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Scalable API-Based infrastructure for inter-wallet digital transactions

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Abstract

The accelerated growth of carrying out financial transactions digitally has given rise to the increasing reliance on electronic wallets (e-wallets) as a means of conducting cashless payments. Interoperability between such e-wallets has, however, remained a major challenge, hindering the conduct of seamless transactions across payment platforms. This study therefore proposes an Application Programming Interface (API) infrastructure to enable users to transfer funds across multiple closed and semi-closed e-wallet systems. The methodology deployed to achieve this goal involves the development of a (Representational State Transfer) REST-based API services deployed on a cloud-based infrastructure, enhancing secure, efficient, and scalable inter-wallet fund transfers. The adopted performance metrics include a measure of concurrent API requests recorded between 50 and 500 Requests per Second (RPS), average API response time between 200ms to 500ms and database transactions between 500 to 1000 Transactions per Second (TPS). The result of this system suggests an improved transaction speed, usability, and security. The findings contribute towards continuous research efforts to improve interoperability among digital transactions targeted at a holistic financial inclusivity.

Keywords: E-Wallet Interoperability, Financial Inclusion, API Infrastructure, Digital Transaction, Secure Fund Transfer.

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INTRODUCTION

Digital modes of payments have gradually become dominant in financial transactions across the globe, leading to the widespread adoption of electronic wallets (e-wallets) as a convenient alternative means to transact without the use of cash (Alam et. al., 2021). E-wallets provide users with the resources to store digital funds and transact in a cashless manner. However, interoperability between various e-wallet service providers is still a bottleneck, hampering users from transferring funds across platforms easily. Recent studies have highlighted the unfolding prospects of digital payments, for instance, a study conducted by the Bank for International Settlements elaborated on the transformative potentials that fast payment systems possess in enhancing transaction efficiency and interoperability (Bank for International Settlements, 2024). In a report published by McKinsey & Company (2023), the need for enhanced interoperability among payment platforms viz a viz its feasibility to meet consumer demands within the global payments' ecosystem requires urgent intervention.

Having identified these gaps, this study specifically aims to address these challenges by:

1. Developing an integrated framework for centralizing consumer wallet data to facilitate secure wallet-to-wallet activities.
2. Deploying an API infrastructure to facilitate inter-operable wallet transactions that provides a seamless and scalable interface for efficient and secure transactions across multiple e-wallet providers.

The remainder of this study is organized into the following sections; section 2 presents previous works related to this study, section 3 details the research methodology, section 4 discusses the results of the study, and section 5 covers the conclusion and recommendation.

RELATED LITERATURE

This section explores the foundational theories that supports the study of e-wallet interoperability.

Theoretical Background

Several digital payment platforms have emerged overtime, each with its unique features, capabilities and limitations (Nizam et. al., 2019). Having a grasp of the theoretical background of these systems provides deep insights into their developmental growth and their potential interoperability solutions. In the study by Rizaldi and Faruqi (2020), the increasing adoption of digital wallets as a means of transaction as well as the significant role they play in financial transactions were the highlights of the study. Handayi and Novitasari (2020) in their study explored the impact of digital wallets in progressively evolving economies. Furthermore, Bianchi et. al. (2023) availed an overview of challenges associated with interoperability in mobile payment systems while highlighting the need for standardized framework and highlighting policy-based interventions as a means to enhance interoperability. More so, research by Soegoto and Tampubolon (2020) elaborates on the role e-wallets play in modern cashless societies, reiterating the need for improved infrastructure.

Review of Existing Inter-Wallet Solutions

An array of solutions has been proffered to enable inter-wallet transactions though often facing drawbacks related to scalability, security, and regulatory compliance. For instance, Wang et. al. (2020) proposed an anonymous authentication and management flow for mobile payment aimed at supporting secure transactions to prevent the disclosure of users' information and to reduce identity theft. Their approach integrated transaction key generation, encryption and decryption matching to process users' personal information and biometric characteristics based on mobile equipment authentication carrier. In the study of Akpan et. al. (2018), the focus was on the need for a standardized API framework to guarantee seamless integration across several platforms. Kazan et. al. (2018) examined the competition in mobile payments platforms, while identifying the main factors affecting interoperability. Igudia (2018) reviewed the adoption of the e-payment option in Nigeria citing the necessity of

efficient inter-wallet solutions. Additionally, a bibliometric analysis of 778 documents from the Scopus and Web of Science databases wasanalyzed to determine the trends and evolution as it relates to digital wallets research, while pinpointing specific areas where interoperability has remained a challenge (Pizzan-Tomanguillo et al., 2024). A study by Innovations for Poverty Action in 2024 synthesized recent evidence on instant interoperable payment systems, discussing their potential to address the limitations of existing digital payment systems and enhance economic outcomes (Innovations for Poverty Action, 2024)

RESEARCH METHODOLOGY

System Analysis

This research adopts a system development approach, emphasizing API-based interoperability for e-wallet transactions. The existing challenges with inter-wallet transactions, including security vulnerabilities and lack of standardization, which are analyzed to inform system requirements.

System Design

The proposed system is designed using the REST (Representational State Transfer) architecture, providing standardized API endpoints for authentication, wallet integration, and fund transfers. Specifically, the system will enable users to connect multiple wallets, facilitating smooth integration across various platforms, share their data across multiple wallets based on their explicit permissions hence, eliminating the need for intermediary banking transactions and enhancing the convenience of digital payments. The system deployed on a Cloud-based infrastructure as a web service integrates encryption protocols to enhance transaction security and access control.

In Figure 1, the overall architectural design of the API infrastructure for inter-wallet transactions is presented. It provides a high-level overview of the system components, the data flow between models, and their interactions. Key elements such as the user authentication module, transaction processing engine, wallet management module, and third-party integrations are incorporated within the architecture. Furthermore, the architecture highlights the communication between client application, endpoints, and database storage enabling secure and efficient operations of inter-wallet transactions. The design adopts a REST API approach, leveraging cloud-based deployment for scalability and reliability.

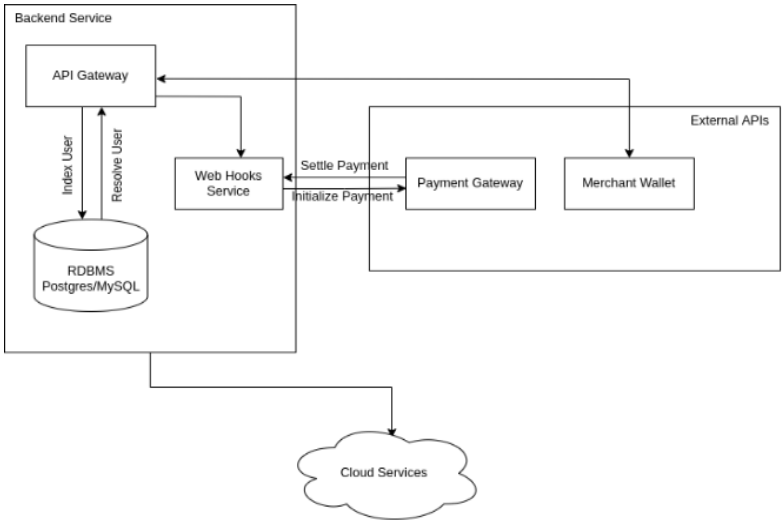

Figure 1: Architectural Design of the API Infrastructure

Implementation Strategy

To ensure that security and scalability is sustained, the API is hosted on a cloud platform. Furthermore, the agile development methodology was adopted for iterative improvements and continuous testing of the implemented solution.

RESULTS AND DISCUSSION

System Implementation

The proposed API infrastructure for inter-wallet transactions is developed on a modular architecture, establishing the enabling environment for seamless functionality across different components. It is made up of three core modules; the user Registration/Authentication module which is responsible for onboarding users and securing API requests, the Wallet Account module that that handles creating and managing virtual wallet accounts, and the Transaction module responsible for disbursing funds, wallet payments and integration with third-party payment gateways. These modules collectively deliver a robust and efficient system for secure digital transactions that are interoperable.

The selection of appropriate implementation tools is critical in ensuring that the proposed system functions effectively. Hence, the proposed system adopted the use of Visual Studio Code (VS Code) as the Integrated Development Environment (IDE), for the backend development, it utilizes Typescript/JavaScript, Express.js, Node.js, SQLite, MySQL, and Postgres while the frontend design was achieved using ReactJS/NextJS and TailwindCSS. Postman was used for API testing while MYSQL Workbench and PGAdmin were deployed for database visualization. Docker was used to support containerization for deployment. The system was hosted and deployed on Vercel and Railway which ensures accessibility and scalability via Google Chrome which serves as the primary web browser.

System Testing

To ensure system reliability, a test-driven approach was implemented, unit tests were conducted on the separate core modules and API endpoints in isolation to verify their functionality. On the confirmation that each of the components are error free, they were incorporated, followed by a holistic integration and end-to-end testing to facilitate the assessment of the performance of the entire system. Final system testing was performed using an API testing tool and a web client to confirm compliance with system requirements and ensure the anticipated functionality. The developed API infrastructure successfully enables inter-wallet transactions across multiple e-wallet service providers.

Presentation of Results

In this section, the results obtained from the proposed system are presented. These findings emphasize the effectiveness of the developed API infrastructure in creating an enabling environment that supports inter-wallet transactions by ensuring seamless fund transfers, maintaining integrity and sustaining security. The system's usability and adherence to functional specifications are evaluated using several testing scenarios. Depicted in Figure 2 is the user authentication module, which functions as the secure access gateway. It consists of the login and registration processes that include input fields for obtaining credentials such as usernames, passwords and Multifactor Authentication (MFA). This module prioritizes secure access to the API by verifying user credentials before approving authorization, in furtherance to enhance security, it integrates session management and token-based authentication to enhance security and prevent unauthorized access.

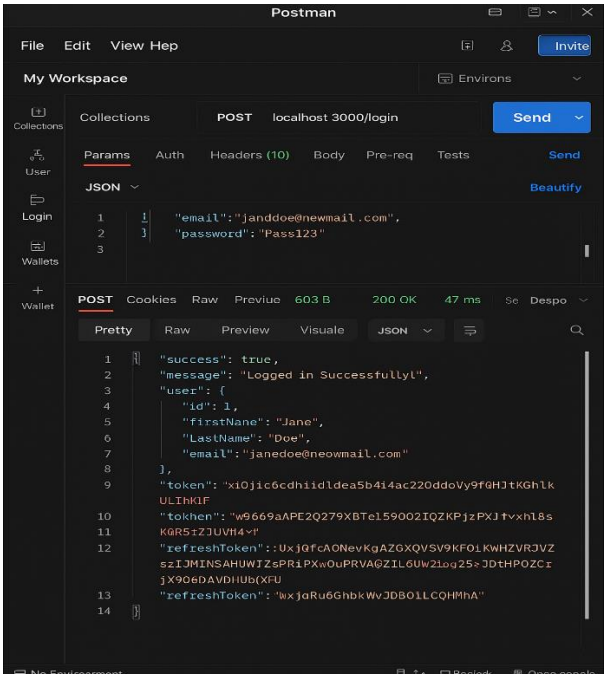

Figure 2: User Authentication Module

Figure 3 shows the Wallet PIN module saddled with securing wallet transactions by implementing a user-defined Personal Identification Number (PIN). It displays the interface where users can create, reset or update their PIN, guaranteeing an added layer of security for inter-wallet transactions. In this module, users are required to verify their PIN before access to wallet is granted, funds transfer are authorized, or sensitive modification of accounts are approved. This security feature aids in protecting users from being susceptible to fraudulent activities and unauthorized access.

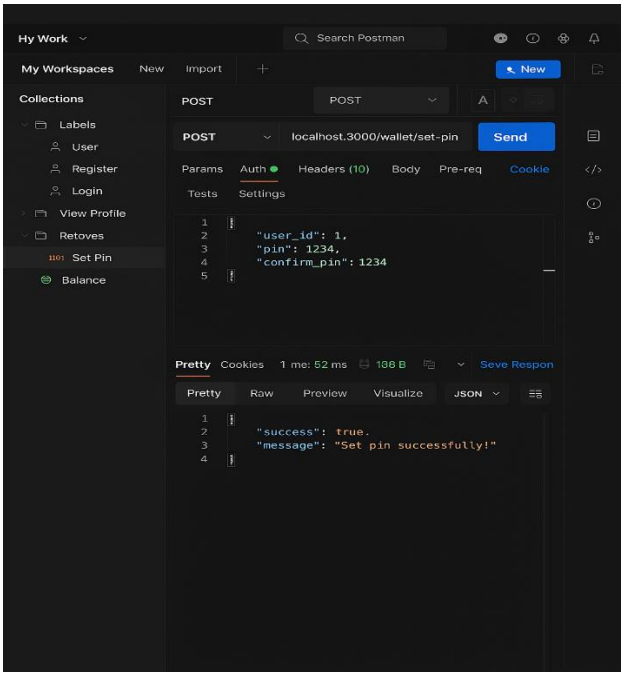

Figure 3: Wallet PIN Module for Securing Wallet Activities

System Performance Evaluation

To evaluate the performance of the proposed system, key metrics such as concurrent API requests handles, average API response time, and database transactions were used. Concurrent

API request handled involves the measurement of the system's ability to manage multiple simultaneous users without encountering any performance issues, this measurement is critical for scalability. Average API response time conveys the system's efficiency in processing and returning requests, this metric directly impacts user experience, especially for time-sensitive tasks such as inter-wallet transactions. Additionally, database transactions monitor the efficiency of data operations, ensuring that sensitive operations like wallet updates are processed reliably and without delay. Table 1 presents the results of the performance metrics adopted in this study.

Table 1
Performance Metrics Results for the Deployed System

Performance metric	Value
Concurrent API requests	50 - 500 Requests per Second (RPS)
Average API response time	200ms - 500ms
Database transactions	500 - 1000 Transaction per Second (TPS)

As highlighted in Table 1, the proposed system handled between 50 - 500 Request per Second (RPS) portraying the ability of the system to scale and manage multiple users or services interacting simultaneously without overloading the server. The Average API response time was between the range of 200ms and 500ms, this indicates that the system possesses significant transaction speed, reducing the time required to carry out fund transfer from several minutes to an impressive time of milli-seconds. Recording an average of 500-1000 Transactions per Second (TPS), the system shows efficiency in handling database transactions which ensure that system actions are executed quickly.

The system; architecture having employed a modular approach ensures flexibility, scalability, and security, enabling unproblematic inter-wallet transactions. The performance results demonstrate ease of use and user satisfaction, demonstrating the system accomplishes it intended objectives.

CONCLUSION AND RECOMMENDATION

This research contributes to digital finance by offering a secure and scalable API-based infrastructure developed to support inter-wallet transactions, addressing the interoperability issues associated with digital financial transactions. The findings deduced from the study highlights the strengths of API-based solutions in enhancing the efficiency and security of e-wallet transactions. More so, this study's findings contribute towards proffering solutions aimed at reducing dependency on conventional banking systems which aligns with global efforts to democratize digital payments.

Despite the success recorded in this study, there are existing challenges that must be looked into to gain a widespread adoption of this proposed system. Challenges such as regulatory compliance and platform adoption are key considerations for future research. Further research can be conducted to explore additional security measures and broader regulatory compliance framework to support widespread adoption. It is recommended that e-wallets providers integrate API solutions to enhance financial inclusivity and user convenience.

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