I. PROJECT BACKGROUND

A. General Background

Financial inclusion is defined as the availability and equality of opportunities to access financial services. It equips both individuals and businesses with access to appropriate, affordable, and timely financial products and services, including banking, loan, equity, and insurance products. It enables the poorest and most vulnerable in society who are unbanked or underbanked to have the ability and tools to manage their money and even step out of poverty. From a broader perspective, it may finally be able to help develop entire communities and economic growth.

Nowadays, there are still quite many people who are excluded from the traditional banking system, especially vulnerable or marginalized populations such as women and poor people in rural areas. Due to the lack of financial infrastructure and finance-related knowledge, many underserved communities suffer. A survey showed that around 1.7 billion adults had no bank account till 2018. These groups suffer from discrimination and marginalization and may face financial distress. Finding a way to accommodate individuals of greater scale in financial services is critical and rewarding.

These years, financial inclusion has made strong strides forward. There are methods such as Microfinance, Increasing the number of rural banks and issuing unique cards, and raising National Strategy. It indicates that financial inclusion is a practical idea, and it may truly help people’s living if well-organized.

Apart from those traditional ways, new innovative solutions are rising. With the development of financial technology, these solutions are becoming more and more feasible. Blockchain provides a revolutionary way to store data. Cryptocurrency provides an exchange way without the reliability of any central authority. Cryptography offers encryption methods such as zero-knowledge proof helps to validate the transaction securely.

Our study is to find a FinTech way to achieve financial inclusion.

B. Problem Statements

As discussed in the general background, substantial amounts of the population still have no convenient access to financial services due to a lack of financial infrastructure. But regular online financial service solutions based on Internet connection may not apply since the target population does not always have stable Internet access. A financial inclusion solution that supports offline functionalities is thus in urgent need.

In this project, we plan to design an e-wallet system to provide secure and fundamental saving and payment services that work both online and offline and come up with technical details of the key designs.

C. Related Works

Two key problems, the method to guarantee the security and integrity of the transaction records, and the approach to enable offline transactions, are crucial to the design and implementation of the proposed e-wallet. The former is an inevitable problem for all kinds of transaction tools, and the latter is a specific requirement for the proposed e-wallet for financial inclusion as one of the features. Much exploration was done on these two issues by previous research.

[1] proposed implementation of blockchain in the card payment system. Blockchain is a distributed ledger technology (DLT) formed by a growing list of record blocks linked to each other, referring to a shared database or ledger with a certain level of security. The utilization of blockchain in payment systems bypasses traditional financial institutions, and therefore reduces transaction costs and raises the level of cybersecurity to some extent. The study provided possibilities of applying blockchain with its decentralized features to card payment systems and suggested better data integrity credited to blockchain.

Bamert et al. [2] proposed "BlueWallet", using hardware tokens as physical Bitcoin wallets. Elliptic Curve Digital Signature Algorithm (ECDSA) was designed to be used for verification and transaction signing to achieve an adequate level of security in data transfer and storage. Though the hardware token can authorize transactions offline, the counterparty must be connected to the Bitcoin network so that the transaction can be validated and recorded in the blockchain. Thus, it still does not support offline peer-to-peer (P2P) transactions.

A blockchain cryptocurrency system, DelegaCoin, for offline coin delegation is proposed by Li et al. in [3]. Remarkably, they suggested the utilization of trusted execution environments (TEE) for the reliable execution of certain protocols. With some cryptographic procedures inside TEE, a coin owner can delegate the right of using the coin to a delegatee without connecting to the blockchain network. Although DelegaCoin is only a model for coin delegation instead of offline transactions, it provides some hints for offline data transfer for token transactions.

In [4], the authors introduced an implementation of offline cryptocurrency transactions called Pure Wallet (PW)
in the context of blockchain. It uses Ethereum smart contract and a new token to manage offline transactions and validation securely. PW successfully managed an offline transaction of 10 tokens, proving the architecture to be feasible for blockchain offline transactions. However, the authors claimed limitations such as token divisibility, falsified token detection, and different environment adoption.

This project will be built on all related studies, including but not limited to the four mentioned above, and further investigations and evaluations will be taken.

D. Desirability of the Project

Given the exploration of financial inclusion and the development of financial technology (mentioned in A. general background), and the revision of related work done by previous researchers, we believe that the research on the financial technology solution of financial inclusion is necessary as well as feasible.

II. PROJECT OBJECTIVE

A. Purpose of the Project

This project aims to design a mobile e-wallet platform to facilitate payment and transfer for the unbanked and vulnerable groups, especially those with poor access to the Internet and traditional banking system, hence providing relatively equal opportunities for all to access financial services.

B. Scope

The primitive idea of the project is to design an e-wallet system with a backend and client frontend to provide secure and fundamental saving and payment services. The main focuses of the e-wallet are security and functionalities under both offline and online circumstances. Preliminarily, the e-wallet will obsess following features:

- online or in-person money deposit and withdrawal;
- online transactions;
- offline interest calculation and accumulation;
- offline P2P transactions;
- online or in-person loan making and offline loan maintenance (optional).

Some features, like online money deposit and withdrawal, online transactions, and loan making, already have mature solutions and will not be discussed in detail in the project. For the other features, some key problems are identified as follows to be our scope for in-depth research and discussion.

- Store and manipulate data on client side: To facilitate middle or long-term offline usage, we need to find a secure and efficient way to store and manipulate data on the client applications so that the stored data can only be modified according to the pre-defined protocols.
- Store data on the server side: Client and transaction data will also be stored on the server side. Therefore, we should also find an efficient structure to organize and utilize data securely on the backend.
- Offline P2P data transfer and verification: To enable offline P2P transactions, a protocol must be found or created together with some physical media to transfer data between the two parties and check the validity of the transaction.

- Server-client data transfer and synchronization: Intuitively, the proposed e-wallet system will be a half-offline and half-online system. The data transfer procedure and synchronization issue will be crucial problems to the system.

C. Deliverables

Upon completion, the project is expected to deliver a report and some code demos. The report will discuss the proposed e-wallet system in detail, analyze the feasibility of approaches learned from existing solutions, and describe and evaluate the newly proposed innovative solution. The code demos are expected to demonstrate the innovative protocols of the core solutions to the key problems. Notably, they will not be completed and readily available products but simple and direct samples to showcase the ideas of the solutions.

III. PROJECT METHODOLOGY

A. Literature Review and Evaluation

Given the considerable amount of related works on the topic, literature will be reviewed to analyze the advantages and disadvantages of the solutions to corresponding problems in the implementation of our e-wallet. They will probably be examined on a problem-by-problem basis. For each key problem in our design, relevant solutions will be evaluated from different aspects, including feasibility and compatibility.

B. Problem Solving with Innovation

Based on the analysis of the previous literature, we will attempt to address the key design problems with our own knowledge. The building blocks of innovation include but are not limited to blockchain technology for data storing, zero-knowledge proof for validation, cryptography methods for data encryption and decryption, and network communication technologies for data transfer.

C. Performance Analysis

After coming up with the solutions, we will analyze the performance of the proposed methods. Measurements will be taken from security, efficiency, scalability, and all other reasonable aspects. Comparisons will be made between our proposed solutions and existing approaches. And limitations and future research directions will also be discussed.

IV. PROJECT SCHEDULE AND MILESTONES

This project commenced in August 2022 and is expected to be completed in late April 2023. Milestones, as shown in table I, include several deliverables and presentations, as well as some evaluation procedures.

<table>
<thead>
<tr>
<th>No.</th>
<th>Date</th>
<th>Task</th>
<th>Remark</th>
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<tbody>
<tr>
<td>1</td>
<td>Oct 2, 2022</td>
<td>Complete detailed project plan; initialize project webpage.</td>
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<tr>
<td>2</td>
<td>Nov 30, 2022</td>
<td>Complete reviewing and analyzing related literatures and write a draft report on this part.</td>
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<tr>
<td>3</td>
<td>Dec 31, 2022</td>
<td>Come up with self-designed solution to at least one key problems with code demo.</td>
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<td>Date</td>
<td>Event Description</td>
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<tr>
<td>Jan 9 - 13, 2023</td>
<td>First presentation. Content of the presentation may include literature review part and partially finished self-designed solutions.</td>
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<tr>
<td>Jan 22, 2023</td>
<td>Complete detailed interim report. Same as 4.</td>
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<tr>
<td>Feb 28, 2023</td>
<td>Finish all self-designed solutions to all key problems with code demos, wrap up the whole design.</td>
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<td>Mar 20, 2023</td>
<td>Complete the evaluation of proposed methods and overall conclusion and discussion.</td>
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<tr>
<td>Apr 18, 2023</td>
<td>Complete final report and all code demos; wrap up the entire project.</td>
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<td>Apr 17 - 21, 2023</td>
<td>Final presentation.</td>
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<td>May 3, 2023</td>
<td>Project exhibition.</td>
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<tr>
<td>May 30, 2023</td>
<td>Project competition. Selected projects only.</td>
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REFERENCES