Published: 12 January 2024

ICCMB 2024: 2024 7th International Conference on Computers in Management and Business
January 12 - 14, 2024
Singapore, Singapore

RESEARCH-ARTICLE

A Software Architecture Design Based on Microservices for an E-wallet in Ecuador

EFRAIN INSUASTI, Salesian Polytechnic University, Cuenca, Azuay, Ecuador

BRYAN CISNEROS, Salesian Polytechnic University, Cuenca, Azuay, Ecuador

PAULINA MORILLO, Salesian Polytechnic University, Cuenca, Azuay, Ecuador

Open Access Support provided by:

Salesian Polytechnic University

ICCMB '24: Proceedings of the 2024 7th International Conference on Computers in Management and Business (January 2024)
https://doi.org/10.1145/3647782.3647811
ISBN: 9798400716652

A Software Architecture Design Based on Microservices for an E-wallet in Ecuador

A software architecture design for an e-wallet in Ecuador

Efraín Insuasti
Universidad Politécnica Salesiana, Ecuador
einsuastir@est.ups.edu.ec

Bryan Cisneros
Universidad Politécnica Salesiana, Ecuador
bcisnerosc@est.ups.edu.ec

Paulina Morillo*
Universidad Politécnica Salesiana, IDEIAGEOCA Research Group, Ecuador
pmorillo@ups.edu.ec

ABSTRACT

The use of payment apps, also known as mobile wallets, has increased worldwide in recent years, especially after the COVID-19 pandemic. However, in Latin America, implementing this technology still faces challenges associated with the regulation of FinTech, the accessibility of services, and the security of information. In the case of Ecuador, there are some mobile wallet proposals, but they still have restrictions on carrying out different types of financial transactions. A software architecture design for a mobile wallet that promotes inclusion and equality in access to financial services is proposed to address these challenges. The design uses microservices architecture and cloud computing design patterns to give it greater robustness, adaptability, and capacity, offering a better user experience and driving the development of new features. This paper also examines the current legal and regulatory framework for electronic payment systems in Ecuador, and these legal aspects were considered in the design. The technical requirements for building this software architecture, including its interactions and functionalities, are also discussed.

CCS CONCEPTS

• **Software and its engineering**; • **Software creation and management**; • **Designing software**;

KEYWORDS

Mobile Payments, AWS, Cloud Computing, E-Payments, Financial Regulation

ACM Reference Format:
Efraín Insuasti, Bryan Cisneros, and Paulina Morillo*. 2024. A Software Architecture Design Based on Microservices for an E-wallet in Ecuador: A software architecture design for an e-wallet in Ecuador. In *2024 7th International Conference on Computers in Management and Business (ICCMB 2024), January 12–14, 2024, Singapore, Singapore*. ACM, New York, NY, USA, 8 pages. https://doi.org/10.1145/3647782.3647811

ICCMB 2024, January 12–14, 2024, Singapore, Singapore

ACM ISBN 979-8-4007-1665-2/24/01
https://doi.org/10.1145/3647782.3647811

1 INTRODUCTION

In recent years, financial systems have evolved to meet the requirements of their customers without the need to visit a bank branch physically. Thus, web applications that later migrated to mobile applications have increased thanks to the growing use of smartphones. Further, the demand for efficiency and speed in making transactions and payments has given way to the development and popularization of electronic wallets. In the last decade, China has experienced significant economic growth and has a financial system that requires them to use an electronic wallet. Currently, 80 % of the money in circulation in China is electronic, and e-money plans have been completed in other countries, such as Ukraine and Uruguay [1].

Due to the COVID-19 pandemic, contactless payments using NFC technology had a higher adoption in the United States, with 29 % of payments made through mobile wallets, with PayPal being the most used online payment service [2]. Similarly, 22.7% of transactions in the United Kingdom are made using mobile wallets, and Apple Pay stands out as the most used service. In general, technological development and the COVID-19 pandemic have decreased the use of cash to prevent the spread of the virus and as a security measure [3]. As a direct consequence, there was an increase in the acquisition of smartphones to use online financial transactions, such as service payments and bank transfers.

Therefore, adopting a mobile wallet as a means of payment has proven viable in many countries, but several factors must be considered for its implementation. According to [4], the government can play a crucial role by offering incentive programs to encourage the use of mobile wallets, which helps to reduce the circulation of cash and, therefore, the costs associated with its maintenance and printing. Moreover, security and ease of use also play a crucial role in using digital payment methods, as put in the analysis conducted in [5] through interviews with 145 users in Indonesia. This study considered user satisfaction, ease of use, and compatibility with the current financial system. It concluded that 61.6% of the population intended to use this type of mobile wallet, while user satisfaction reached 68.2%. With this consideration, the article in [6] presents an e-wallet architecture designed for Bangladesh. Its design has been proposed considering the connection with the national payment network of that country, known as the National Payment Switch (NPS). Likewise, as discussed in [7], architectures based on the Universal Payment Platform of India (UPI) also possess improvements in terms of security. This analysis reveals points of failure in existing implementations. It highlights how minor modifications, like the inclusion of notification and blocking systems for failed attempts, can significantly improve mobile wallets' security.

In addition to the factors mentioned, it is essential to consider each country's laws and financial policies for implementing a mobile wallet. In different parts of the world, such as Singapore, significant changes have been made to the legislation [8] , allowing for a relaxation of policies, which in turn has resulted in the creation of a transparent, open, and favorable legal framework for the adoption of these new technologies Contrarily, although Indonesia has progressed in adopting mobile wallets and financial technologies, and even though the operation of fintech is regulated in the country, obtaining licenses to operate could be bureaucratic, which harms the penetration of digital financial services [9].

On the other hand, in Latin America, less than 40% of the population has access to some traditional bank account [10]. This fact is mainly due to the requirement for many documents and evidence of solvency. However, digital bank accounts and payment transactions have increased significantly in the last three years, mainly in Mexico and Brazil [11]. In 2020, the Central Bank of Brazil introduced PIX, a system for instant payments that represented a significant innovation in the Brazilian financial system, thus eliminating the problem of waiting time in interbank transactions, as was seen in the past [12], similar to the Interbank Electronic Payment System (SPEI) and Transfers 3.0 for Mexico and Argentina, respectively. In the rest of the countries of Latin America and the Caribbean, the use of digital payment has also increased, especially after the pandemic. Still, the massive use of these services presents obstacles, such as obsolete or excessively onerous regulation, lack of standardization, and lack of market access and competition [13].

In the case of Ecuador, laws have been approved to regulate the operation of fintechs. In 2021, more than 600 million banking transactions were carried out, of which 41% were through digital channels [14]. Currently, there are only three mobile wallet alternatives in the country: Peigo, DeUna!, and PayPhone. However, these cannot carry out interbank transactions because Ecuadorian regulations only allow them to be carried out with a banking license, thus limiting the possibility of carrying out transactions freely and quickly. Interbank transactions made through the National Payment System, such as the Direct Payment Agreement, can take up to a day to become effective and have a service cost derived from the value-added tax (VAT), which generates discomfort in the final client. Besides, a study conducted in Colombia [15] indicates that a mobile wallet generates more trust if a recognized financial institution backs it since they have legal regulations and standards. Ergo, implementing an electronic wallet in Ecuador faces significant challenges, principally in technical and legal aspects. Under these conditions, this paper aims to design a software architecture for an mobile wallet based on microservices that comply with Ecuadorian laws and regulations so that interested fintech can have a reference guide for a successful implementation. Furthermore, this work will present the benefits of a Cloud Native architecture applicable to various cloud providers since this architecture offers greater flexibility and availability for users, making the deployment processes more accessible and faster[16]–[18].

This paper is structured in four sections. Section 2 details the methodology used for the software architecture design. Section 3 describes the e-wallet architecture design, considering the components, their interactions, technical constraints, and non-functional requirements. Section 4 presents the technological and social impact of a possible mobile wallet implementation. Finally, Section 5 offers the conclusions and prospects of this work.

2 METHODOLOGY

The methodology followed in the design of the electronic wallet consists of two phases. The first is the analysis of Ecuadorian regulations for the operation of digital payments. Secondly, the technical requirements analysis is performed, where all the needs raised by the interested parties, both functional and non-functional, are examined. Likewise, the essential components required to build the mobile wallet platform and ensure adequate interaction with the system are identified.

The e-wallet software architecture design considers Amazon Web Services (AWS) cloud services because it has the largest market share compared to its competitors, Microsoft Azure and Google Cloud Platform [19], and due to AWS being shown as a leader in Gartner's Magic Quadrant 2022. AWS Platform as a Service (PaaS) can be leveraged to allow the development team to focus on applications and business logic rather than infrastructure maintenance. In this way, the operating costs associated with infrastructure management could reduced [20]. Other services, such as Amazon Managed Streaming for Apache Kafka (MSK), can also be used for database management. Elastic Cache and Amazon RDS for cache management. Amazon S3 for file storage. Amazon CloudFront as a content distributor. AWS Cognito for identity management, Elastic Load Balancing, and Amazon API Gateway for load balancing and API Gateway, respectively.

2.1 Analysis of Ecuadorian technological financial services regulations

This section analyzed the legal requirements for companies that offer digital payment services to comply with to operate in Ecuador. In 2022, the "Organic Law for the Development, Regulation, and Control of Technological Financial Services" (OLDRCTFS) was approved [21]. Article 1 of the law establishes its objective of "regulating Fintech activities carried out by technological initiatives related to all financial activities, including financial, securities and insurance markets." Furthermore, Article 2 focuses on "promoting innovation and the development, adoption, and use of new technologies in financial products and services to improve financial inclusion, national productivity and contribute to the reduction of socioeconomic inequality gaps in a context arm's length competition and provide protection to users and consumers of services." The following three articles establish the types of entities this law covers and their activities. Article 6 presents the principles that govern companies that carry out these activities. Point six of this article establishes that the processing of personal data is governed by the "Organic Law on Protection of Personal Data" (OLPPD) [22] Article 37 of OLPPD highlights the importance of implementing some encryption strategy for storing this data. Articles 8 and 26 deal with consent and processing of sensitive data, establishing that companies must obtain the explicit consent of the user to handle their sensitive data.

Back to article 6 of the OLDRCTFS, point seven states the importance of ensuring that the data in transit are confidential, for which encryption systems are implemented in the transit of sensitive data. Finally, point eight refers to the need to have a monitoring and traceability system where the concealment of confidential information is guaranteed. This item also has relevance with the "Law for the Prevention of Money Laundering and Financing of Crimes" (LPMLFC) [23], which, in Article 4 Section C, mentions that it must: "Record individual operations and transactions whose amount is equal to or greater than ten thousand United States dollars or its equivalent in other currencies, as well as multiple operations and transactions that, in the aggregate, are equal to or greater than such value." The same article, but in section A, mentions the obligation to keep a record of the customer's identity, i.e., personal data, economic activity, marital status, and domicile information.

The articles and sections of the laws analyzed directly affect the decision-making process for the design of the e-wallet software architecture. In this way, the technical requirements, both functional and non-functional, are formulated. In addition, another requirement is that any entity wishing to provide technological and financial services in Ecuador must be legally incorporated, as mentioned in Article 7 of the Fintech Law. Also, this entity must be supervised and controlled by the Central Bank of Ecuador, the Superintendence of Securities and Insurance Companies, and the Superintendence of Banks.

A part of legal analysis, a brief analysis of the current financial system revealed that two fundamental aspects are needed to improve the user experience. The first one is to renew the technology of the entity that handles interbank transactions, i.e., the Central Bank of Ecuador, since it is ancient and does not carry out transfers automatically and in real-time, but in stages and supported by manual processes, which slows down the processes and makes them inefficient. The second aspect is the need to generate a regulation that eliminates the costs associated with transactions between banks, cooperatives, and financial companies and standardizes the application programming interface based on the Banking Industry Architecture Network (BIAN), which promotes interoperability and practices of Open Banking.

2.2 Technical Requirements

The design approach of a mobile wallet is a complex task since it must comply with commercial, legal, and technical requirements, which implies high availability, resilience, and security. On the product side, usability and a good user experience must be ensured to retain and increase the number of active users. For this reason, functional and non-functional aspects are considered to achieve a minimum viable product that can guarantee compliance with Ecuador's legal and operational requirements. In the same way, the essential components of the system and their interactions are established.

2.2.1 Functional Requirements. This mobile wallet must allow the registration of new users and guarantee security through a second authentication factor. It must be compatible with various payment methods and nationwide banking networks. Additionally, it must allow access to the history of transactions made and be accessible on a wide range of mobile devices, allowing users to manage their finances on the go. The mobile wallet should also send users notifications about transactions, balance changes, and suspicious activity. Table 1 summarizes the identified requirements.

2.2.2 E-wallet Components. Part of the design involves identifying the main components that will make up the mobile wallet system at a high level. In this part, the structure, organization, and technologies of mobile wallet are defined to guide the future implementation of the software (Figure 3).

The first component is the mobile application, a platform designed to provide users with a user-friendly and easy-to-use interface, giving them access to various microservices through the API Gateway. Then there is the Authorization Service, also known as Customer Identity and Access Management (CIAM), responsible for verifying user credentials and allowing them to access protected resources according to assigned permissions and roles. On the other hand, the threat and attack protection layer, Web Application Firewall Policies (WAF), establishes rules to block known attacks and filter suspicious web traffic. The API Gateway and Load Balancers are another component; together, they are responsible for routing, validating, and authenticating incoming requests and efficiently managing and distributing traffic among resources.

Further, the Backend for Frontend (BFF) is a specific backend for mobile application functionalities, allowing greater adaptability. Behind it, specialized services are executed and reusable by other BFFs, communicating with each other through internal interfaces. Another essential element is the centralization of logs, which guarantees a unified view of the system and facilitates audits, concentrating all the events recorded by the components in a single place. Finally, the Database layer is responsible for storing data related to the system's business.

2.2.3 Interactions of e-wallet components. The interactions between the system components are defined as follows: the application communicates with the exposed services through the API Gateway, which oversees authentication, authorization, and security, as well as redirecting the requests to the corresponding internal services. The Web Application Firewall Policies act as a protection mechanism in the middle of the system based on rules, security policies, and filters for known malicious addresses. Besides, the Backend for Frontend provides an abstraction layer of the internal services, receiving requests from the application and offering specific functionalities and services for this purpose. It uses the APIs exposed by the internal services for data processing. In addition, inside services communicate through defined internal interfaces, such as REST API, gRPC, Websockets, etc., allowing seamless communication between different services. When integration with external providers is required, these services communicate through vendor-defined interfaces—payment services, authentication, maps, etc. All these interactions should be collected and stored in a centralized system that allows auditing and obtaining information about the performance of the whole architecture.

2.2.4 Non-functional Requirements. Non-functional requirements ensure the quality of the architecture, and this study focused on attributes affecting security, compliance, performance, usability,

Table 1: Identified functional requirements.

User management	Payment management
Access using a username and password	Send money
Identity validating	Receive money
Update information	Check the balance
	Add money
	Receive notifications and alerts

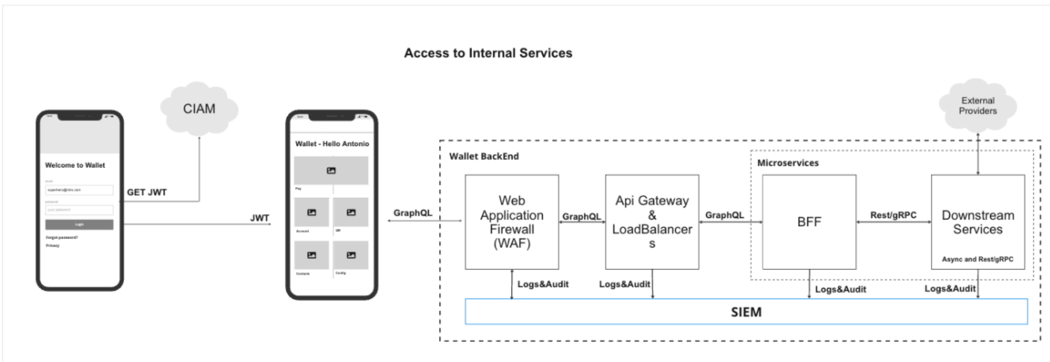

Figure 1: Diagram of High-Level Architecture

scalability, availability, and support. Security and regulatory compliance are closely linked since Ecuadorian laws require the implementation of an encryption system for sensitive data in transit. Therefore, to address this point, we propose using the AES algorithm, recommended for mobile applications, due to its speed and low computational requirements [24]. Furthermore, performance, scalability, usability, and availability are requirements known as ilities. These requirements describe the quality characteristics of the system in terms of the ability to grow according to the user load, response time on requests, and ease of use. These requirements can be delegated or shared with a public or hybrid cloud provider facilitated maintenance and scalability processes, providing applications with greater flexibility and efficiency. Regarding support and maintenance, although it is not the focus of this work, a functional and regression testing scheme should be designed. A work team should be established, preferably with agile methodology, to develop new features, bug fixes, and technical support.

3 E-WALLET SOFTWARE ARCHITECTURE DESIGN

Since a mobile wallet is a mission-critical application, it is necessary to implement security, load balancing, monitoring, and auditing. From a global view, the application would work according to the scheme shown in Figure 3, where the main components of the solution are located. Using the BFF "Backend For FrontEnd" cloud design pattern proposed by [25], "Downstream Services" can be built using microservices, with which they can interact synchronously and asynchronously using choreography and orchestration, so a generic framework and structure is proposed for their use.

3.1 Microservice Architecture

Microservices architecture is a software development approach in which an application is decomposed into multiple small, independent services that can be developed, deployed, and scaled independently. These services are known as microservices. Each is a self-contained functional unit [26]. A generic structure has been defined for the development of microservices. Figure 4 describes the connections a microservice must have and the internal structure of a microservice deployed in Kubernetes with Envoy.

Each microservice must have its database and cache, and in case it is used synchronously, it must have its own subscription and publication techniques. Some microservices have external providers, which are primarily third-party APIs. In the case of a mobile wallet, a Digital Identity Platform is needed to validate the client's identity through a photo stored in a government entity, in the case of Ecuador, the Civil Registry. The connection with this entity could validate the customer's information and life status. On the other hand, a tool is also needed to manage and improve customer relationships; this tool is known as the CRM Platform, which will help to optimize communication, sales, and customer satisfaction.

For transaction management, a Core Banking and a Transactional Switch are required to handle operations such as account opening, regulatory reporting, and routing of electronic transactions. Additionally, customer information providers must comply with the regulations outlined in section 2.1, such as the Civil Registry, Credit Bureau, and AML Denylist verification systems.

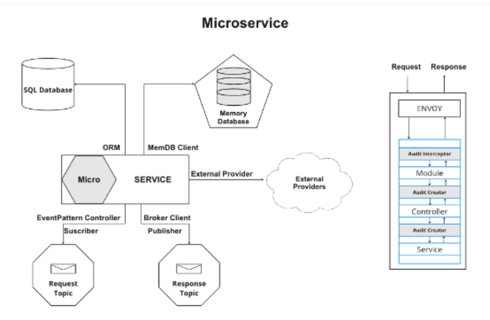

Figure 2: Microservice Diagram.

3.2 Orchestration and Choreography of Microservices

Orchestration and choreography are different approaches to coordinating and managing interaction in a microservices architecture. In the case of Orchestration, there is a centralized component known as the orchestrator, in charge of controlling and coordinating the interactions between the microservices [27]. The orchestrator defines the sequence of actions that must be performed to complete a task or business process and also coordinates and executes each microservice function indicated by the orchestrator through an API or messages to request data or perform specific actions. It is also responsible for directing the workflow and can handle routing, authentication, transactionality, error recovery, and scalability tasks. A typical example of orchestration is workflow engines such as Camunda, Activiti, or AWS Step.
In choreography, on the other hand, there is no centralized component that coordinates all interactions. Instead, each microservice responds to the events or messages it receives and acts accordingly. Microservices interact by sending messages or events and reacting to events generated by others; each has its internal logic and works in response to the events it receives, creating decentralized communication. Choreography is more flexible and allows greater autonomy for microservices, but it can also be more complex to manage and debug. Some common examples of tools to implement choreography are Apache Kafka, RabbitMQ, or AWS Simple Notification Service (SNS).

Using a combination of both approaches leverages the benefits of each in appropriate contexts, e.g., in situations requiring asynchronous communication and greater independence between microservices, the choreographic approach is the ideal choice. Moreover, this combination has better fault tolerance since if one microservice fails, the other microservices can continue to operate independently. This synergy allows greater flexibility when designing software architectures. Figure 3 shows the communication between microservices.

3.3 Main Microservices of a e-wallet

The essential flows for executing an mobile wallet are Onboarding, payments, and entry to the application (Login and Home Screen). The architecture diagrams are available at the following link: https://miro.com/app/board/uXjVNX1fu2Q=/?share_link_id=51890069329. These diagrams show the execution sequences of each microservice. Figure 4 shows the services that interact in the main flows.

3.3.1 *Onboarding.* It is the process that users follow when registering and logging in for the first time in a mobile banking application, and it should be designed to facilitate the entry of new users and ensure that they have a positive and smooth experience when using the application. It should also include the following points: registration, identity verification, consent and approval of terms and conditions, security configuration (2FA second factor authentication generation process), explanation of features, and customer service. AML (Anti Money Laundering) processes are executed within the identity verification process. Efficient, fast, and well-designed onboarding increases the adoption rate of the application and reduces the possibility of users abandoning the registration process due to complexity or lack of clarity. Besides, it provides a solid foundation for building a trusting relationship with the customer, achieving excellent retention and loyalty with the bank in the long term. Figure 5 shows the designs and flows for user creation, KYC (Know Your Customer), account creation with OTP validation, and data update for AML processing.

3.3.2 *Login and Home.* The First Login refers to the process customers follow to access the banking application for the first time after completing the registration or Onboarding. The account is created and verified on the user's first encounter with the application. The steps of this flow are welcome or home screen of the

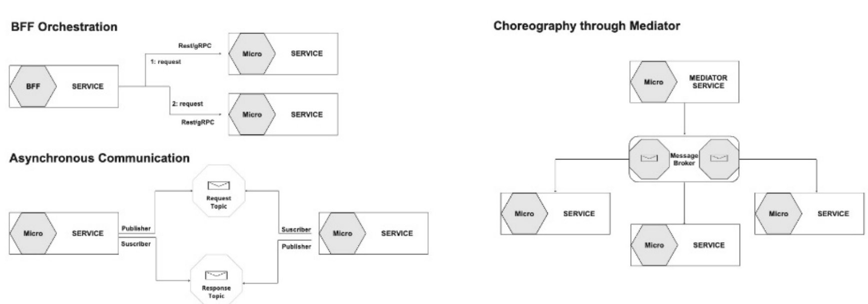

Figure 3: Communication between Microservices.

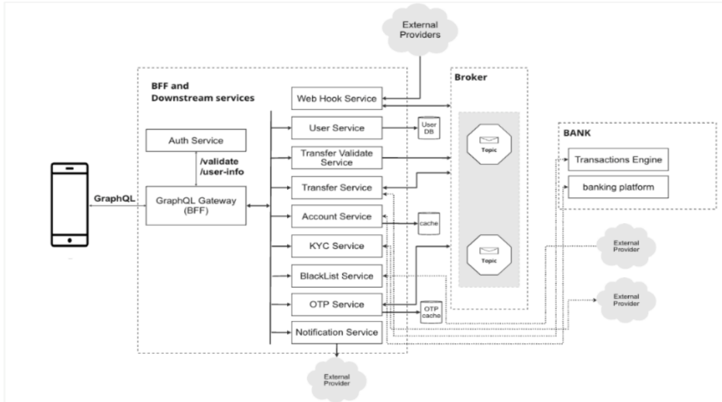

Figure 4: Main Microservices of a Wallet

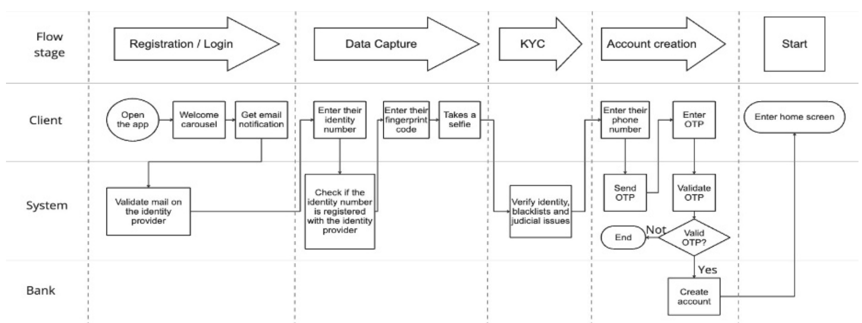

Figure 5: Onboarding Flowchart.

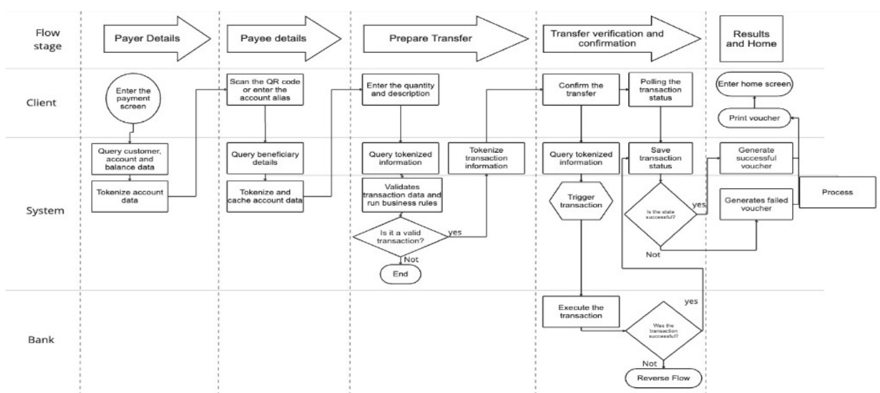

Figure 6: Payments Flowchart.

application, identity confirmation or Login screen, and the main screen or Home is presented.

The Home screen (main page or home screen) is the primary interface shown to the user after the First Login and every time the application is opened. This central screen offers a visual summary of the most relevant information and the application's critical options. Also, it is recommended to have an account summary, the date and time of the last Login, and links or buttons to access critical services such as payments and collections. At last, a menu or navigation bar that allows the user to access other application sections, such as customization options and access to help and support.

3.3.3 Payments. In a banking application, the payment flow must be intuitive, easy to follow for users, and secure to guarantee a positive and reliable experience with clear indications at each process step. Security is paramount, so safeguards must be implemented to prevent fraud and ensure users' financial information privacy. The typical steps that make up the payment flow are payment type selection, transaction details entry, transaction confirmation, security verification, payment processing, notifications, receipt delivery, and the updated balance display. The application may require additional verification to confirm the authenticity of the user and the transaction, such as a password, security pattern, fingerprint, or two-factor authentication (2FA) code. Similarly, compliance considerations for a payment depend on the amount and recurrence. Figure 6 shows the flows of validation of the beneficiary's account, preparation or tokenization of the transaction, confirmation of the transaction, and verification of the transaction status in synchronous format.

4 IMPACT AND DISCUSSION

The use of mobile wallets has a significant impact on the way people manage their finances and conduct transactions. The impact of digital payment methods is reflected not only for the individual but also for society. According to a study by the World Bank Group, access to financial services contributes to the reduction of poverty and the economic growth of countries [28]. Another study in 111 developing countries revealed that digital payment methods reduce corruption perception [29]. Furthermore, managing money digitally minimizes users' exposure to theft or loss and reduces the costs of printing and maintaining printed money [30]. It also makes it easier for people to participate in e-commerce and buy and sell online products, which opens new business opportunities for SMEs and entrepreneurs [31]. Thus, there has been rapid growth in digital payment services in recent years, also driven by the contactless measures adopted during the COVID-19 pandemic [32], [33]. In Latin America and the Caribbean, there has also been a boom in the fintech sector; countries such as Argentina, Mexico, and Brazil have successfully implemented digital payment methods, increasing digital penetration and access to financial accounts [34].

Despite the clear advantages of digital payment methods, their implementation faces challenges associated with country regulations and data security [35]. In Ecuador, there have been proposals and technological solutions for implementing the mobile wallet, although its implementation has been carried out mainly by private banking. In 2016, studies were presented that demonstrated that the implementation of public or private e-payments was technically viable [36], [37]. In addition, the participation of all actors was shown, including the role of the Central Bank of Ecuador as a promoter of implementing a public electronic payment method that allows access to mainly people who are limited from participating in private banking. Likewise, a recent work [38] shows a software architecture design that makes possible the development of an e-wallet that guarantees secure transactions. In this context, the design of the software architecture of the e-wallet proposed in this work allows the operational processes to be almost completely automated, thus improving internal processes and reducing costs associated with operation and maintenance. A mobile wallet with these characteristics does not require direct customer service windows since this entire process can be carried out through digital channels. Although users are still resistant to this technology, it is undeniable that due to recent advances in artificial intelligence, specifically in natural language models, there is a change in how people interact with systems [39], [40]. On the other hand, developing this type of solution guarantees accessibility to various payment methods to the population and represents a significant advance for the financial sector in Ecuador since it would facilitate cash flow, executing it more safely and efficiently.

5 CONCLUSIONS AND FUTURE WORK

This work proposes the design of a software architecture for a mobile wallet that promotes inclusion and equality in access to financial services, as well as compatibility with a wide range of devices, ensuring that it can be used by most users, regardless of their technological capabilities. The proposed solution also effectively adapts to the local laws of Ecuador. The design of this mobile wallet uses microservices architecture and cloud computing design and implementation patterns, considered de facto standards in today's technology industry, as they provide greater robustness, adaptability, and capacity, offering a better user experience and driving the development of new features.

In future work, implementing a mobile wallet that works transparently and encourages the creation of new consumption spaces for customers would be a promising way to advance and boost Ecuador's financial and economic development. Once the proposed software architecture is implemented, the costs associated with the cloud services required to operate the electronic wallet could be analyzed.

ACKNOWLEDGMENTS

This work was supported by IDEIAGEOCA Research Group of Universidad Politécnica Salesiana in Quito, Ecuador.

HISTORY DATES

In case of submissions being prepared for Journals or PACMs, please add history dates after References as (*please note revised date is optional*):

Received November 2019; revised August 2020; accepted December 2020

REFERENCES

[1] J. Xu, "Developments and Implications of Central Bank Digital Currency: The Case of China e-CNY," Asian Economic Policy Review, vol. 17, no. 2, pp. 235–250, Jul. 2022, doi: 10.1111/aepr.12396.
[2] N. Shaw, B. Eschenbrenner, and D. Baier, "Online shopping continuance after COVID-19: A comparison of Canada, Germany and the United States," Journal of Retailing and Consumer Services, vol. 69, p. 103100, Nov. 2022, doi: 10.1016/j.jretconser.2022.103100.
[3] Statista, "Mobile payments in the United Kingdom (UK) - statistics & facts." Accessed: Nov. 09, 2023. [Online]. Available: https://www.statista.com/topics/6757/mobile-payments-in-the-uk/#topicOverview
[4] X.-M. Loh, V.-H. Lee, G. W.-H. Tan, K.-B. Ooi, and Y. K. Dwivedi, "Switching from cash to mobile payment: what's the hold-up?," Internet Research, vol. 31, no. 1, pp. 376–399, Oct. 2020, doi: 10.1108/INTR-04-2020-0175.
[5] D. Gea and N. I. Al-Azhar, "The Analysis of Factors Affecting Using Interest of QRIS Payment Systems on E-wallet Applications in Indonesia," in 2021 International Conference on Information Management and Technology (ICIMTech), IEEE, Aug. 2021, pp. 111–115. doi: 10.1109/ICIMTech53080.2021.9535036.
[6] M. Salah Uddin and A. Yesmin Akhi, "E-Wallet System for Bangladesh an Electronic Payment System," International Journal of Modeling and Optimization, vol. 4, no. 3, pp. 216–219, Jun. 2014, doi: 10.7763/IJMO.2014.V4.376.
[7] K. K. Lakshmi, H. Gupta, and J. Ranjan, "UPI Based Mobile Banking Applications – Security Analysis and Enhancements," in 2019 Amity International Conference on Artificial Intelligence (AICAI), IEEE, Feb. 2019, pp. 1–6. doi: 10.1109/AICAI.2019.8701396.

[8] E. Leong, "Open Banking: The Changing Nature of Regulating Banking Data - A Case Study of Australia and Singapore," Banking & Finance Law Review, vol. 35, no. 3, pp. 443–469, Aug. 2020, [Online]. Available: https://www.proquest.com/scholarly-journals/open-banking-changing-nature-regulating-data-case/docview/2435720729/se-2?accountid$=$32861

[9] M. Aulia, A. F. Yustiardhi, and R. O. Permatasari, "An overview of Indonesian regulatory framework on Islamic financial technology (fintech)," Jurnal Ekonomi & Keuangan Islam, vol. 6, no. 1, pp. 64–75, Jan. 2020, doi: 10.20885/jeki.vol6.iss1.art7.

[10] D. Rojas-Torres, N. Kshetri, M. M. Hanafi, and S. Kouki, "Financial Technology in Latin America," IT Prof, vol. 23, no. 1, pp. 95–98, Jan. 2021, doi: 10.1109/MITP.2020.3028486.

[11] M. Sumlinski *et al.*, "The Rise and Impact of Fintech in Latin America," Fintech Notes, vol. 2023, no. 003, p. 1, Mar. 2023, doi: 10.5089/9798400235474.063.

[12] I. Kónya *et al.*, New age of central banking in emerging markets. Budapest: Corvinus University of Budapest, 2023. doi: 10.14267/978-963-503-941-8.

[13] "Accelerating Digital Payments in Latin America and the Caribbean," Washington, D. C., May 2022. doi: 10.18235/0004256.

[14] ASOBANCA, "El avance de la banca digital en Ecuador." Accessed: Nov. 09, 2023. [Online]. Available: https://asobanca.org.ec/wp-content/uploads/2022/07/Transacciones-digital.pdf

[15] A. A. Bailey, C. M. Bonifield, A. Arias, and J. Villegas, "Mobile payment adoption in Latin America," Journal of Services Marketing, vol. 36, no. 8, pp. 1058–1075, Oct. 2022, doi: 10.1108/JSM-04-2021-0130.

[16] A. Balalaie, A. Heydarnoori, and P. Jamshidi, "Migrating to Cloud-Native Architectures Using Microservices: An Experience Report," 2016, pp. 201–215. doi: 10.1007/978-3-319-33313-7_15.

[17] R. M. Munaf, J. Ahmed, F. Khakwani, and T. Rana, "Microservices Architecture: Challenges and Proposed Conceptual Design," in 2019 International Conference on Communication Technologies (ComTech), IEEE, Mar. 2019, pp. 82–87. doi: 10.1109/COMTECH.2019.8737831.

[18] L. De Lauretis, "From Monolithic Architecture to Microservices Architecture," in 2019 IEEE International Symposium on Software Reliability Engineering Workshops (ISSREW), IEEE, Oct. 2019, pp. 93–96. doi: 10.1109/ISSREW.2019.00050.

[19] B. Gupta, P. Mittal, and T. Mufti, "A Review on Amazon Web Service (AWS), Microsoft Azure & Google Cloud Platform (GCP) Services," in Proceedings of the 2nd International Conference on ICT for Digital, Smart, and Sustainable Development, ICIDSSD 2020, 27-28 February 2020, Jamia Hamdard, New Delhi, India, EAI, 2021. doi: 10.4108/eai.27-2-2020.2303255.

[20] S. A. Bello *et al.*, "Cloud computing in construction industry: Use cases, benefits and challenges," Autom Constr, vol. 122, p. 103441, Feb. 2021, doi: 10.1016/j.autcon.2020.103441.

[21] Asamblea Nacional República del Ecuador, "Ley orgánica para el desarrollo, regulación y control de los servicios tecnológicos (LEY FINTECH)." Accessed: Nov. 09, 2023. [Online]. Available: http://esacc.corteconstitucional.gob.ec/storage/api/v1/10_DWL_FL/eyJjYXJwZXRhIjoicm8iLCJ1dWlkIjoiMDc1ZWQ3MzQtZjNkNi00MmZmLTgwNGYtYjU3N2VlMjE4ZmU1LnBkZiJ9

[22] Asamblea Nacional República del Ecuador, "Ley Orgánica de protección de datos personales." Accessed: Nov. 09, 2023. [Online]. Available: https://www.finanzaspopulares.gob.ec/wp-content/uploads/2021/07/ley_organica_de_proteccion_de_datos_personales.pdf

[23] Asamblea Nacional República del Ecuador, "Ley prevención de lavado de activos y del financiamiento de delitos." Accessed: Nov. 09, 2023. [Online]. Available: https://www.gob.ec/sites/default/files/regulations/2018-10/Documento_Ley-de-Prevenci%C3%B3n-Detecci%C3%B3n-y-Erradicaci%C3%B3n-del%20Delito-del-Lavado-de-Activos-y-Financiamiento-de-Delitos.pdf

[24] A. Al Hasib and A. A. Md. M. Haque, "A Comparative Study of the Performance and Security Issues of AES and RSA Cryptography," in 2008 Third International Conference on Convergence and Hybrid Information Technology, IEEE, Nov. 2008, pp. 505–510. doi: 10.1109/ICCIT.2008.179.

[25] S. Newman, Building microservices. " O'Reilly Media, Inc.," 2021.

[26] M. Wu, X. Ding, and R. Hou, "Design and Implementation of B2B E-commerce Platform Based on Microservices Architecture," in Proceedings of the 2nd International Conference on Computer Science and Software Engineering, New York, NY, USA: ACM, May 2019, pp. 30–34. doi: 10.1145/3339363.3339369.

[27] A. Megargel, C. M. Poskitt, and V. Shankararaman, "Microservices Orchestration vs. Choreography: A Decision Framework," in 2021 IEEE 25th International Enterprise Distributed Object Computing Conference (EDOC), IEEE, Oct. 2021, pp. 134–141. doi: 10.1109/EDOC52215.2021.00024.

[28] World Bank Group, "Digital Financial Services." Accessed: Nov. 09, 2023. [Online]. Available: https://pubdocs.worldbank.org/en/230281588169110691/Digital-Financial-Services.pdf

[29] T. K. Setor, P. K. Senyo, and A. Addo, "Do digital payment transactions reduce corruption? Evidence from developing countries," Telematics and Informatics, vol. 60, p. 101577, Jul. 2021, doi: 10.1016/j.tele.2021.101577.

[30] J. Álvarez-Gamboa, P. Cabrera-Barona, and H. Jácome-Estrella, "Territorial inequalities in financial inclusion: A comparative study between private banks and credit unions," Socioecon Plann Sci, vol. 87, p. 101561, Jun. 2023, doi: 10.1016/j.seps.2023.101561.

[31] M. A. Carare, L. Franco, M. Hadzi-Vaskov, J. Lesniak, D. Vasilyev, and M. Y. Yakhshilikov, Digital Money and Remittances Costs in Central America, Panama, and the Dominican Republic, no. 2022–2238. International Monetary Fund, 2022.

[32] H. Abushamleh, N. Al-Hiyari, and A. Qusef, "The Intention to Use E-wallet During Covid-19 Pandemic in Developing Country," in 2021 12th International Conference on Information and Communication Systems (ICICS), IEEE, May 2021, pp. 310–316. doi: 10.1109/ICICS52457.2021.9464554.

[33] H. M. Aji, I. Berakon, and M. Md Husin, "COVID-19 and e-wallet usage intention: A multigroup analysis between Indonesia and Malaysia," Cogent Business & Management, vol. 7, no. 1, p. 1804181, Jan. 2020, doi: 10.1080/23311975.2020.1804181.

[34] American Market Intellygence, "Digital Payments And E-Commerce In Latin America [2023-2026 Data And Projections]." Accessed: Nov. 09, 2023. [Online]. Available: https://americasmi.com/insights/digital-payments-and-e-commerce-in-latin-america-data-projections/#aioseo-volumen-del-comercio-electronico-de-america-latina-2022

[35] S. Ioannou and D. Wójcik, "The limits to FinTech unveiled by the financial geography of Latin America," Geoforum, vol. 128, pp. 57–67, Jan. 2022, doi: 10.1016/j.geoforum.2021.11.020.

[36] L. Teran, C. Horst, B. Fausto Valencia, and P. Rodriguez, "Public electronic payments: A case study of the electronic cash system in Ecuador," in 2016 Third International Conference on eDemocracy & eGovernment (ICEDEG), IEEE, Mar. 2016, pp. 65–70. doi: 10.1109/ICEDEG.2016.7461698.

[37] L. F. G. Vasquez, D. A. C. Dutan, and E. E. O. Figueroa, "Analysis of mobile wallet model applicable for Ecuador," in 2016 IEEE NW Russia Young Researchers in Electrical and Electronic Engineering Conference (EIConRusNW), IEEE, Feb. 2016, pp. 827–832. doi: 10.1109/EIConRusNW.2016.7448313.

[38] F. S. Acosta and D. J. Pinto, "Design and Implementation of An Architecture for Electronic Billing Through Web Services and Mobile Devices," in The International Conference on Advances in Emerging Trends and Technologies, 2019, pp. 79–89.

[39] R. De Cicco, S. Iacobucci, A. Aquino, F. Romana Alparone, and R. Palumbo, "Understanding Users' Acceptance of Chatbots: An Extended TAM Approach," 2022, pp. 3–22. doi: 10.1007/978-3-030-94890-0_1.

[40] X. Ma and Y. Huo, "Are users willing to embrace ChatGPT? Exploring the factors on the acceptance of chatbots from the perspective of AIDUA framework," Technol Soc, vol. 75, p. 102362, Nov. 2023, doi: 10.1016/j.techsoc.2023.102362.