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Hyper-local Circular Economy Platform: A Trusted, Community-centric Digital System for Sharing, Renting and Reuse

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Abstract - ***This paper proposes a hyper-local digital platform that enables verified community members (housing societies, family groups, college hostels) to lend, borrow, rent, and share goods within a closed ecosystem. Unlike open public marketplaces, the platform emphasizes trust (community verification + trust score), AI-driven item categorization and price prediction, and low-latency messaging (Redis pub/sub with archival in PostgreSQL). Building on taxonomies and archetypes of circular-economy (CE) platforms, systematic literature on digital platforms for CE, and studies on the sharing economy, we design architecture and an evaluation plan to measure adoption, trust, prediction accuracy, and environmental impact. We show how a hybrid PostgreSQL + Redis architecture supports both ACID transactional data and real-time interactions, while a modular Python ML microservice provides category and price predictions. Expected outcomes include improved resource circulation within communities, higher trust and lower transaction friction than public marketplaces, and measurable lifecycle benefits.***

Key Words: *Hyper-local platform, circular economy, sharing economy, trust score, PostgreSQL, Redis, ML microservice.*

1. INTRODUCTION

The CE enables a sustainable production and consumption model wherein products and material are restored, reused, and recycled to extend their lifecycle. The emergence and proliferation of digital technologies have turned digital platforms into enabling factors of circularity by connecting users, sharing data, and facilitating the exchange of resources. These digital platforms improve resource efficiency and reduce or eliminate waste through digital innovation and smart coordination along value chains.

However, most of the existing platforms, including but not limited to OLX, Quikr, and even Facebook Marketplace, function in an open environment with little checks and balances or verification mechanisms. Users have problems arising from fake listings, a lack of accountability, and miscommunication of transactions. These public marketplaces are designed with a buy-sell mindset rather than sharing or lending at a community level. This makes them quite less effective in driving true circular behavior, even at a purely local scale.

In addressing these issues, the present study has put forward a Hyper-local Circular Economy Platform that facilitates the facility to lend, borrow, and rent items among verified members of a community, be it the residents of a housing society, college hostel, or even a family group. The platform enforces trust, safety, and bonding among the community through verified users, invite-only onboarding, and a Trust Score system that computes reliability based on peer rating and transaction history.

Additionally, the proposed system has embedded AI/ML models for the automation of item categorization and prediction of rental prices, hence reducing manual efforts and increasing consistency. It uses a PostgreSQL and Redis

backend architecture, where PostgreSQL maintains structured community and transaction data, while Redis handles real-time chat and caching for fast, scalable interactions. This hybrid setup ensures both reliability and performance for an engaging user experience.

The present research will try to fill this huge gap identified in the previous CE literature by combining trust mechanisms, AI intelligence, and real-time interaction in a closed-community environment. The platform enables not only sustainability through reuse but also localized collaboration and circular resource flow, hence creating a scalable model for future digital platforms that support community-driven sustainability.

2. LITERATURE SURVEY

[1] Digital platforms have become essential tools for enabling the circular economy (CE) by facilitating collaboration, transparency, and data-driven resource management. According to *Petrik et al. (2025)* in *"Digital Platforms for Circular Economy,"* digitalization supports various CE strategies—such as reuse, repair, and product-life extension—by connecting stakeholders through multi-sided platforms. The study introduces six archetypes of CE platforms and emphasizes the role of digital architecture in promoting sustainable product flows. However, it remains largely theoretical and lacks practical implementation focused on local or community-based ecosystems where trust and verification are critical factors.

[2] A *systematic literature review by Tian et al. (2024)* explores how digital platforms contribute to CE adoption across industries. The authors identify that trust, innovation, and data integration are central to effective circular models. Yet, their review highlights a major gap in empirical validation and real-world deployment of these platforms. The study also calls for future research on community trust mechanisms, behavioral adoption, and the integration of AI technologies to improve resource matching and decision-making—areas directly addressed in the present work.

[3] The paper *"Sharing Economy as Part of the Circular Economy"* by *Trigkas et al. (2025)* links sharing practices with CE outcomes, showing that peer trust, social belonging, and user readiness are key determinants for adoption. Their findings indicate that technological design alone cannot ensure participation unless users feel secure and connected within their communities. However, the study lacks a technical framework for achieving this trust through system design, leaving room for solutions that combine social validation and digital verification methods.

[4] Overall, the reviewed literature confirms that while digital platforms are vital for circular economy advancement, current research lacks a trust-centric, community-driven, and AI-integrated model. Most existing approaches emphasize global scalability but overlook hyper-local applicability, which is essential for building genuine collaboration and reducing consumption within small communities. The proposed Hyper-local Circular Economy Platform fills this gap by introducing a verified community structure, a measurable trust score, and intelligent automation for item categorization and pricing—advancing both social and technological dimensions of circular innovation.

3. RESEARCH OBJECTIVES AND GOALS

The primary aim of this research is to design and implement a Hyper-local Circular Economy Platform that enables verified community members to lend, borrow, rent, or share items within a trusted digital ecosystem. The project emphasizes sustainability, trust, and intelligent automation — bridging gaps identified in previous studies that highlighted the absence of community-focused, data-driven circular platforms.

The objectives and goals of the proposed research are outlined as follows:

3.1 To develop a secure, community-centric digital platform Create a web and mobile-based system that connects verified users within specific communities such as residential societies, college hostels, or corporate campuses. The platform will use invite codes, address verification, and administrative approval to ensure a closed, trustworthy environment for all transactions.

3.2 To implement a trust-based reputation mechanism Design and integrate a Trust Score System that quantifies user reliability based on successful transactions, peer reviews, and verification level. This mechanism enhances accountability and minimizes fraudulent or irresponsible activity within the network.

3.3 To integrate AI/ML for intelligent decision-making Develop and deploy machine learning models that automatically categorize listed items and predict fair rental prices using parameters such as item type, demand trends, and condition. These models aim to simplify the listing process and improve pricing transparency.

3.4 To design a hybrid backend architecture using PostgreSQL and Redis
Leverage PostgreSQL for structured, relational data storage and Redis for caching, session management, and real-time chat functionality. This combination ensures both data integrity and system performance, supporting scalable community operations and live communication between users.

3.5 To implement a real-time communication module Develop a chat feature using Redis Pub/Sub for instantaneous message delivery between item owners and borrowers. Messages will be periodically synchronized to PostgreSQL to maintain a reliable conversation history and ensure data persistence.

3.6 To evaluate system performance and sustainability impact Assess the platform based on metrics such as AI prediction accuracy, response latency, trust system efficiency, user adoption rate, and environmental benefit. The evaluation will measure how effectively the system promotes reuse, reduces waste, and builds local collaboration.

4. METHODOLOGY

4.1 System Architecture:
The proposed system follows a monolithic Spring Boot architecture divided into modular layers to maintain scalability and performance.

- The frontend layer, built with React.js (web) and React Native (mobile), ensures a responsive user interface for both community members and administrators.
- The backend layer, developed in Spring Boot, manages user authentication, community verification, AI integration, and data synchronization.
- The database layer uses PostgreSQL for structured data management and Redis for real-time caching and communication.

This combination allows both reliability (for transactions and trust data) and low latency (for chat and notifications).

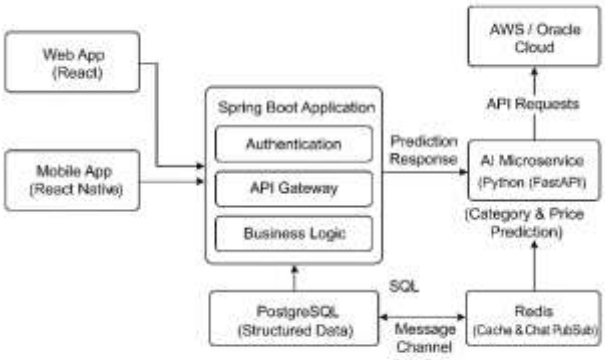

Figure 1: System Architecture Diagram

4.2 Workflow Design:

- User Registration & Verification: Users register with their email or phone number and join their community using a unique code or QR. The admin verifies them, ensuring only trusted members are allowed.
- Item Listing: Members can list items for lending, borrowing, or renting by adding a description, condition, and photo.
- AI-Driven Processing: The backend sends the data to a Python-based ML microservice, which automatically categorizes the item and suggests a rental price.
- Item Discovery & Request: Verified users can browse and request items available

within their community, filtered by category, price, or availability.

- Chat and Transaction: When a request is accepted, both parties can chat in real time using Redis Pub/Sub. Upon completion, they rate each other, updating their Trust Scores.
- Archival & Feedback: Chat data and transaction logs are archived in PostgreSQL for future reference and analytics.

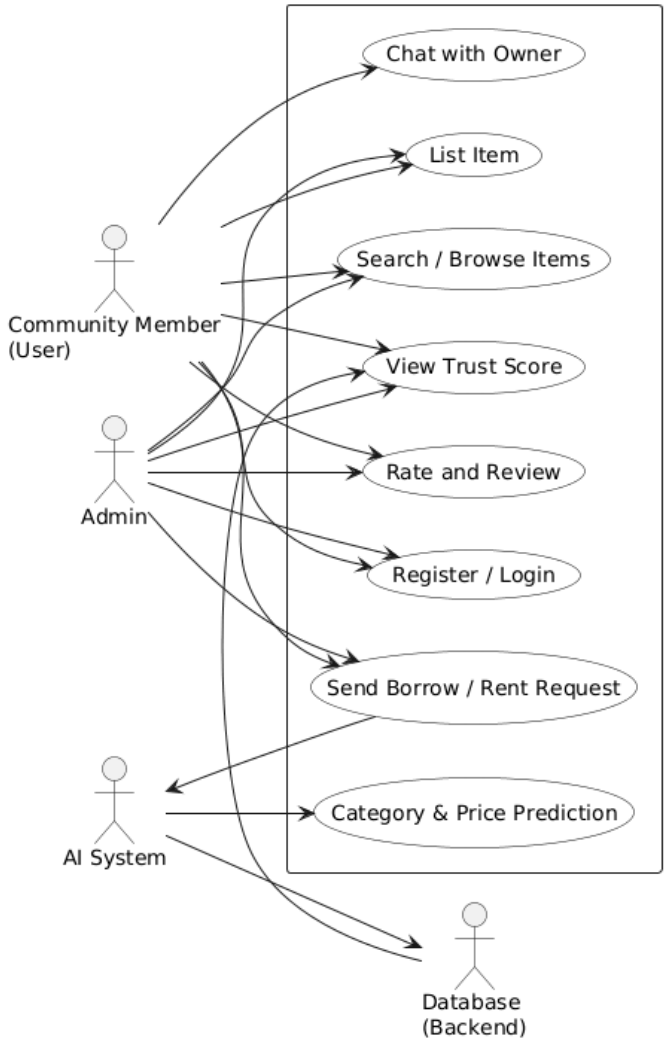

Figure 2: Use Case Diagram

4.3 AI/ML Integration for Categorization and Pricing:

- Categorization Model: Uses natural language processing (NLP) for text data and computer vision for images to classify items.
- Price Prediction Model: Suggests fair rental prices using historical patterns and community-level data.
- Integration: The Spring Boot backend sends API calls to the FastAPI microservice, receives predictions, and stores results in PostgreSQL.
- Caching: Redis stores frequent predictions temporarily to reduce API load and improve response time.

4.4 Trust Score and Verification Mechanism:

Trust and safety are central to the platform. Each user's Trust Score is calculated using:

- Verification level (email, admin approval)
- Number of successful transactions
- Timely item returns
- Peer ratings and feedback
- Length of community membership

Low-trust users face restricted privileges, while reliable users gain full access. This ensures a safe, reputation-driven environment for item sharing and renting.

4.5 Chat Module (Real-time Communication):

The chat feature is powered by Redis Pub/Sub, allowing quick and reliable message exchange:

- Each active transaction creates a unique Redis channel between the borrower and lender.
- Messages are transmitted in real-time and periodically stored in PostgreSQL for long-term retention.
- Push notifications (via Firebase Cloud Messaging) alert users of new messages or requests.

This hybrid communication model combines the speed of Redis with the persistence of PostgreSQL, ensuring both instant communication and data reliability.

4.6 Workflow Summary:

The system operates through the lend → borrow → return → rate cycle, mirroring the circular economy principle of reuse. It integrates AI-based automation, verified community structure, and trust analytics, providing both technological efficiency and social reliability within small, private communities.

5. ADVANTAGES

The proposed Hyper-local Circular Economy Platform introduces several innovations that enhance user trust, sustainability, and operational efficiency. Its unique combination of verified community interaction, AI intelligence, and real-time architecture addresses critical shortcomings of existing public sharing systems.

5.1 Community-based Trust and Safety:

Unlike public marketplaces, the proposed system restricts access to verified local communities, ensuring authenticity and accountability. The Trust Score mechanism further enhances reliability by quantifying user behavior and encouraging responsible participation.

5.2 AI-driven Efficiency:

The integration of machine learning models for item categorization and rental price prediction automates manual processes, improving user convenience and pricing transparency. This feature also enables data-driven decision-making, which is rarely implemented in traditional sharing platforms.

5.3 Hybrid Database Architecture:

By combining PostgreSQL for structured transactional data with Redis for caching and real-time communication, the system achieves both data integrity and low-latency responsiveness. This hybrid setup optimizes user experience and ensures scalability.

5.4 Promotion of Sustainability and Reuse:

The platform directly contributes to resource optimization by enabling reuse and sharing within communities. It reduces unnecessary purchases, waste generation, and the overall environmental footprint — aligning with the broader goals of the circular economy.

5.5 Seamless User Interaction:

Features such as real-time chat, in-app notifications, and an intuitive interface enhance engagement between community members, fostering collaboration and long-term adoption of sustainable behaviors.

6. LIMITATIONS

Despite its strong technical and social foundations, the system faces certain challenges that need to be addressed for broader scalability and reliability.

6.1 Limited Scalability Across Communities:

While the hyper-local model enhances trust, it also restricts interactions between communities. Scaling the platform across cities or organizations requires more complex verification and logistic frameworks.

6.2 User Participation Dependency:

The effectiveness of the system depends on active user engagement. If members are unwilling to share or lend, community activity and platform value decrease over time.

6.3 AI Data Limitations:

Machine learning features such as categorization and price prediction rely on sufficient training data. In early stages, cold-start problems may lead to less accurate predictions or inconsistencies.

6.4 Privacy and Security Concerns:

Since the platform involves verified identities and community-level data, it must ensure robust data privacy and security policies. Handling user information requires compliance with data protection standards.

6.5 Network and Infrastructure Constraints:

Real-time operations like chat and live notifications depend on stable internet connectivity. In low-connectivity environments, performance or synchronization delays may occur.

7. CONCLUSION AND FUTURE SCOPE

The proposed Hyper-local Circular Economy Platform demonstrates how digital technology can bridge the gap between sustainability goals and community engagement. By integrating verified community networks, AI-driven automation, and a real-time backend, the system effectively enables trusted sharing, lending, and renting of items within localized ecosystems. Unlike open-market platforms that focus primarily on buying and selling, this approach prioritizes trust, accountability, and resource optimization, aligning directly with the core principles of the circular economy.

The project successfully addresses key research gaps identified in earlier studies by implementing a trust-based architecture that operates within closed communities. Its AI models enhance user convenience through intelligent categorization and price prediction, while the PostgreSQL–Redis hybrid infrastructure ensures fast communication and data reliability. Together, these features create a sustainable, scalable, and user-friendly environment for promoting reuse and minimizing waste.

However, broader deployment of the system requires addressing limitations such as scalability across communities, AI model optimization, and privacy compliance. Future research can focus on improving prediction accuracy through larger datasets, integrating blockchain-based verification for enhanced transparency, and extending the platform into multi-community or city-level sharing ecosystems. Additionally, expanding to a mobile-first deployment with real-time analytics dashboards can further improve usability and adoption.

In conclusion, the proposed system provides a technological framework and social model for advancing the circular economy at a grassroots level. By fostering collaboration, trust, and responsible consumption, it lays the foundation for sustainable digital ecosystems that empower local communities and contribute meaningfully to environmental and social well-being.

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