Bridging the Digital Physical Currency Gap Using a Location Aware P2P Cash–UPI Exchange System

[1]Madhav Vedpathak, [2]Shravani Thorat, [3]Pruthviraj Kashid, [4]Kalyani Rahurkar, [5]Atish Nikalje
[1]*Prof. Arti D. Dhumal, TSSM's BSCOER*

***Abstract*—This paper presents a novel methodological approach for bridging the gap between digital UPI payments and physical cash needs through a secure, peer-to-peer (P2P) exchange system. The primary objective is to detail the architecture and techniques used for secure authentication, real-time location-based service discovery, and reliable transaction management. The system employs a multi-layered technical stack utilizing Flutter for cross-platform development and Firebase for backend services. Key techniques include the Geo-fencing Proximity Algorithm for efficiently discovering nearby cash providers within a dynamic radius, and a Two-Factor Transaction Completion Protocol for secure cash handover and payment confirmation; Firebase Authentication and a verified UPI ID registry are used to establish baseline trust. The developed system effectively enables instant, secure cash-to-UPI exchanges, where real-time location sharing via MapLibre significantly improves coordination and safety, and the use of the giver's existing Google Pay QR code/link simplifies UPI payment integration. This methodology demonstrates a robust and scalable solution for decentralized cash access, reducing dependency on conventional banking infrastructure, and establishing a reliable, community-based framework for P2P financial services.**

***Index Terms*— Peer-to-Peer (P2P) Transactions, Geo-fencing Proximity Algorithm, Real-Time Location Tracking, Firebase, UPI, Service Discovery.**

I. INTRODUCTION

India's financial landscape has been transformed by the rapid growth of digital payments via the Unified Payments Interface (UPI) [8], driving society towards a cashless economy. However, physical cash remains crucial for emergency situations, travel, or small retail purchases where digital payments are not feasible. This imbalance highlights the need for a structured peer-to-peer (P2P) exchange system allowing users to convert digital balance into physical cash conveniently.

Our proposed system, A Location-Aware P2P Cash Exchange Solution, addresses this by developing a mobile application that connects nearby users for instant cash–UPI exchange. The paper details the novel technical architecture employed, focusing specifically on the methods for real-time location-based user discovery and the secure transaction flow, differentiating our solution from existing standard payment platforms. The techniques draw inspiration from distributed P2P applications and existing payment security mechanisms.

II. RELATED WORK

Existing financial systems are reliant on traditional methods like Automated Teller Machines (ATMs) and Bank Branches for physical cash, and established UPI-based Applications (e.g., Google Pay, PhonePe) for digital transfers. While reliable, these systems are not designed for the specific need of real-time, peer-to-peer exchange of digital balance for physical cash.

P2P systems have been widely studied, including blockchain-based platforms for crowdsourcing and distributed incentive mechanisms [1, 2]. Furthermore, P2P exchange models have been proposed for general currency exchange, often focusing on facilitating cross-border transactions [5]. However, these systems do not address the unique challenges of coordinating a hyper-localized, same-currency exchange of a digital balance for physical notes. The inherent convenience of purely digital P2P platforms is also being enhanced by new research into features like programmable, offline payment schemes to better emulate the function of physical cash [7].

Research on financial security emphasizes the use of Deep Learning and Explainable AI for anomaly detection in transactions to prevent issues like money laundering [3, 4]. Standard P2P platforms employ robust security measures like multi-factor authentication, device verification, and algorithmic

transaction monitoring [8]. Despite these general advances, a major challenge in P2P commerce is the trust and risk associated with unknown counterparties [6]. This risk is significantly magnified in models that mandate a physical, face-to-face exchange of value.

Our system differs by applying P2P principles to the localized, physical exchange of currency. This requirement introduces unique face-to-face counterparty risks and, therefore, requires customized security layers (e.g., verified profiles, proximity-based matching, live GPS tracking, and an emergency alert system) beyond standard digital transaction validation and established P2P security frameworks [6, 8].

III. PROPOSED METHODOLOGY AND TECHNICAL NOVELTY

The system employs a client-server architecture built on Flutter and Firebase. The methodology is centered on three secure phases: Authentication, Geo-Spatial Service Discovery, and Secure Transaction Completion.

3.1. Methodology Diagram

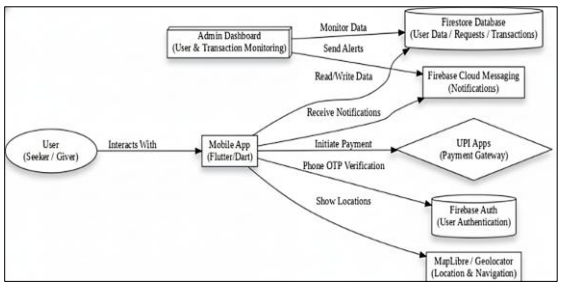

Figure 1: System Architecture of the P2P Cash Exchange Platform

The system architecture is designed as a secure, distributed, client-server model leveraging the Mobile App (Flutter/Dart) as the core user interface and the Firebase ecosystem for the backend. The primary goal is to ensure real-time data synchronization, secure authentication, and reliable transaction processing.

The architecture is composed of the following interconnected components, which facilitate the seamless P2P exchange:

1. Mobile Application (Flutter/Dart): This serves as the primary interface through which the User (Seeker/Giver) interacts with the system. Developed using Flutter and the Dart programming language, the application handles all UI, navigation, and core logic, enabling cross-platform functionality (Android and iOS).
2. Backend Services (Firebase Ecosystem):
   - Firestore Database: This is the cloud database used to store all essential information, including user profiles, verified UPI IDs, real-time location data, cash requests, and the complete transaction history. The application reads and writes data here to manage transaction status and user roles.
   - Firebase Auth (User Authentication): Handles all user sign-up, login, and phone OTP verification. It ensures verified and secure account access by managing credentials and generating session tokens.
   - Firebase Cloud Messaging (FCM): Manages all communication and push notifications. It sends instant, reliable alerts to nearby Givers when a Seeker creates a request, and updates users upon payment confirmation.
3. Location and Navigation:
   - MapLibre / Geolocator: This component provides the real-time GPS data necessary for the Geo-fencing Proximity Algorithm. It allows the application to show locations on the map and display the movement of both the Seeker and Giver during an active exchange, which is critical for safety and coordination.
4. External Payment Integration:
   - UPI Apps (Payment Gateway): The mobile app initiates payment by utilizing deep-linking to the Giver's existing Google Pay QR code or link. This crucial integration leverages the robust, external UPI network to process and verify the digital money transfer, supporting the Two-Factor Transaction Completion Protocol.
5. Administrative Layer:
   - Admin Dashboard: This separate component monitors all data, allowing administrators to review transaction trends, manage disputes, resolve complaints, and send necessary alerts. This oversight ensures the security,

transparency, and reliability of the P2P platform.

3.2. Two-Factor Transaction Completion Protocol (Novel Security Layer)

To build trust and secure the physical exchange, we use a novel Two-Factor Transaction Completion Protocol which requires sequential validation from both the digital payment network and the users' in-app actions [7].

- Factor 1: UPI Payment (External Verification): The Seeker makes a digital payment by scanning the Giver's existing, verified Google Pay (GPay) QR code or link. This payment is processed and verified by the robust UPI network, external to our application.
- Factor 2: Digital Confirmation Lock (In-App Verification): Following the physical cash handover, the transaction status is only finalized and recorded in Firebase Firestore after both the Seeker and the Giver independently mark the transaction as 'Completed' within the app.

This dual confirmation layer ensures mutual agreement and provides an essential audit trail for the physical exchange. Furthermore, Real-Time Location Sharing via MapLibre during the transaction enhances safety and coordination.

IV. SYSTEM MODULES AND IMPLEMENTATION

The system is compartmentalized into functional modules.

- User Registration and Authentication: Uses Firebase Authentication for secure email and password login, verifying user credentials and generating session tokens.
- User Profile Management: Stores user details and their UPI ID in Firebase Firestore.
- Role Switching Functionality: Allows users to switch between Cash Seeker and Cash Giver modes dynamically, increasing network participation.
- Nearby User Discovery: Implements the Geo-fencing Proximity Algorithm using real-time GPS data and MapLibre visualization.
- Request Notification System: Utilizes Firebase Cloud Messaging (FCM) to send instant alerts to nearby Givers with request details.
- Transaction Completion: Records transaction details, including user IDs, timestamp, and amount in Firestore for transparency and record-keeping.
- Admin Management: Provides tools for monitoring users, resolving complaints, and ensuring the platform remains secure and reliable.

V. DISCUSSION

The implemented architecture, leveraging the cross-platform capability of Flutter/Dart and the real-time synchronization of the Firebase ecosystem, provides a high-performance solution that effectively addresses the friction point between the widespread adoption of digital payments via UPI and the enduring necessity for physical cash. The foundation is built upon Firebase Firestore for storing user data, requests, and real-time locations, while Firebase Authentication ensures verified and secure account access. This reliance on established, scalable cloud services guarantee the necessary speed, security, and real-time data synchronization demanded by a dynamic, mobile-first financial service.

The core operational significance lies in the Peer-to-Peer (P2P) Cash Exchange model. The system's Role Switching Functionality allows users to instantly toggle between a Cash Seeker (needs cash) and a Cash Giver (gives cash, receives UPI payment). This inherent flexibility maximizes network participation, directly increasing the availability of Givers and enhancing the platform's feasibility for real-world, dynamic use. The integration of a Geo-fencing Proximity Algorithm uses real-time GPS data and MapLibre/Geolocator to efficiently match Seekers with Givers within a specified radius, optimizing resource usage and ensuring fast, location-based exchanges. Furthermore, Firebase Cloud Messaging (FCM) facilitates a Request Notification System that sends instant alerts to nearby Givers, ensuring minimal delay in transaction initiation and smooth communication across the platform.

The most critical finding relates to security and the Two-Factor Transaction Completion Protocol, which directly addresses the inherent security risks of P2P physical cash exchanges. The process mandates two key verifications: first, the digital transfer where the

Seeker pays by scanning the Giver's existing Google Pay QR code via a UPI App, ensuring the transaction is auditable and reliable within the official banking system; and second, both users must confirm the physical cash handover within the app to mark the transaction as complete. This dual confirmation, combined with verified user profiles and Real-Time Location Sharing during the transaction, establishes a necessary layer of trust and transparency, effectively providing an auditable record for dispute resolution.

In relation to existing literature and the current financial context, this system directly challenges the dependency on conventional Automated Teller Machines (ATMs) and bank branches. While existing systems are reliable for digital transactions, they are explicitly "not designed for real-time cash needs in physical settings". The A Location-Aware P2P Cash Exchange Solution application thus serves as a viable, decentralized solution for urgent cash needs, promoting a secure, community-based financial ecosystem that successfully bridges the gap between digital and physical currency by providing immediate cash access independent of traditional banking hours or infrastructure.

VI. CONCLUSION AND FUTURE SCOPE

The A Location-Aware P2P Cash Exchange Solution system successfully delivers a secure, real-time platform for P2P digital-to-physical currency exchange. The core technical contribution is the implementation of the Geo-fencing Proximity Algorithm for scalable service discovery and the Two-Factor Transaction Completion Protocol for transaction integrity.

Future scope includes extending compatibility to advanced payment options, and deploying AI-driven fraud detection techniques to monitor suspicious activity. Further development of a robust Trust and Reputation System will strengthen user reliability through dynamic scoring.

REFERENCES

[1] Y. He, H. Li, X. Cheng, Y. Liu, C. Yang and L. Sun, "A Blockchain-Based Truthful Incentive Mechanism for Distributed P2P Applications," *IEEE Access*, vol. 6, pp. 27324-27333, Apr. 2018. DOI: 10.1109/ACCESS.2018.2821705.

[2] K. O. Asamoah, et al., "A Blockchain-Based Crowdsourcing Loan Platform for Funding Higher Education in Developing Countries," *IEEE Access*, vol. 11, pp. 24162-24174, 2023.

[3] B. Dumitrescu, A. Băltoiu and Ş. Budulan, "Anomaly Detection in Graphs of Bank Transactions for Anti-Money Laundering Applications," *IEEE Access*, vol. 10, pp. 47699-47714, Apr. 2022. DOI: 10.1109/ACCESS.2022.3170467.

[4] D. V. Kute, B. Pradhan, N. Shukla and A. Alamri, "Deep Learning and Explainable Artificial Intelligence Techniques Applied for Detecting Money Laundering: A Critical Review," *IEEE Access*, vol. 9, pp. 82300-82317, Dec. 2021. DOI: 10.1109/ACCESS.2021.3086230.

[5] Y. Shevchenko & U.-D. Reips, "Geofencing in location-based behavioral research: Methodology, challenges, and implementation," *Behavior Research Methods*, vol. 56, no. 7, pp. 6411-6439, 2024.

[6] Zimbelman EG, Keefe RF, Strand EK, Kolden CA, Wempe AM. Hazards in Motion: Development of Mobile Geofences for Use in Logging Safety. Sensors (Basel). 2017 Apr 10;17(4):822. doi: 10.3390/s17040822. PMID: 28394303; PMCID: PMC5422183.

[7] Anwar NM, Ahmad SSS, Kausar N, Stević Ž, Gaba YU. Multiple biometric authentications for online banking system based on multiple fuzzy approach. *Sci Rep*. 2025 Sep 25;15(1):32824. doi: 10.1038/s41598-025-13571-6.

[8] Shree S, Pratap B, Saroy R, Dhal S. Digital payments and consumer experience in India: a survey based empirical study. *J BANK FINANC TECHNOL*. 2021;5(1):1–20. doi: 10.1007/s42786-020-00024-z.