizes that systems should be created to match the demands and capabilities of the end-user and highlights the significance of simplicity of use and intuitive design in technological interfaces. According to the

conduct survey's findings, the system complies with these guidelines and has an easy-to-use interface that needs little effort to utilize.

With 62.50% of respondents finding the instructions extremely clear and 31.50% rating them as clear, the system appears to excel in providing clear guidance to its users. This finding is in line with the work of Krug in "Don't Make Me Think" [55], where he advocates for straightforward and self-explanatory interfaces in web design. Krug's principles underscore the importance of clear instructions in enhancing user experience and reducing cognitive load, which appears to be effectively achieved in this system.

The survey's indication of a high level of user satisfaction and ease of use reflects broader trends in fintech UXD, as discussed in the research by Norman in "The Design of Everyday Things" [56]. Norman's work highlights the significance of user-centered design (UCD) in increasing the adoption and satisfaction rates of technology products, particularly in the fintech sector. This is supported by insights from several industry studies, which emphasize the critical role of user experience (UX) in financial technology. These studies highlight how effective UX design contributes significantly to user engagement and retention in FinTech applications, a trend widely acknowledged by experts in the field [57].

Transaction Efficiency

The high satisfaction with transaction speed, where 81.25% rated it as very fast and 18.75% as fast, reflects the critical importance of speed in financial transactions. This is supported by research from Patri [36], who emphasize that in digital financial systems, speed is a key determinant of user satisfaction and system efficiency. The ability to conduct transactions rapidly is not just a convenience but a necessity in modern financial ecosystems.

Additionally, with 81.25% finding the transaction processed extremely efficient and 18.75% very efficient, the survey data echo the findings Suryono et al. [51]**.** They also argue that efficiency in financial transactions is crucial for reducing operational costs

and increasing user satisfaction. Efficient systems minimize the time and effort required for transactions, which is essential in the fast-paced financial sector.

Moreover, the high overall satisfaction rate, with 87.50% of users being very satisfied, is indicative of the system's success in meeting user needs. This aligns with the customer satisfaction theory addressed by Khadka and Maharjan [56], which states that satisfaction is derived from a product's ability to meet or exceed expectations. Reliability, transaction speed, and simplicity of use are frequently associated with user satisfaction in the context of financial systems.

Furthermore, the strong propensity to recommend the system with 81.25% extremely likely to do so, demonstrates a high level of user endorsement. This is consistent with the Net Promoter Score (NPS) concept discussed by Reichheld [58], where the willingness to recommend a service is a key indicator of customer loyalty and satisfaction. It suggests that users not only find the system beneficial for their needs but also trust its reliability and efficiency enough to recommend it to others.

In conclusion, the automated USSD-based mobile payment system has emerged as a significant improvement over traditional manual money transfer process. It successfully addresses key issues of efficiency and accuracy, as evidenced by the high percentage of users anticipating improved accuracy and increased efficiency. The system's user-friendly interface and clear instructions resonate well with established principles of usability and human-computer interaction, contributing to high user satisfaction and ease of use. Additionally, the enhanced speed and efficiency of transactions, as reported by users, align with the critical requirements of modern financial systems. Overall, the system not only meets but exceeds user expectations, leading to high satisfaction levels and a strong likelihood of recommendation. This underscores the system's effectiveness in transforming the landscape of money transfers and setting a new benchmark in financial technology.

6.2 Conclusion

The research conducted in this study comprehensively addressed the posed research questions, shedding light on the effectiveness of automated USSD-based mobile payment systems. The study's findings reveal a significant improvement in transaction speed and accuracy when comparing these automated systems to traditional manual processes. This enhancement in operational efficiency is particularly pivotal for the financial sector in regions where manual transactions are common. The widespread adoption of automated USSD-based mobile payment systems has the potential to revolutionize financial transaction processes in regions with high dependence on manual methods, enabling significantly faster transaction speeds and reduced error rates.

The positive reception of the system's integration, which includes technologies such as Laravel, C#, Flutter, and MySQL, is noteworthy. The participants expressed high level satisfaction with the system's user-friendly navigation, efficient transaction flow, and real-time transaction tracking features, which surpassed their expectations in terms of usability and effectiveness. This positive user experience has directly contributed to the system's real-world success.

6.3 Recommendations

Based on the research findings, several key recommendations can be prioritized for future development. Expanding the system's compatibility to include other available operators has the potential to increase the user base, significantly enhancing financial inclusion in underserved regions. Additionally, incorporating user-friendly features like real-time transaction updates, as suggested by one of the participants, could boost user confidence and transaction volume.

Furthermore, addressing the technical challenges identified during the research, such as the initial costs of implementation and ongoing security concerns, is essential for the broader adoption of these systems. These challenges present

opportunities for future research, particularly in finding cost-effective and secure solutions for system deployment.

REFERENCES

[1] G. Demombynes and A. Thegeya, “Kenya’s Mobile Revolution and the Promise of Mobile Savings,” *Policy Research Working Paper*, Mar. 2012.

[2] The World Bank, “Mobile Money in Somalia Household Survey and Market Analysis,” Apr. 2017. Accessed: Jan. 04, 2024. [Online]. Available: https://www.rfilc.org/wp-content/uploads/2020/08/Mobile_Money_in_Somalia_-_WBank.pdf

[3] A. C. K and U. W. I, “A prototype mobile money implementation in Nigeria,” *African Journal of Business Management*, vol. 6, no. 6, pp. 2195–2201, Feb. 2012.

[4] M. Omar, “Why mobile payment services in foreign currency re-places the Somali Shilling as local currency? Study on EVC-plus in south and central Somalia.,” M.A. Thesis, LAB UNIVERSITY OF APPLIED SCIENCES, Finland, 2021.

[5] A. Yassin Sheikh Ali, “Factors Influencing Mobile Money Transfer Adoption Among Somali Students,” *International Journal of Business, Economics and Law*, vol. 3, p. 1, Dec. 2013.

[6] World Bank Group, “Somalia Economic Update: Rapid Growth in Mobile Money--Stability or Vulnerability?,” Aug. 2018. Accessed: Jan. 04, 2024. [Online]. Available: https://documents1.worldbank.org/curated/en/975231536256355812/pdf/REPLACEMENT-PUBLIC-Somalia-Economic-Update-3-FINAL.pdf

[7] Omar Mohammed, “Somalia issues its first mobile money licence to Hormuud Telecom,” *Reuters*, Feb. 2021. Accessed: Jan. 04, 2024. [Online]. Available: https://www.reuters.com/article/somalia-telecom-idUSL8N2KX07T/

[8] A. P. Binitie, O. S. Innocent, F. Egbokhare, and A. O. Egwali, “Implementing Existing Authentication Models in USSD Channel,” in *International Conference on Electrical, Computer, and Energy Technologies, ICECET 2021*, Institute of Electrical and Electronics Engineers Inc., Dec. 2021.

[9] P. Dayang, A. H.-I. J. of Wireless, and undefined 2021, “Using USSD-based Mobile Payment in Context of Low Internet Connection,” *International Journal of Wireless Communications and Mobile Computing*, Sep. 2021.

[10] K. E. Agbezoutsi, P. Uriene, and T. M. Dandjinou, “Towards Blockchain Services for Mobile Money Traceability and Federation,” in *2019 3rd Cyber Security in Networking Conference, CSNet 2019*, Institute of Electrical and Electronics Engineers Inc., Oct. 2019, pp. 14–20.

[11] A. Demirguc-Kunt, L. Klapper, D. Singer, S. Ansar, and Jake Hess, *The Global Findex Database 2017: Measuring Financial Inclusion and the fintech revolution.* 2018.

[12] K. Donovan, "Mobile Money for Financial Inclusion," in *Maximizing Mobile*, Information and communications for development, 2012.

[13] M. Ahmed Mohamed, "The Impact of Mobile Banking on Economic Development in Puntland- Somalia," *International Journal of Contemporary Applied Researches*, vol. 6, no. 12, Dec. 2019.

[14] C. Vargas-Silva, "Literature Review: Remittances Sent to and from Refugees and Internally Displaced Persons," in *KNOMAD WORKING PAPER 12*, Global Knowledge Partnership on Migration and Development (KNOMAD), Mar. 2016.

[15] D. Porteous, "Key issues in design and implementation of surveys on financial inclusion surveys on financial inclusion," in *AFI Global Policy Forum*, Bankable Frontier Associates, Sep. 2009.

[16] P. Fabio, *Human Computer Interaction with Mobile Devices*. Springer, 2002.

[17] M. Suoranta, "Adoption of mobile banking in Finland," *Jyväskylä studies in business and economics*, Jan. 2003.

[18] T. Pelkonen and N. Dholakia, "Understanding Emergent M-Commerce Services by Using Business Network Analysis: The Case of Finland," in *Wireless Communications and Mobile Commerce*, Idea Group Inc, Oct. 2011.

[19] Susie Lonie, "M-PESA: Finding New Ways to Serve the Unbanked in Kenya," in *Innovations in Rural and Agriculture Finance*, International food policy research institute, Jul. 2010.

[20] K. Okiro and J. Ndungu, "The impact of mobile and internet banking on performance of financial institutions in Kenya," *Eur Sci J*, vol. 9, no. 13, pp. 1857–7881, May 2013.

[21] T. ERIC, "Applying location-based service using USSD on low-end phones (mulikalocation)," UNITED STATES INTERNATIONAL UNIVERSITY, 2017.

[22] K.K Upadhayay, "USSD: A Communication Technology to Potentially Ouster SMS Dependency," *International Journal of Research and Reviews in Computer Science*, 2022.

[23] C. Dibyendu, M. Sasmita, and S. Katrina, "Study on Cell Phone Feature Perception and Usage Behaviour among Students," *KIIT Journal of Management*, vol. 10, Jun. 2014.

[24] K. K. Lakshmi, H. Gupta, and J. Ranjan, "USSD-Architecture analysis, security threats, issues and enhancements," in *Trends and Future Directions*, Institute of Electrical and Electronics Engineers Inc., Jul. 2017, pp. 798–802.

[25] G. Mosweunyane, T. Seipone, T. Z. Nkgau, and O. J. Makhura, “Design of a USSD system for tb contact tracing,” in *Proceedings of the IASTED International Conference*, Environment and Water Resource Management, Sep. 2014.

[26] J. A. Osae-Larbi, “Bridging the language barrier gap in the health of multicultural societies: report of a proposed mobile phone-based intervention using Ghana as an example,” *Osae-Larbi SpringerPlus*, vol. 5, no. 1, pp. 1–7, Dec. 2016.

[27] S. N. Ochoa, J. Y. Talavera, and J. M. Paciello, “Applying a geospatial visualization based on USSD messages to real time identification of epidemiological risk areas in developing countries,” in *2015 Second International Conference on eDemocracy & eGovernment (ICEDEG)*, Institute of Electrical and Electronics Engineers Inc., Apr. 2015, pp. 85–89.

[28] A. Mallik, C. Tran, and A. Twagirumukiza, “USSD Digital Wallet,” in *2020 Intermountain Engineering, Technology and Computing (IETC)*, Institute of Electrical and Electronics Engineers Inc., Oct. 2020.

[29] Prabhat. Pandey and M. Mishra. Pandey, *Research methodology: tools & techniques*. Bridge Center, 2015.

[30] jack fraenkel, norman wallen, and helen hyun, *How to Design and Evaluate Research in Education*. 2012.

[31] J. M. GLENFORD, B. TOM, and S. COREY, *The art of software testing 3rd edition*. John Wiley & Sons, Inc, 2012.

[32] J. Rubin and D. Chisnell, *Handbook of Usability Testing Second Edition How to Plan, Design, and Conduct Effective Tests*. Wiley Publishing, Inc., 2008.

[33] I. Ahmed and S. Ishtiaq, “Reliability and validity Importance in Medical Research,” *J Pak Med Assoc*, Oct. 2021.

[34] M. A. Hassan and Z. Shukur, “A Secure Multi Factor User Authentication Framework for Electronic Payment System,” in *2021 3rd International Cyber Resilience Conference (CRC)*, Institute of Electrical and Electronics Engineers Inc., Jan. 2021.

[35] A. V. Mota, S. Azam, B. Shanmugam, K. C. Yeo, and K. Kannoorpatti, “Comparative analysis of different techniques of encryption for secured data transmission,” in *2017 IEEE International Conference on Power, Control, Signals and Instrumentation Engineering (ICPCSI)*, Institute of Electrical and Electronics Engineers Inc., Sep. 2017, pp. 231–237.

[36] P. Patri, “Robotic Process Automation: Challenges and Solutions for the Banking Sector,” *International Journal of Management (IJM)*, vol. 11, no. 12, pp. 322–333, Dec. 2020.

[37] Aniket Dabas and Chetna Dabas, “Implementation of Real Time Tracking using Unstructured Supplementary Service Data,” *World Acad Sci Eng Technol*, 2009.

[38] Woochul Kang, Sang Hyuk Son, John A Stankovic, and K Ramamritham, “Design, Implementation, and Evaluation of a QoS-Aware Real-Time Embedded Database,” in *IEEE Transactions on Computers*, IEEE, Jan. 2012, pp. 45–59.

[39] M. N. Masrek, “The impact of perceived credibility and perceived quality on trust and satisfaction in mobile banking context,” *Asian Economic and Financial Review*, vol. 8, no. 7, pp. 1013–1025, Jan. 2018.

[40] J.C. Chao, M. Komaravolu, C. Lin, and G. Yiu, “Modeling internal controls of automated teller machine (ATM) systems: A computerized decision aid for design and evaluation,” in *Proceedings Seventh Annual Computer Security Applications Conference*, IEEE, Dec. 1991, pp. 1–7.

[41] R. Ball, S. Jayaraman, and L. Shivakumar, “The Complementary Roles of Audited Financial Reporting and Voluntary Disclosure: A Test of the Confirmation Hypothesis,” *SSRN Electronic Journal*, pp. 1–9, Oct. 2009.

[42] Daniele PALUMBO, “The Flutter Framework: Analysis in a Mobile Enterprise Environment,” M.A. Thesis, Politecnico Di Torino, Italy, 2021.

[43] A. A. Mangukiya, “Laravel: A framework for building PHP Apps,” *Journal of Innovation Information Technology and Application (JINITA)*, pp. 1–7, Dec. 2020.

[44] Raphaël Saunier, *Getting Started with Laravel 4*. Packt Publishing Ltd, 2014.

[45] Microsoft Learn, “How to Create Windows Services.” Accessed: Jan. 04, 2024. [Online]. Available: https://learn.microsoft.com/en-us/dotnet/framework/windows-services/how-to-create-windows-services

[46] S. Baron, Z. Peter, and T. Vadim, *High Performance MySQL: Optimization, Backups, and Replication - Baron Schwartz, Peter Zaitsev, Vadim Tkachenko*. O Reilly Media, 2008.

[47] M. Hamed, M. Hefny, Y. Helmy, and M. Abdelsalam, “Open Banking API Framework to Improve the Online Transaction between Local Banks in Egypt Using Blockchain Technology,” *Journal of Advances in Information Technology*, vol. 14, Jan. 2023.

[48] A. Khatri, N. Singh, and N. Gupta, “Big data analytics: direction and impact on financial technology,” *Journal of Management, Marketing and Logistics (JMML)*, vol. 8, no. 4, pp. 218–234, Dec. 2021.

[49] S. Y. Leng, A. Talib, and A. Gunardi, “Financial Technologies: A Note on Mobile Payment,” *Jurnal Keuangan dan Perbankan*, pp. 51–62, Feb. 2018.

[50] Foteini Michailidou, “RegTech and SupTech: Opportunities and Challenges in the Financial Sector,” M.A. Thesis, Università Ca’ Foscari, Italy, 2020.

[51] R. R. Suryono, I. Budi, and B. Purwandari, “Challenges and trends of financial technology (Fintech): A systematic literature review,” *Information (Switzerland)*, vol. 11, no. 12, pp. 1–20, Dec. 2020.

[52] L. J. Mester, “Cybersecurity and Financial Stability,” in *Financial Stability Conference*, Federal Reserve Bank of Cleveland and the Office of Financial Research, Nov. 2019.

[53] M. Nourallah, “A tale of two FinTech solutions: Loyalty in mobile bank applications and initial trust in financial robo-advisors,” PhD. Thesis, Mid Sweden University, Sweden, 2023.

[54] Jakob Nielsen, *Usability Engineering*. Morgan Kaufmann, 1994.

[55] Steve Krug, *Don’t make me think! Web & Mobile Usability*, 3rd ed. New Riders, 2013.

[56] K. Khadka and S. Maharjan, “Customer satisfaction and customer loyalty,” M.A. Thesis, Centria University of Applied Sciences, Finland, 2017.

[57] Santo Dewatmoko, Udayat2, and Desy Tri Anggarini, “The Influence of Financial Technology (Fintech) And User Experience on Trust in Financial Transactions Mediated by Perceptions of Security,” *Management Studies and Entrepreneurship Journal*, vol. 4, no. 6, pp. 9819–9825, Jun. 2023.

[58] F. F. Reichheld, “The One Number You Need to Grow,” *Harvard Business Review OnPoint*, pp. 1–12, Dec. 2003.

APPENDIX

SURVEY QUESTIONNAIRE

DESIGN AND DEVELOPMENT OF AUTOMATED USSD-BASED MOBILE PAYMENTS FOR MONEY TRANSFER COMPANIES.

I am a master's student at Atilim University, conducting a study on the development and implementation of an automated USSD-based mobile payment system. This research is focused on exploring the efficiency and accuracy of mobile money transfers using this system. The purpose of this study is to gather data that will contribute to the fulfillment of my master's degree requirements. This research is strictly for academic purposes, and all information provided will be kept confidential.

Please feel free to select the response that best represents your agreement or experience.

Email: _____

Section A: DEMOGRAPHIC DATA

1. Gender:
   - ○ Male
   - ○ Female
2. Age: _____ years old
3. Education Level:
   - ○ Intermediate
   - ○ Bachelor
   - ○ High School
   - ○ Master
4. How many years of experience do you have in manual transfer role?

_____

Section B: Transaction Handling and Manual Process Evaluation

5. On average, how many money transfer transactions do you handle manually each day?

   _____

6. How much time does it typically take you to complete each transaction?

   _____

7. How often do you experience errors when conducting manual money transfers?

   ○ Always
   ○ Often
   ○ Sometimes
   ○ Rarely
   ○ Never

8. If an error occurs during a manual money transfer, how much time takes to rectify that mistake?

   _____

9. How many employees are there at your workplace who perform similar money transfer tasks as you do?

   _____

Section C: Views on Automated Money Transfer Systems

10. What are the main challenges you face with manual fund transfers?

    ○ Time-consuming
    ○ Error-prone
    ○ Inconvenient
    ○ Lack of security
    ○ Others:
    _____
    _____
    _____

11. What benefits do you think an automated money transfer system would bring?

    ○ Increased efficiency
    ○ Improved accuracy

- ○ Convenience
- ○ Enhanced security

12. What challenges do you foresee in implementing an automated system for money transfers?
    - ○ Technical difficulties
    - ○ Security concerns
    - ○ High initial costs
13. How do you think an automated system would affect the speed of money transfers?
    - ○ Significantly faster
    - ○ Somewhat slower
    - ○ Somewhat faster
    - ○ Significantly slower
    - ○ Neutral
14. What level of training do you think would be necessary for users to effectively adopt this automated money transfer system?
    - ○ Extensive training
    - ○ Minimal training
    - ○ Moderate training
    - ○ No training needed

Section D: Perception and Satisfaction with Automated USSD-based Mobile Payment System

15. Which feature would you consider most important in an automated fund transfer system?
    - ○ Speed
    - ○ Security
    - ○ Accuracy
    - ○ Others: _____
    - ○ Ease of use
16. How confident are you in the security of automated money transfer systems?
    - ○ Very confident
    - ○ Somewhat unconfident
    - ○ Somewhat confident
    - ○ Not confident at all
    - ○ Neutral

17. How easy do you think it would be to integrate this automated money transfer system with existing financial systems?
    - ○ Very easy
    - ○ Easy
    - ○ Neutral
    - ○ Difficult
    - ○ Very difficult
18. Do you believe the benefits of an automated money transfer system outweigh the potential costs and challenges?
    - ○ Strongly agree
    - ○ Agree
    - ○ Neutral
    - ○ Disagree
    - ○ Strongly disagree
19. How easy was it to navigate and use the automated USSD-based mobile payment system?
    - ○ Very easy
    - ○ Easy
    - ○ Neutral
    - ○ Difficult
    - ○ Very difficult
20. How clear were the instructions and functions within the system?
    - ○ Extremely clear
    - ○ Clear
    - ○ Moderately clear
    - ○ Slightly clear
    - ○ Not clear at all
21. How would you rate the speed of transactions when using this automated system compared to manual system?
    - ○ Very fast
    - ○ Fast
    - ○ Average
    - ○ Slow
    - ○ Very slow
22. How efficient do you find the transaction process in this automated system compared to manual system?
    - ○ Extremely efficient
    - ○ Very efficient

- ○ Moderately efficient
- ○ Not efficient at all
- ○ Slightly efficient

23. Overall, how satisfied are you with this automated USSD-based mobile payment system?
    - ○ Very satisfied
    - ○ Dissatisfied
    - ○ Satisfied
    - ○ Very dissatisfied
    - ○ Neutral
24. How likely are you to recommend the automated USSD-based mobile payment system to others?
    - ○ Extremely likely
    - ○ Unlikely
    - ○ Likely
    - ○ Extremely unlikely
    - ○ Neutral
25. On a scale from 1 to 10, how would you rate the performance of your system?
    - ○ 1
    - ○ 6
    - ○ 2
    - ○ 7
    - ○ 3
    - ○ 8
    - ○ 4
    - ○ 9
    - ○ 5
    - ○ 10

Section E: Suggested Improvements

26. What aspects of this software do you think are open to improvement?

    _____

    _____

    _____

    _____

    _____