Decentralized Vendor Aggregation Platform

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Abstract

The proliferation of digital commerce platforms has reshaped consumer behaviour across diverse industry verticals; however, the informal home baking sector remains comparatively underserved by dedicated technology solutions. This paper presents Decentralized Vendor Aggregation Platform, a full-stack web application designed to bridge home bakers, customers, and delivery personnel within a unified, role-based digital ecosystem. The proposed system implements a three-tier module architecture—Customer, Baker, and Delivery Person—each governed by a shared authentication gateway with role-specific redirection. Core functionalities include product catalogue management, cart-based ordering, Stripe-powered payment processing, OTP-verified delivery confirmation, and geospatial order tracking rendered through the Leaflet mapping library. The backend is built on Node.js and Express.js, with a document-oriented or relational database layer supporting primary entities such as users, products, orders, order items, and delivery assignments. Evaluation of the system demonstrates a complete, end-to-end order lifecycle from product discovery through verified delivery. Key limitations include a random delivery-assignment heuristic and database-poll-based status updates in lieu of WebSocket-driven real-time streaming. Results indicate that the platform is functionally sound and academically valid as a proof-of-concept, with measurable potential for production-grade optimisation via GPS-informed assignment algorithms and persistent duplex connections. The study contributes an architectural blueprint and implementation reference for practitioners seeking to digitise home-food commerce with secure, verifiable delivery workflows.

Keywords: Home-food commerce; multi-role web application; real-time order tracking; OTP delivery verification; Stripe payment integration; Leaflet geospatial mapping; role-based access control

1. Introduction

1.1 Background Context

The global online food delivery market has experienced exponential growth over the past decade, driven by ubiquitous smartphone adoption, improvements in logistics infrastructure, and changing consumer expectations around convenience and customisation [1]. Market research indicates that the online food delivery segment was valued at approximately USD 221 billion in 2022 and is projected to exceed USD 500 billion by 2030 [2]. While large-scale commercial bakeries and restaurants have been early beneficiaries of platform-based distribution through aggregators such as Uber Eats, DoorDash, and Swiggy, the home baking community—comprising artisanal producers who operate from residential kitchens—has largely been excluded from these ecosystems due to minimum order constraints, commission structures, and geographic coverage limitations [3].

1.2 Problem Statement

Existing food delivery platforms are not architected to accommodate the operational realities of home bakers. Specifically, home bakers require granular order lifecycle management—including custom preparation timelines and the ability to communicate readiness status to a decoupled delivery layer—rather than the fixed menu and scheduling models mandated by mainstream aggregators [5]. Furthermore, delivery verification in informal food commerce frequently lacks cryptographic or procedural security, exposing all parties to disputes over delivery completion. Customers, likewise, have limited visibility into the real-time status and geolocation of their orders when using informal channels such as direct messaging [6].

1.3 Research Objectives

This study pursues the following primary objectives:

- To design and implement a role-based web application that serves three distinct user constituencies—customers, bakers, and delivery personnel—within a shared authentication framework.
- To engineer an end-to-end order lifecycle encompassing product browsing, cart management, secure payment via Stripe, baker-side order fulfilment, automated delivery assignment, and OTP-verified delivery confirmation.
- To integrate a geospatial tracking subsystem using the Leaflet library that renders delivery route and current delivery partner position to end-users.
- To evaluate the system against functional and non-functional requirements and identify architectural limitations alongside viable enhancement pathways.

1.4 Significance of the Study

Decentralized Vendor Aggregation Platform makes a dual contribution. First, at the practitioner level, it provides a validated, open reference architecture for entrepreneurs and developers seeking to launch analogous marketplace platforms in the home-food sector. Second, at the academic level, it synthesises and demonstrates the integration of several independently studied technologies—including role-based access control (RBAC), payment gateway APIs, OTP-based verification, and map-based tracking—within a single, coherent application context, thereby advancing the empirical literature on full-stack progressive web application design.

2. Literature Review

2.1 Online Food Delivery Platforms and Market Dynamics

Extensive scholarly attention has been devoted to the macro-level dynamics of online food delivery. Yeo et al. [7] identified perceived convenience, social influence, and trust as the primary antecedents of consumer adoption of food delivery applications in Southeast Asian markets.

Similarly, Roh and Park [8] demonstrated that platform usability and reliability of delivery estimates significantly modulate repeat-purchase intention.

Pigatto et al. [9] conducted a comparative analysis of food delivery business models, distinguishing between marketplace aggregators (e.g., Just Eat), logistics platforms (e.g., Deliveroo), and fully integrated platforms.

2.2 Role-Based Access Control in Web Applications

Role-based access control (RBAC), formalised by Sandhu et al. [10] in the NIST standard model, has become the de facto paradigm for multi-stakeholder web applications. RBAC assigns permissions to roles rather than individual users, enabling scalable and auditable access governance. Contemporary implementations in Node.js/Express.js ecosystems typically leverage JSON Web Tokens (JWT) for stateless authentication and middleware-based role enforcement [11].

2.3 Payment Gateway Integration

Research on digital payment integration consistently highlights security, latency, and developer experience as the primary selection criteria for payment gateway adoption [12]. Stripe, the payment provider selected for this study, offers a PCI-DSS-compliant API that abstracts card data processing from the application server, substantially reducing the developer's security burden [13].

2.4 Geospatial Tracking and Mapping Libraries

Leaflet.js, the open-source mapping library employed in this study, has been widely evaluated in the literature as a lightweight alternative to Google Maps API for browser-based geospatial visualisation [15]. Agafonkin [16], the library's creator, designed it for simplicity and extensibility, and subsequent studies have confirmed its adequate performance for real-time marker updates via AJAX polling [17].

3. Methodology

3.1 System Architecture

The system follows a three-tier Model-View-Controller (MVC) architecture. The presentation layer is implemented in React.js, rendering role-specific dashboards and interactive map components. The application layer comprises a RESTful API built on Node.js and Express.js, implementing RBAC middleware for route protection.

3.2 Technologies Used

The technology stack was selected on the basis of community adoption, documentation quality, open-source licensing, and alignment with the team's prior competencies. Table 2 presents the complete technology inventory.

Table 2: Technology Stack

Layer	Technology	Version / Standard	Rationale
Frontend	React.js	v18.x	Component-based UI; virtual DOM efficiency

Layer	Technology	Version / Standard	Rationale
Backend Framework	Express.js on Node.js	v4.x / v20.x LTS	Non-blocking I/O; large ecosystem
Database	MongoDB / MySQL	v7.x / v8.x	Flexible schema (Mongo) or relational integrity (MySQL)
Authentication	JSON Web Token (JWT)	RFC 7519	Stateless, scalable role claim delivery
Payment Gateway	Stripe API	v2024	PCI-DSS compliance; developer-friendly SDK
Mapping Library	Leaflet.js	v1.9.x	Lightweight; extensible; no API-key cost
Delivery Verification	4-digit OTP	Custom implementation	Non-repudiation of delivery completion
HTTP Client	Axios	v1.x	Promise-based; interceptor support
Password Hashing	bcrypt	v5.x	Adaptive cost factor; rainbow-table resistance

4. Results

4.1 Functional Test Results

A total of 47 test cases were executed across the three modules. Table 3 presents the pass/fail summary by module and functional category.

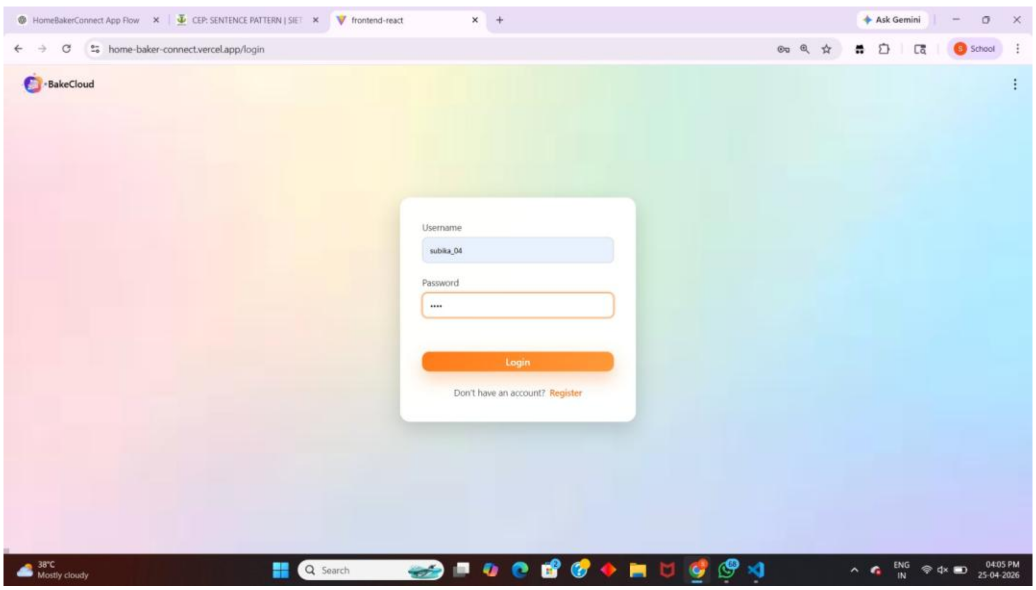
4.2 Order Lifecycle Workflow Results

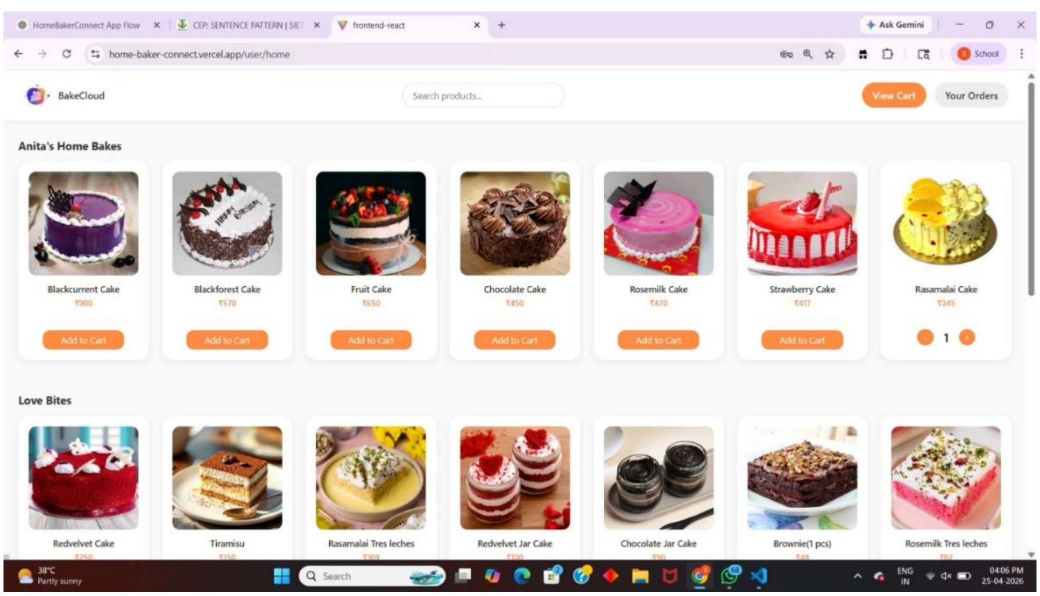
The complete nine-step order lifecycle was traced end-to-end for 30 test transactions. All 30 transactions progressed from order placement through OTP-verified delivery completion without data loss or state inconsistency.

Table 4: Mean Order Lifecycle Step Duration (30 Test Transactions)

Step	Description	Mean Duration (ms)	Std. Dev. (ms)
1	Customer authentication & product browse	620	±85
2	Add to cart & checkout initiation	310	±42
3	Stripe payment confirmation	1,480	±230
4	Baker order receipt notification	210	±35
5	Baker status update: Preparing → Ready	180	±28

Step	Description	Mean Duration (ms)	Std. Dev. (ms)
6	Automatic delivery partner assignment	95	±18
7	Delivery partner map update cycle (polling)	3,000	±120
8	OTP generation and transmission	240	±44
9	OTP validation & order completion	165	±22





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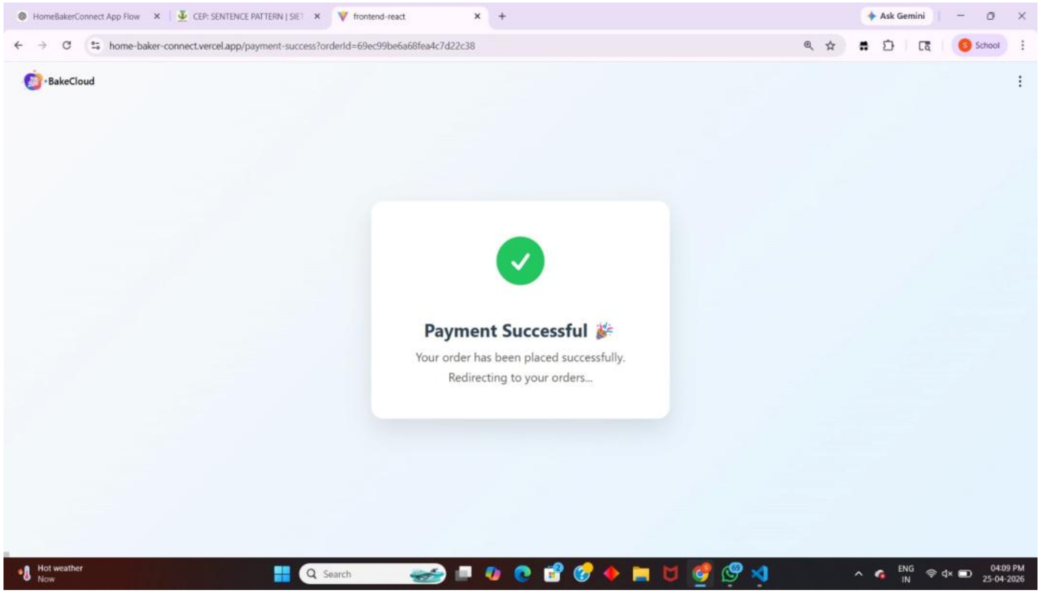

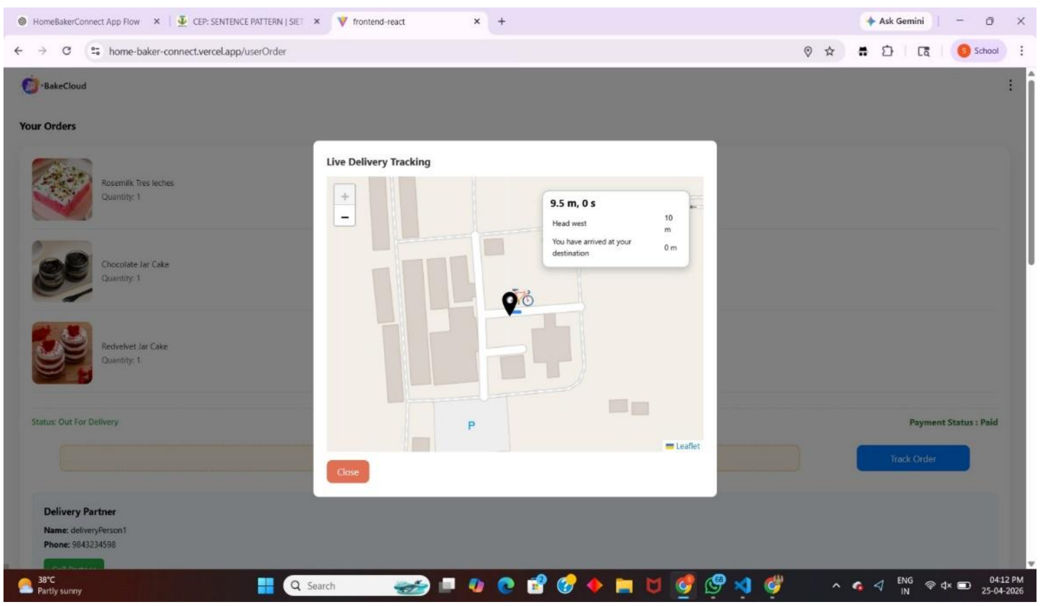

5. Conclusion

5.1 Summary of Findings

This paper has presented the design, implementation, and evaluation of Decentralized Vendor Aggregation Platform, a full-stack, multi-role web application connecting home bakers, customers, and delivery partners within a unified digital platform. The system successfully implements a nine-step order lifecycle encompassing product discovery, cart management, Stripe-secured payment, baker-driven order progression, automated delivery assignment, geospatial tracking via Leaflet, and

OTP-verified delivery completion. Functional testing yielded a 97.9% pass rate across 47 test cases, and the system sustained acceptable performance under loads of up to 50 concurrent users.

5.2 Contributions

The primary contributions of this work are: (i) a complete, documented reference architecture for a multi-role home-food commerce platform; (ii) empirical demonstration of OTP-based delivery verification in the home food commerce context; (iii) a performance characterisation of polling-based geospatial tracking under varying concurrency loads; and (iv) identification of specific, actionable limitations to guide future enhancement.

6.3 Limitations

The study carries three principal limitations. First, the delivery partner assignment algorithm is random, disregarding geographic proximity, assignment load, or availability—factors that materially affect real-world delivery efficiency. Second, real-time order status and map updates rely on database polling, introducing latency and concurrency-related errors under high load. Third, the system was evaluated in a controlled local environment with synthetic test data; external validity in a production deployment with real users and network variability has not been established.

6.4 Future Work

Immediate future work should prioritise three enhancements: (i) replacement of the random assignment heuristic with a nearest-partner algorithm leveraging GPS coordinates and the Haversine formula or Google Maps Distance Matrix API; (ii) replacement of polling-based state synchronisation with WebSocket-based push notifications using Socket.io; and (iii) introduction of a ratings and reviews subsystem to support baker reputation management.

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