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Hyperlocal E – Commerce using Haversine Algorithm

Syed Suhaila S

Assistant Professor, Department of Computer Science Engineering, Alagappa Chettiar Government College of Engineering and Technology, Karaikudi, India

Abstract: The rise of hyperlocal e-commerce presents a transformative opportunity for local businesses to compete in the digital marketplace. This research explores the development and implementation of a hyperlocal e-commerce platform that bridges the gap between local vendors and consumers by leveraging geolocation technology. The platform uses the Haversine algorithm to calculate the proximity between users and nearby businesses, enabling faster and more efficient deliveries. Additionally, it incorporates collaborative filtering to personalize user experiences by recommending relevant products based on browsing history. To ensure seamless order management and secure transactions, the system integrates Twilio for real-time messaging and PayPal as the payment gateway. Unlike traditional e-commerce models, which often overlook local needs, this platform fosters community-driven commerce, supports small businesses, and provides users with a personalized and efficient shopping experience. The paper outlines the challenges of building such a system, evaluates its performance, and suggests future improvements for scalability and enhanced functionality.

Keywords: Hyperlocal E-commerce, Local Businesses, Geolocation Technology, Haversine Algorithm, Deliveries, Collaborative Filtering, Personalization, Order Management, Secure Transactions, Twilio, PayPal, Community-Driven Commerce, Small Businesses, Personalized Shopping Experience, Scalability, Enhanced Functionality.

I. INTRODUCTION

The e-commerce industry has grown exponentially over the past decade, enabling consumers to access products and services from across the globe. However, this global focus often overlooks the needs of local businesses and nearby consumers. Many local businesses, especially in smaller communities, struggle to compete with larger e-commerce platforms like Amazon and Flipkart, which prioritize large-scale operations and centralized supply chains. This leads to longer delivery times, less personalization, and reduced opportunities for small vendors to grow within their local markets.

Hyperlocal e-commerce presents a solution to these challenges by focusing on the local economy and connecting nearby consumers with businesses in their vicinity. By leveraging geolocation, hyperlocal platforms enable faster deliveries and personalized shopping experiences, fostering community-driven commerce. This paper discusses the development of a hyperlocal e-commerce platform that integrates advanced geolocation technologies such as the Haversine algorithm to calculate distances between users and vendors. Additionally, the platform uses collaborative filtering to offer product recommendations based on user preferences and browsing behaviour.

In contrast to traditional e-commerce systems, the proposed platform supports small businesses by allowing them to compete without the need for extensive inventory. Instead, the platform connects consumers with vendors based on proximity, ensuring quicker deliveries and promoting a more sustainable and localized economic model. Through the integration of Twilio for order notifications and PayPal for secure payments, the system also ensures efficient communication and smooth transaction processing.

This paper outlines the platform's architecture, highlights the benefits of hyperlocal commerce, and discusses the challenges faced in developing a geolocation-based e-commerce system. By focusing on local communities, this platform aims to empower small businesses, provide faster deliveries, and enhance the overall customer experience.

II. RELATED WORKS

The concept of hyperlocal e-commerce has gained significant traction in recent years, especially with the growing need to support small businesses and offer personalized, proximity-based services. Various studies have highlighted the benefits of hyperlocal business models, as well as the technical and logistical challenges involved in their implementation.

1. Hyperlocal E-commerce Platforms

Several hyperlocal e-commerce platforms have emerged to connect local consumers with nearby vendors, leveraging geolocation technologies. In these systems, the focus is on delivering goods and services to customers within a defined geographical area. Research by **Khatri and Ranjan (2020)** discusses the role of geolocation in calculating distances to nearby stores, ensuring faster deliveries and enhanced customer experience. While this model significantly improves delivery times, a major limitation is the lack of direct interaction between the seller and customer, which can sometimes result in a less personalized experience.

2. Hybrid Hyperlocal Models

The hybrid model, which combines features of both the aggregator-based and inventory-based models, has been explored as a way to manage product availability while ensuring efficient delivery. According to **Dhanani et al. (2022)**, this hybrid approach allows vendors to manage their inventory while also leveraging third-party delivery services. Although this model ensures better inventory management, the manual updating of stock after each order introduces inefficiencies, making the process more labour-intensive.

3. Existing E-commerce Platforms and Hyperlocal Strategies

Large e-commerce platforms such as **Amazon Now** and **Big Basket** have incorporated hyperlocal strategies, particularly in the areas of grocery and essential item deliveries. **Amazon Now** uses an ultra-fast delivery model that combines hyperlocal fulfilment with an extensive product range, providing convenience and quick service. However, studies have shown that these platforms face limitations in product variety and delivery efficiency, especially in smaller towns. **Big Basket** uses a hybrid supply chain model, which allows for flexible delivery slots and a wide product range but faces challenges in scalability and delivery timelines in tier-2 and tier-3 cities.

4. Collaborative Filtering for Personalization

Personalization plays a critical role in enhancing the shopping experience for users. Research in collaborative filtering, such as the work by **Das and Yadav (2020)**, emphasizes the importance of recommendation systems that analyse user behaviour to suggest relevant products. The use of collaborative filtering in e-commerce platforms allows for more tailored experiences, increasing user engagement and satisfaction. However, these systems rely heavily on data from user interactions, and in smaller-scale hyperlocal systems, gathering sufficient data to provide meaningful recommendations can be a challenge.

5. Geolocation Technologies in Hyperlocal Platforms

Geolocation technologies are fundamental to the success of hyperlocal e-commerce platforms. The **Haversine algorithm** has been widely used in calculating the shortest distance between two points on the Earth's surface, allowing for proximity-based vendor recommendations. In hyperlocal platforms, this ensures that customers are connected to the nearest vendors, optimizing delivery times. However, as discussed in the literature, the accuracy of geolocation services can vary based on network availability and infrastructure, particularly in rural or underdeveloped regions.

6. Payment Integration in Hyperlocal Platforms

Securing transactions in hyperlocal e-commerce is crucial for maintaining consumer trust. Platforms like **PayPal**, which offer multi-currency support and secure payment gateways, are commonly integrated into e-commerce systems to streamline transactions. According to **Jindal et al. (2021)**, the use of PayPal's sandbox environment during development helps simulate real-world scenarios, allowing for robust testing of the payment system before going live. Despite this, ensuring secure transactions in areas with limited digital infrastructure remains a challenge for hyperlocal platforms.

S.NO.	TITLE	TECHNIQUES	ADVANTAGES	DISADVANTAGES
1	Hyperlocal E-commerce	Geolocation is used to calculate the distance of the nearby stores	The customization for every individual customers improves the customer experience.	no interaction between the seller and the customer
2	Hyperlocal E-commerce platform	This paper focus on making use of the existing location of the retailers with manual location entry.	The implementation of is much easier since it does not involve much API calls	Since there is no involvement of live LBS the optimal distance can be miscalculated
3	Hyperlocal delivery service application Development using flutter	It is the hybrid of aggregator model and inventory based model which makes the system semi-automatic	The hybrid model helps to manage the inventory of the retailers well	The manual updating of the inventory on every order makes the process tedious

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III. PROPOSED METHODOLOGY

In the proposed methodology, the hyperlocal e-commerce platform adopts a non-inventory-based model, specifically designed to support and promote local, non-wholesale businesses. By eliminating the need for a centralized inventory, the platform allows local vendors to list products directly, which reduces overhead costs and increases flexibility. This model ensures that small, independent stores can compete effectively without the burden of managing a large stock, fostering a community-driven marketplace where local stores can flourish. This approach is especially beneficial for smaller businesses, as it empowers them to focus on fulfilling customer needs while minimizing logistical challenges and streamlining operations.

Additionally, the platform integrates geolocation technologies to enhance delivery efficiency by connecting users with nearby vendors. By utilizing geolocation APIs and the Haversine algorithm, the platform accurately calculates the distance between users and vendors, ensuring that customers are matched with the closest stores for faster deliveries. This proximity-based model not only accelerates the delivery process but also reduces transportation costs, contributing to more sustainable and eco-friendly operations. This emphasis on promoting local businesses and providing timely deliveries through advanced geolocation ensures a tailored, user-friendly shopping experience, directly benefitting both vendors and customers.

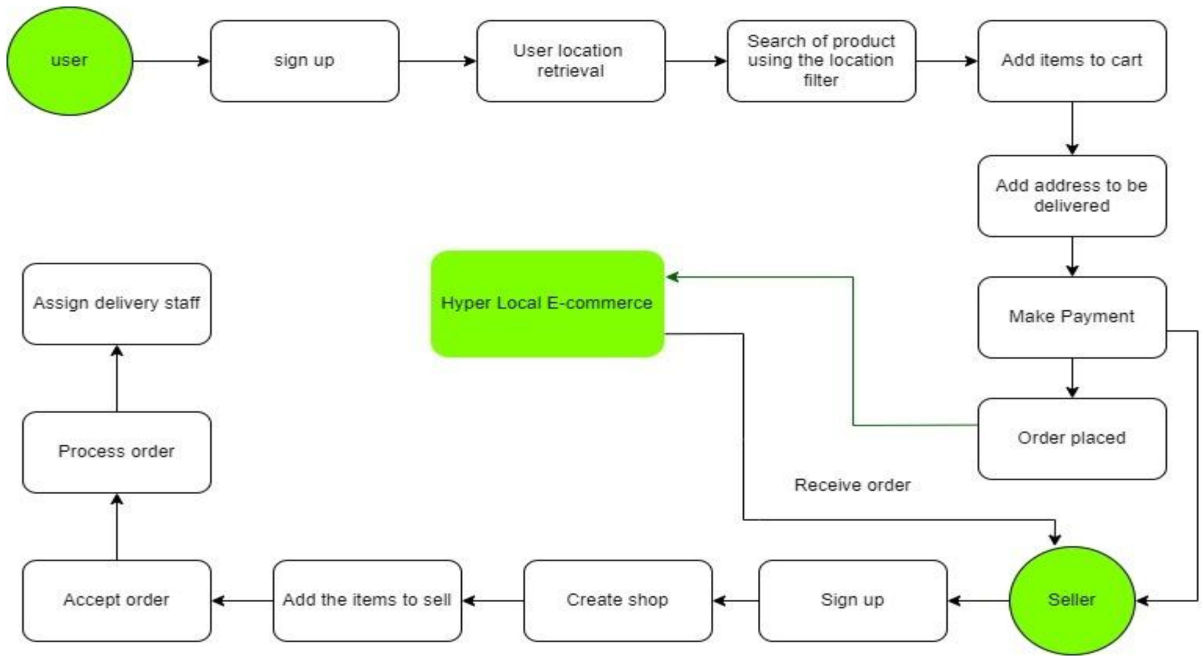

Fig 1: Proposed System Architecture

IV. IMPLEMENTATION

The development of the hyperlocal e-commerce platform involves a systematic approach that integrates various technologies to connect local businesses with consumers. This section outlines the architecture, data flow, and technologies employed in the platform, as well as the steps taken to ensure efficient functionality and user satisfaction.

1. System Architecture

The proposed system architecture consists of three main components: the frontend, backend, and third-party services. This modular design ensures scalability, maintainability, and flexibility in responding to user demands.

- **Frontend**: The user interface is built using **React components**, **Axios** for making HTTP requests, and handles **event-driven interactions**. This combination provides an interactive platform for consumers to browse products, view vendor details, and place orders. Additionally, it manages **database connections** for fetching and displaying data. The

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frontend is designed to be responsive and user-friendly, ensuring a seamless experience on both desktop and mobile devices.

- **Backend**: The backend is developed using **Node.js** and **Express.js**, which handle user authentication, product management, and order processing. A relational database (e.g., **MySQL**) is used to store data related to users, vendors, and products, ensuring quick access and updates.
- **Third-party Services**: Integration with third-party services is crucial for enhancing functionality:
  - **Geolocation**: The platform utilizes geolocation APIs to accurately identify user locations and calculate distances to nearby vendors.
  - **Payment Processing**: PayPal is integrated as the primary payment gateway to facilitate secure transactions, supporting multiple currencies for broader reach.
  - **Communication**: Twilio is used to send real-time notifications to both vendors and customers regarding order statuses and updates.
  -

2. Geolocation and Distance Calculation

The platform implements the **Haversine algorithm** to calculate the shortest distance between the user and local vendors based on latitude and longitude coordinates. This algorithm ensures that the nearest vendors are displayed prominently for faster delivery options.

The Haversine formula is used to calculate the shortest distance between two points on the Earth's surface, given their latitudes and longitudes. It is especially useful for calculating great-circle distances, which take the Earth's curvature into account. It can be defined as

$$a=\sin2(2\Delta\phi)+\cos(\phi1)\cdot\cos(\phi2)\cdot\sin2(2\Delta\lambda)$$
$$c=2\cdot\text{atan2}(\sqrt{a}, \sqrt{1}-a)$$
$$d=R.c$$

Where:

- $\phi1$ and $\phi2$ are the latitudes of the two locations.
- $\Delta\phi$ and $\Delta\lambda$ represent the changes in latitude and longitude.
- R is the radius of the Earth (approximately 6,371 km).
-

3. Collaborative Filtering for Recommendations

To enhance the shopping experience, the platform employs collaborative filtering techniques that analyze user behavior and preferences. By creating a user-item interaction matrix, the system can recommend products based on similar user profiles and previous purchase patterns.

- **Data Collection**: The platform gathers data from user interactions, including product views, purchases, and ratings. When users browse products, the platform tracks which items they are interested in. This helps in understanding individual preferences better. Additionally, purchase history is collected to tailor future recommendations. User ratings provide feedback, influencing which products are suggested to others based on popularity and satisfaction. This comprehensive data collection allows the system to offer personalized suggestions that match user preferences and enhance the overall shopping experience.

- **Recommendation Algorithm**: he system leverages cosine similarity to determine relationships between different products. This technique measures the angle between two product vectors, representing the preferences of different users. A smaller angle between vectors indicates a higher similarity, meaning the users who interacted with these products share common interests. Based on this similarity, the system suggests products that other users with similar shopping behaviours have purchased.

The Cosine Similarity formula is used to measure the similarity between two items or data points (represented by vectors A and B). It works by calculating the cosine of the angle between these two vectors in a multidimensional space.

$$\text{Similarity}(A,B)=A\cdot B/||A||\times||B||$$

Where:

- A and B are the interaction vectors for products.
- $||A||$ and $||B||$ are the magnitudes of the vectors.

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4. User Authentication and Management

The platform provides a secure user authentication mechanism to ensure that users can safely create accounts, log in, and manage their profiles. This is implemented using **JWT (JSON Web Tokens)** for secure session management.

- **User Registration**: New users can register on the platform by submitting essential details such as their name, email address, password, and possibly their phone number or location. This information is securely captured through a user-friendly registration form. Once the data is entered, the system encrypts sensitive information like passwords to ensure security before storing it in the database. The stored data is then used to create a unique profile for each user, allowing them to log in, access personalized services, and track their orders. This process ensures a smooth and secure onboarding experience for all users.

- **Login Process**: Users log in by entering their registered email or username and password, which the system verifies against stored data. If authenticated, the system generates a **JSON Web Token (JWT)** that serves as a secure key for the session. This token allows users to access features like product browsing and order management. It ensures secure, uninterrupted access without needing to log in repeatedly during the session.

5. Order Processing and Delivery Management

Order processing is managed by the backend, which coordinates interactions between customers, vendors, and delivery personnel. The following steps are followed:

- **Cart Management**: Users can easily add products to their cart while browsing the platform. Each time a product is added, the system updates the cart with the selected item, including details like quantity, price, and any preferences such as size or color. Users can view their cart at any time to review or modify their selections before completing the purchase. Once they are ready, they can proceed to the checkout process, where they confirm their order details and payment method. This smooth cart management system ensures a convenient shopping experience from selection to purchase.

- **Order Confirmation**: After a user places an order, the system immediately processes the request and generates an order confirmation. This confirmation includes important details such as the products purchased, quantities, delivery address, and payment status. Simultaneously, the platform uses **Twilio** to send a notification to the respective vendor, informing them about the new order. This notification allows the vendor to begin preparing the order for delivery. The user also receives an order confirmation via email or SMS, ensuring both parties are promptly informed and can proceed with the next steps efficiently.
- **Delivery Routing**: To ensure efficient and timely deliveries, the platform utilizes **Google OR-Tools**, a powerful optimization tool designed for solving various logistical challenges. Once an order is confirmed, the system assesses the locations of both the vendor and the customer to determine the most effective delivery route. Google OR-Tools analyzes multiple factors, including traffic conditions, distance, and delivery windows, to optimize the route taken by delivery personnel.

6. Payment Processing

The integration of PayPal as the payment gateway allows for secure and flexible transaction options. The steps for processing payments include:

- **Sandbox Testing**: During development, developers use **PayPal's sandbox environment** to test payment integrations without real funds. This setup allows for the creation of test accounts to simulate various transaction scenarios, such as successful payments and refunds. By identifying potential issues early, developers ensure the system functions correctly. This process ultimately enhances the reliability and security of the payment system for users once it goes live.

- **API Integration**: The platform integrates the **PayPal SDK**, allowing users to complete transactions seamlessly with multiple payment methods. This integration supports credit and debit cards, PayPal accounts, and other payment options. By providing a user-friendly interface, the system facilitates quick and secure payments during the checkout process. This streamlined approach enhances the overall shopping experience, making it easier for customers to finalize their purchases. Ultimately, the API integration ensures that users have flexible payment options while maintaining transaction security.

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- **Transaction Confirmation**: After a successful payment, users receive confirmation notifications through both email and SMS. These notifications include essential details such as the transaction amount, order number, and a summary of the purchased items. This immediate confirmation provides users with assurance that their payment has been processed and their order is being fulfilled. Additionally, it helps maintain transparency and communication between the platform and the users. Overall, this prompt confirmation enhances customer satisfaction by keeping them informed throughout the purchasing process.

7. Message Module

The Message Module in the proposed system architecture is responsible for real-time communication between the platform, users, and vendors. This module ensures that users receive timely notifications about their orders and updates, improving the overall customer experience. The module integrates Twilio services for reliable and efficient communication.

- **Integration with Backend**: The backend, built using Node.js and Express.js, integrates Twilio's API to handle real-time messaging. Twilio credentials, including the Account SID and Auth Token, are securely stored in environment variables and used to authenticate each request made to Twilio's messaging service.

- **Communication Triggers:** Several triggers have been implemented to initiate communication based on user actions. These triggers are activated upon specific events, such as order placement, vendor updates, and delivery status changes. When an event occurs, the platform sends automated SMS messages to users and vendors using Twilio, keeping them informed in real-time.
- **Custom Notifications**: This module supports customizable messages based on the context of the notification. For example, the system generates personalized messages for users, containing their order ID, name, and delivery details. Twilio's API is used to format and deliver these messages directly to users' mobile devices via SMS

- **Monitoring and Error Management**: Twilio's monitoring tools are utilized to track message delivery status. If an SMS fails due to incorrect phone numbers or network issues, the system logs the failure and attempts to resend the message. This ensures high reliability and consistent communication with both users and vendors.

- **Twilio API:** The platform uses the Twilio SDK for seamless API integration. The SDK allows for sending notifications, managing delivery reports, and troubleshooting any messaging errors, providing a robust framework for real-time messaging.

V. RESULTS

Welcome Page: Upon successful login, users are directed to a Welcome page displaying a warm greeting and their personal dashboard.

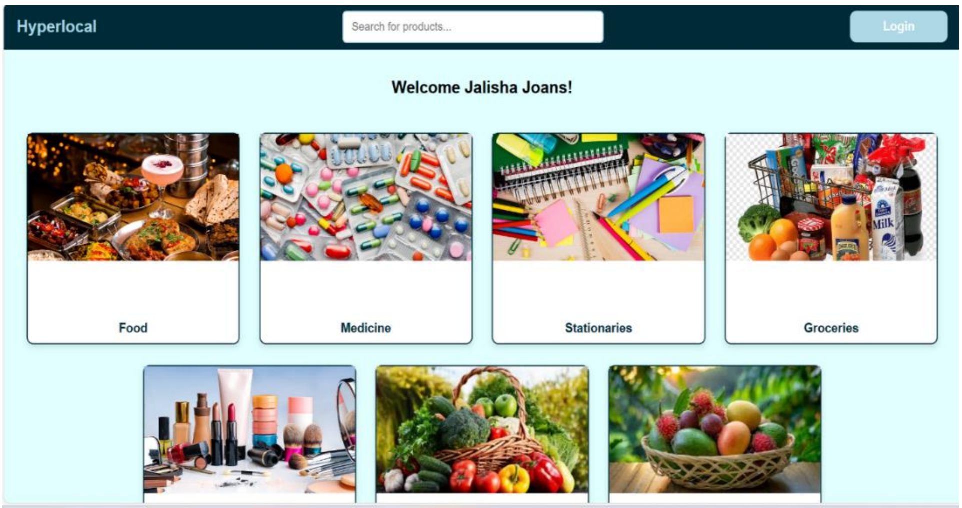

Figure 2: Welcome Page

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Cart Page: The cart page accurately displays items, calculates totals, and allows users to initiate the checkout process.

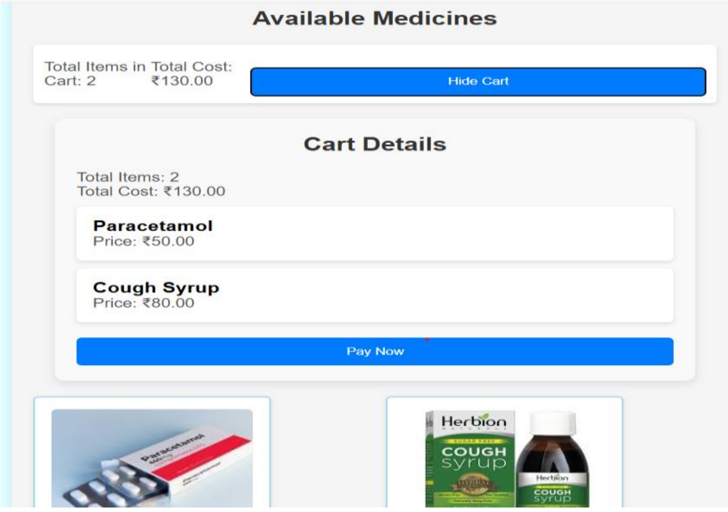

Figure 3: Cart

Twilio SMS: Twilio integration enables the system to send order confirmation SMS to the vendor upon order placement.

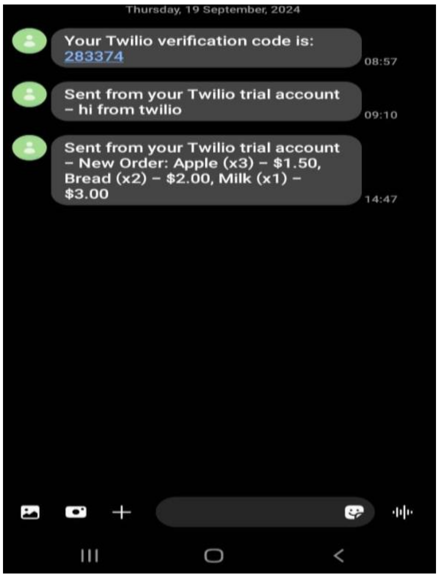

Figure 4: Message

PayPal for Payment Processing: The PayPal integration successfully processes transactions, deducting funds from the user's PayPal account and crediting the vendor's account. Testing confirms successful end-to-end payment flow.

1. Create Developer Account- Access PayPal sandbox for testing.

2. Obtain API Credentials- Get Client ID and Secret from PayPal developer.

3. Integrate PayPal SDK- Add PayPal SDK/API to website.

4. Set Up Sandbox- Test transactions without using real funds

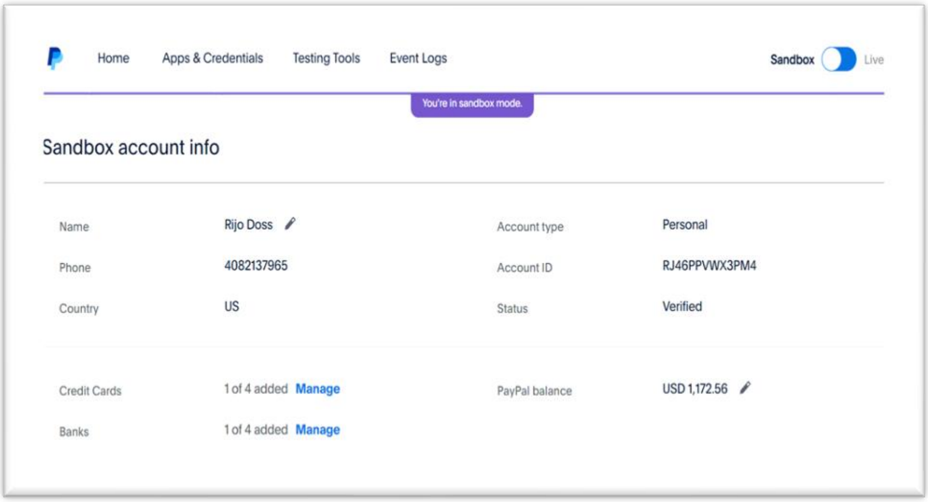

Figure 5: Sandbox Account

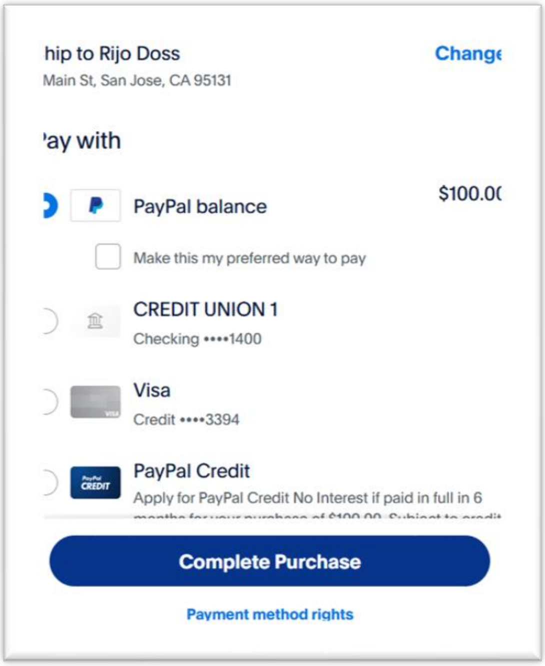

Figure 6: PayPal Payment

VI. CONCLUSION

In conclusion, the development of a hyperlocal e-commerce platform as outlined in this research offers a compelling solution to bridge the gap between local businesses and consumers. By adopting a non-inventory-based model, the platform empowers small and independent vendors to compete in the digital marketplace without the logistical burdens of managing large inventories. The integration of geolocation technologies, particularly the Haversine algorithm, ensures that users are connected with nearby stores, facilitating faster and more efficient deliveries.

Moreover, the platform incorporates advanced features such as collaborative filtering for personalized recommendations and secure payment processing through PayPal, enhancing the user experience while maintaining trust and security. The use of real-time messaging via Twilio further streamlines communication between vendors and customers, ensuring transparency throughout the order process. Ultimately, this platform not only strengthens the local economy by promoting non-wholesale businesses but also provides a more personalized and efficient shopping experience for consumers. Looking forward, future enhancements can focus on scaling the platform to serve larger communities while maintaining the focus on local commerce and sustainability.

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