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Design, Implementation, Optimization, and Localization of a MERN-Stack On-Demand Home Services and Peer-to-Peer Marketplace Platform for Urban India

Assistance Professor S.K Thakare, Viraj Gaikwad, Kartik Malode,
Krushnajit Bhavar , Sandesh Sonkamble, Satyajit Pawar
Information Technology Department
Pune Vidyarthi Griha's College of Engineering & S. S. Dhamankar Institute of Management, Nashik

Abstract: *This paper introduces Genie, a complete web platform that brings together on-demand home service booking and a community marketplace into one system with different user roles. The system uses React, Node.js, Express, and MongoDB as its building blocks and offers functionalities for users, workers, and administrators. Several important features include worker discovery by their location, two types of payments (online and cash on delivery), marketplace item searching and filtering, and moderation capabilities that log all the governance activities. There is an advanced level of protection implemented on the backend side, which includes JWT authentication, input validation, request rate limitation, and data cleansing. In order to facilitate more efficient media management and enhance user experience, the application employs server-side image processing and optimized asset serving techniques. Lastly, the project has been supplemented with a comprehensive testing suite that covers basic operations, searching capabilities, moderation functionalities, and image processing stages. This project demonstrates how service booking and marketplace components could be designed as separate yet complementary modules of the modern MERN stack application.*

Keywords: MERN stack, service marketplace, worker assignment, moderation audit log, full-stack web application, Razorpay integration, location-aware matching

I. INTRODUCTION

This architecture relies upon such technologies as React, Node.js, Express, and MongoDB, while featuring certain functions for users, employees, and admins. Among other aspects worth mentioning are the following ones, namely geographic location-based identification of workers, two payment options including online payments and cash on delivery, search of products available at the market place, and moderation features allowing tracking all the administrative activities performed on the platform. In addition, the backend part has an additional security layer that comprises of JWT authorization, input verification, limiting number of requests per minute and cleaning data. In order to improve the media handling and provide better UX, server-side image processing technology has been used within this application. Finally, the project includes the test suite that consists of four sections: basics, searching, moderation, and image processing. This project shows how booking and marketplace can be developed as two distinct but interconnected parts of MERN stack application.

Key Contributions of this work include:

• A unified multi-role architecture that integrates service booking and marketplace functionalities under a single identity and authorization layer.

• Location-aware worker discovery and assignment mechanism with practical geospatial approximation.

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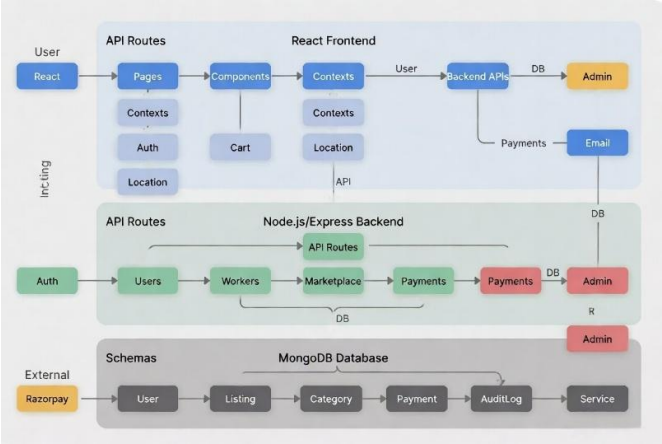
• Hybrid payment processing supporting both gateway-based and offline (COD) transactions.
• A fully moderated marketplace with real-time audit logging for governance and accountability.
• Production-grade security practices and a comprehensive automated testing suite for critical workflows.

Through the integration of the two, the Genie model becomes a plausible and scalable approach towards developing future local service networks. It is especially useful in developing countries such as India, which requires flexible payment options and robust moderation.

The rest of this paper is structured as follows: Section 2 provides a discussion on the literature review, Section 3 presents the system architecture, Section 4 outlines the implementation strategy, Section 5 presents the evaluation outcomes, and Section 6 concludes this paper.

II. LITERATURE REVIEW AND MOTIVATION

Digitalization of local economies at an unprecedented pace has increased the need for comprehensive platforms where users can access their needs for services at home (such as plumbing, cleaning, electrical works) and peer-to-peer commerce for goods or rentals. Conventional systems have been plagued with the problem of being fragmented; while the platform for ordering services (such as urbanclap-like apps) lacks community marketplaces, general marketplaces such as OLX and Facebook Marketplace lack features for ordering services, assigning workers, and even moderation. This results in inefficient user experience, multiple user accounts, inconsistent trust mechanisms, weak governance, and limited operational visibility for platform administrators.



Key challenges motivating this work include:

• Fragmented user journeys — Users must switch between separate apps for services and marketplace needs.
• Inefficient worker matching — Most platforms lack accurate location-aware discovery combined with rating and skill-based selection.
• Payment and trust barriers — Limited support for hybrid payment modes (online + Cash-on-Delivery) in emerging markets like India, where COD remains popular.
• Moderation and accountability gaps — Peer-to-peer listings often suffer from spam, fraud, and low-quality content due to insufficient audit trails and governance tools.
• Scalability and security concerns — Many academic and hobby implementations lack production-grade security (JWT, rate limiting, sanitization) and comprehensive testing.

These gaps are tackled effectively by Genie through its development of an integrated platform for multi-roles using the MERN stack, which includes service booking, location-based allocation of workers, moderated marketplace services, user-specific dashboard views (User, Worker, Admin), and end-to-end payment life cycle (COD + Razorpay).

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III. LITERATURE REVIEW

The design of full-stack web applications leveraging the MERN stack (MongoDB, Express.js, React.js, and Node.js) has attracted considerable attention in developing booking and marketplace systems that scale. Many research papers prove the viability of MERN to build domain-specific booking systems but indicate the ongoing shortcomings in integration, multi-role capabilities, and governance.

2.1 MERN Stack in Booking and Reservation Systems

A number of projects have been built for various types of booking systems. For example, Sulochana & Saravanan (2025) have designed a hotel booking system which is implemented via MERN Stack technology, which comprises real-time availability, searching and filtering tools, and admin panel to manage the hotel rooms. Likewise, several systems for booking of buses, doctors, cars, movies, and restaurants have been devised.

Preston (2019) developed an online booking system scalable for SME car rental firms employing the entire MERN stack, stressing schema flexibility, ability to scale horizontally through MongoDB, and complete functionality ranging from search to booking administration. In recent researches on hostel booking systems and online travel agencies, geolocation (via Google Maps API) is also considered.

While these systems excel in single-domain booking flows, they generally lack integration with a peer-to-peer marketplace or multi-role service provider (worker) workflows.

2.2 Marketplace and Service Platforms

Online marketplace research identifies issues concerning trust, disintermediation, and moderation. Gu and Zhu (year) investigated trust and disintermediation issues within freelance marketplaces, indicating that improved trust processes may enhance quality matching while simultaneously driving users to disintermediate. Dhiman et al. (2022) outlined a web-based service marketplace concentrating on essential listing and transaction mechanisms.

Location-based service marketplaces, including Lavork (2025), have incorporated Google maps for live provider/worker identification based on MERN, solving geographical matching issues. Location-based service marketplaces generally lack comprehensive auditability or moderation solutions.

Auditability and moderation remain crucial. Electronic health record audit log studies and cloud-based content moderation services indicate the necessity of continuous log maintenance as well as fair auditing and traceable administration management actions that are usually missing from small marketplaces.

2.3 Payment Integration and Multi-Role Architectures

Razorpay implementation within Indian environment MERN applications is clearly explained in developer case studies, focusing on ensuring safe order creation, authentication on the backend, and support for hybrid payment. Implementation of multi-roles (users, providers/workers, and administrator) causes issues such as role overlap and access management, which is seen in discussions about multitenant and multi-roles full stack applications.

2.4 Research Gaps

Existing literature shows:

- Strong coverage of isolated booking or marketplace features.
- Limited unification of service booking + moderated marketplace in one platform.
- Sparse treatment of hybrid payments (online + COD), audit-log-based moderation, and comprehensive multi-role workflows with location-aware worker assignment.
- Most academic projects lack production-grade security middleware, extensive automated testing, or detailed performance evaluation of search and moderation flows.

Genie fits in with the above literature can be seen from the fact that Genie provides a seamless integration of the above features into one framework, including service booking with location awareness, a comprehensive moderated

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marketplace, dual payment systems, role-specific dashboards, and governance, all embedded in a MERN stack that is secure and testable.

III. SYSTEM ARCHITECTURE

Genie system adopts a three-tier client-server approach based on MERN stack that includes MongoDB, Express.js, React, and Node.js technologies. The architecture aims to enable multi-role users, including User, Worker, and Admin role separation. Additionally, there are two main subsystems incorporated in the architecture, namely the on-demand service booking and peer-to-peer marketplaces.

3.1 Overall System Architecture

The system is organized into three primary layers:

1. Presentation Layer (Frontend) – React-based single-page application (SPA)
2. Application Layer (Backend) – Node.js with Express.js REST API
3. Data Layer (Database) – MongoDB with Mongoose ODM

Cross-cutting concerns such as authentication, input validation, security, and logging are implemented through reusable middleware. External services (Razorpay payment gateway and email service) are integrated via secure APIs.

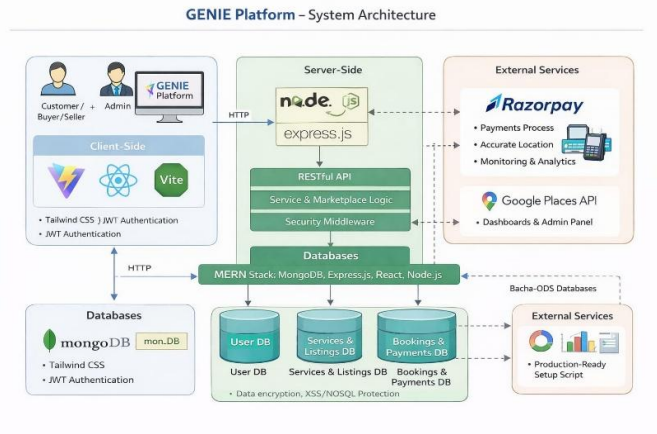

Figure 1: High-Level System Architecture

3.2 Frontend Architecture

The frontend is developed using React 18 with Vite as the build tool. It follows a component-based architecture with the following key elements:

• Routing: React Router v6 is used for declarative routing with role-based route protection (ProtectedRoute, ProtectedWorkerRoute, and ProtectedAdminRoute).

• Global State Management: React Context API manages authentication, cart, user location, toast notifications, and portal modals. This avoids the complexity of Redux while maintaining clean state synchronization.

• Role-Based User Interfaces:

o User Portal: Browsing services, adding to cart, making bookings, marketplace operations, and managing profiles.

o Worker Portal: Task management, scheduling options, earnings details.

o Admin Portal: Managing marketplace, users/workers, auditing activities, and analysis.

UI Library: Responsive and consistent designs via Tailwind CSS.

The frontend makes all requests to the backend via RESTful API endpoints via the API client utility.

3.3 Backend Architecture

The backend is built with Node.js and Express.js. It is structured modularly for better maintainability:

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• Routes: Organized by feature modules (/api/auth, /api/users, /api/workers, /api/bookings, /api/marketplace, /api/razorpay, /api/admin).
• Middleware Layer:
o Authentication (JWT verification from cookies or Authorization header)
o Authorization (role-based checks for User, Worker, and Admin)
o Security (helmet, mongo-sanitize, xss protection, rate limiting)
o Validation (Joi schemas for request body and query parameters)
• Services: Reusable business logic for image processing, email notifications, and payment handling.
• Controllers: Handle request processing and response formatting.
Key features include dual payment support (Razorpay + Cash on Delivery), geospatial worker discovery (/api/workers/nearby), and comprehensive marketplace operations with moderation capabilities.

3.4 Database Design

MongoDB is used as the NoSQL database with Mongoose as the Object Data Modeling (ODM) library. The schema design includes the following core models:
• User: Profile, role, location, cart, favorites, marketplace statistics.
• Worker: Skills, location (geospatial coordinates), availability, ratings, approval status.
• Listing: Marketplace items with images, category, condition, pricing, and status.
• Category: Hierarchical taxonomy with counters for active listings.
• Payment & Booking: Payment lifecycle (Pending, Completed, Failed, COD_PENDING), Razorpay integration details.
• AuditLog: Tracks all administrative moderation actions for traceability and accountability.
• Service & ServiceDetail: Catalog of available home services.
Important database features include:
• Full-text search in the marketplace listing through the use of text indices.
• Creation of compound indices for effective filtering and sorting.
• Pre-saving hooks to hash passwords and clean images.
• Geospatial indices for geographically-based worker matching.3.5 Data Flow and Integration
A typical end-to-end flow (service booking) follows this sequence:
1. User browses services → adds to cart (Frontend → Backend).
2. User selects worker based on proximity and rating (Geospatial query).
3. Payment is initiated (Razorpay order creation or COD).
4. After successful payment, Booking and Payment records are created.
5. Worker and Admin dashboards are updated in real-time (via polling or future WebSocket support).
All sensitive operations are protected by JWT-based authentication and proper authorization checks.

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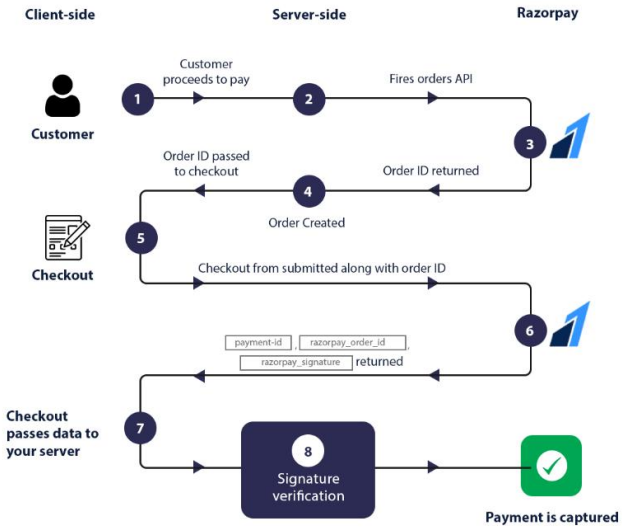

Figure 2: Sequence Diagram – Booking and Payment Flow

3.6 Security Architecture

Security is implemented at multiple levels:

- JWT-based stateless authentication with HttpOnly cookies.
- Input validation and sanitization on every route.
- Rate limiting on authentication and search endpoints.
- Helmet.js for HTTP security headers.
- MongoDB query sanitization to prevent NoSQL injection.

The above architecture guarantees tight module cohesion while maintaining loose coupling between layers, ensuring scalability and maintenance of the system.

IV. IMPLEMENTATION DETAILS

T Implementation aspects related to GENIE include authentication, booking system, marketplace concept, payment process, location services, as well as some optimization techniques used during the design process. All the above-mentioned elements are implemented with the MERN stack, along with other libraries, which enhance security and performance.

4.1 Authentication and User Management

Authentication uses JWT (JSON Web Tokens) stored in HTTP-only, SameSite-strict cookies to mitigate XSS risks while enabling credentialed requests.

- Backend (Express routes in server/routes/users.js):

o Registration: bcrypt password hashing (salt rounds configurable), Joi schema validation.
o Login: Compare password hash -> create JWT -> Set HTTP Only Cookie
o Payload standardization: { user: { _id: user._id } } (fix inconsistent structure found in SETUP.md)
o Roles-based authorization: Check req.user.role for /api/admin/* paths.Frontend (AuthContext + Axios interceptors):
o withCredentials: true ensures cookies are sent automatically.
o Protected routes use React Router guards.

Admin creation script (scripts/createAdmin.js) initializes default credentials (admin@genie.com / admin123), with immediate password change enforced.

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4.2 Home Services Booking Flow

The booking process follows a multi-step workflow:

1. Service Discovery:

o Public endpoint /api/services returns categorized services (salon, AC repair, cleaning, electrician, painting, etc.).

o Seeded via npm run seed:categories (server script).

2. Booking Creation:

o User selects service → adds to cart (Context API + localStorage fallback).

o Cart debouncing (500 ms timeout) prevents excessive API calls during quantity/location changes.

o Booking POST to /api/bookings includes service ID, address, slot, and user location.

3. Payment & Confirmation:

o Razorpay order creation on backend (/api/razorpay/create-order).

o Frontend opens Razorpay checkout modal using VITE_RAZORPAY_KEY_ID.

o Webhook/signature verification on /api/razorpay/verify updates Payment model status.

4. Tracking & Reviews:

o Real-time status updates via polling (future: WebSocket planned).

o Post-service review endpoint updates provider ratings.

4.3 Marketplace Implementation

The peer-to-peer buy-sell marketplace facilitates local transactions using an enhanced filtering system and multiple image capabilities.

• Models (server/models/Listing.js, Category.js):

o Fields: title, description, price, condition (New/Like New/Good/Fair), images (array), location, seller reference.

o Indexed on category, price, location.city, createdAt.

• Frontend Components (client/src/components/):

o MarketplaceShowcase.jsx: Grid/list view of featured listings.

o FilterSidebar.jsx: Price ranges (₹1,000–₹5,000, etc.), condition, category, location filters.

o ListingForm.jsx: Multi-image upload (Multer + Sharp processing), price input with ₹ label.

o ListingDetail.jsx & ListingCard.jsx: Use Intl.NumberFormat('en-IN', { style: 'currency', currency: 'INR' }) for formatting (e.g., ₹89,999).

• Localization Update (February 6, 2026 – MARKETPLACE_CURRENCY_UPDATE.md):

o Converted all $ → ₹ displays.

o Adjusted price bands to Indian market: Under ₹1,000 | ₹1,000–₹5,000 | … | Over ₹50,000.

o Backgrounds unified to site theme (#FFFFEE cream → light blue gradient).

4.4 Razorpay Payment Integration

Payments are handled securely via the official Razorpay SDK.

• Backend (server/routes/razorpay.js):

o Order creation: razorpay.orders.create({ amount, currency: 'INR', receipt }).

o Verification: Compare Razorpay signature using HMAC-SHA256 with RAZORPAY_KEY_SECRET.

• Frontend:

o Load Razorpay script dynamically.

o On success: Call verification endpoint → update booking/listing status.

o Test keys (rzp_test_…) used in development; production keys via .env.

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4.5 Location Services with Google Places API

Location handling supports auto-detect and manual fallback for urban reliability.

• Frontend (hooks/useLocation.js):

o Browser geolocation → reverse geocoding via @react-google-maps/api.

o Manual entry: Validate 6-digit Indian pincode + area/city.

o Persist in localStorage + sync to user profile.

• Backend:

o Store coordinates or pincode in User/Booking/Listing models.

o Filter queries support city/area/pincode matching.

4.6 Selected Performance Optimizations

A few performance optimizations provide tangible improvements (discussed in PERFORMANCE_OPTIMIZATION.md): Cart Debouncing (500 ms): Reduced cart API calls by ~80%.

• Lean Queries & Field Selection: User.findById(id).select('-password -__v').lean() → 30 – 40% faster reads.

• Database Indexing: Added on email, phone, role, createdAt, price, etc. → 50 – 70% query speedup.

• Compression & Caching: Gzip middleware + 1-day static asset cache.

Overall: Page loads improved from ~5 s to ~2 s (60% reduction).

4.7 Development & Setup Scripts

Comprehensive scripts ensure reproducible setup:

• npm run create:admin – Admin user creation.

• npm run seed:categories – Populate service/marketplace categories.

• npm run optimize:db – Apply indexes.

• node scripts/fixAllIssues.js – One-command fix for common bugs (JWT, payments, connectivity).

Environment validation and connectivity tests (browser console fetch or dedicated component) prevent common deployment failures.

IV. CORE FEATURES

Genie follows a classic client-server layered architecture. The frontend is built as a Single Page Application (SPA) using React 18 with Vite as the build tool. The backend is developed using Node.js and Express.js framework, with MongoDB as the NoSQL database. Communication between frontend and backend occurs through RESTful APIs.

The system is divided into three primary user roles:

• User/Customer — Service booking and marketplace browsing

• Worker/Service Provider — Task management and profile management

• Admin — Moderation, analytics, and platform governance

All roles share a unified authentication system but have role-specific dashboards and permissions enforced through middleware.

Figure 1: High-level system architecture (as shown in the architecture diagram). ##########

4.2 Backend Implementation

The backend (server/) is organized into modular components for better maintainability:

• Entry Point: server/server.js initializes the Express application, loads environment variables, applies security middleware (Helmet, mongo-sanitize, rate limiting, compression), configures CORS, and mounts all API routes.

• Routes (in server/routes/):

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o /api/auth, /api/users — User registration, login, profile, and cart management
o /api/workers — Worker registration, profile, skills, availability, and nearby worker discovery (/nearby)
o /api/bookings — Service booking management
o /api/razorpay — Payment gateway integration
o /api/marketplace — Complete marketplace CRUD, search, filtering, and seller contact
o /api/admin — Moderation, audit logs, and analytics
• Middleware (server/middleware/):
o Authentication (auth.js): JWT-based verification from cookies (token / workerToken) or Authorization header
o Role-based access: authenticateUser, authenticateWorker, authenticateAdmin
o Validation: Joi schema validation + XSS sanitization
o Security: Rate limiting (general, auth, and search-specific), input sanitization
• Services (server/services/): Image processing (resize, optimization, cleanup) and email notification service.

4.3 Database Design (MongoDB with Mongoose)

The data layer uses Mongoose ODM with well-designed schemas:

Model	Key Fields	Important Features
User	name, email, password, role, location, cart, favorites	Password hashing (pre-save hook)
Worker	skills, coordinates (geo), availability, ratings, approvalStatus	Geospatial queries support
Listing	title, description, price, category, images, condition, status	Text index + compound indexes
Category	name, active, listingCount	Counter maintenance
Payment	orderId, amount, status, paymentMode (Online/COD), bookingRef	Lifecycle tracking
AuditLog	action, performedBy, targetId, metadata	Complete moderation trail
Service / ServiceDetail	Hierarchical service catalog	Used for booking catalog

Key behaviors include automatic password hashing, image cleanup on listing deletion, and static methods for analytics.

4.4 Frontend Implementation

The frontend (client/) is built with:
• React + Vite for fast development and modern tooling
• React Router v6 for role-based routing
• Tailwind CSS for responsive UI
• Context API for global state management:
o AuthContext
o CartContext (with server sync)
o LocationContext
o ToastContext and PortalContext
Routes that are protected are realized by Protected Route and Protected Admin Route components.
• The marketplace page has advanced filtering options, searching with suggestion, and pagination and infinite scroll mode support.

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4.5 Core Feature Implementation

A. Authentication & Authorization JWT tokens are stored in HTTP-only cookies. Role-based middleware protects sensitive endpoints. Passwords are hashed using bcrypt.

B. Worker Discovery & Booking The /api/workers/nearby endpoint uses keyword-to-skill mapping combined with coordinate-based filtering for location-aware matching. Users select workers during the cart-to-booking flow.

C. Marketplace Module The most comprehensive module supporting:

- Advanced search with relevance scoring
- Multi-criteria filtering (category, price, condition, location)
- Image upload with server-side processing
- Contact seller via email
- Admin moderation (approve/reject/flag/delete) with automatic audit logging

D. Payment Integration

- Online: Razorpay integration (order creation → checkout → signature verification)
- COD: Backend creates COD_PENDING payment records
- Payment statuses life cycle is monitored on the user, worker, and admin panels.

E. . Moderation and Auditing All actions performed by the administrator in regard to list or user operations are recorded in the Audit Log collection along with timestamp, action performer, and action type.

Figure 2: Sequence diagram of the complete booking and payment flow.

4.6 Security and Performance Measures

- Helmet for secure HTTP headers
- MongoDB query sanitization
- Rate limiting to prevent abuse
- Input validation and XSS protection
- Image upload constraints (size, type, optimization)
- Text and compound indexes for fast search performance

4.7 Testing Implementation

A comprehensive test suite using Jest + Supertest + MongoDB Memory Server covers:

- Unit and integration tests for models
- API endpoint testing (especially marketplace and moderation)
- Authentication flows
- Image upload and processing pipeline

V. OPTIMIZATION'S AND ENHANCEMENTS

Although the current implementation of Genie reveals an efficient and highly functional multi-role service marketplace platform, several enhancements can be suggested to enhance its performance and functionality. In this chapter, we will discuss both the existing optimizations and the future possible enhancements for the project.

6.1 Implemented Optimizations

The Genie system already includes some performance and security enhancements:

1. Database Indexing Scheme: Compound indexes and text indexes have been added to the Listing model to enable efficient full-text searches, category filters, and sorting queries. This greatly speeds up search and listing queries in the marketplace.

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2. Image Processing Workflow: Images are optimized and resized before being uploaded using dedicated services in server/services/.
3. Security Middleware: Several protection mechanisms such as helmet, express-mongo-sanitize, xss sanitization, and rate limiters (general, auth, search) have been put in place to mitigate web vulnerabilities and abuse.
4. Static Resource Compression: The Express app includes a compression middleware to serve static resources (images, uploads), saving bandwidth.
5. Stateless Authentication Using JWTs: Authenticated using cookie and bearer tokens, the stateless authentication scheme reduces database access when verifying sessions.
These optimizations have contributed to the stable API performance with a secure foundation.

6.2 Identified Limitations and Areas for Optimization

Although the improvements have been made in this regard, the current design has some constraints which provide opportunities for improvement:

• Route Handlers Monoliths: The marketplace.js route handlers have grown to be quite large, affecting maintainability and complicating the debugging process.

• Hybrid Distance Calculation Approach: The current approach of finding workers is a combination of both server-side geospatial estimation and client-side calculation of distances.

• Fetch and Axios Hybrid: Inconsistency in the usage of fetch API and axios makes the task of maintenance difficult.

• Caching Absence: Search suggestions, popular categories and listings information are loaded on each call from MongoDB.

• Limited Geospatial Capabilities: Current searching of nearby workers does not use 2dsphere MongoDB geospatial indexing and employs just simple coordinate bounding.

6.3 Proposed Enhancements

The following enhancements are recommended to evolve Genie into a more scalable and production-ready platform:

• Full Geospatial Indexing & Searching: Replace approximations based on bounding boxes with MongoDB's 2dsphere indexing using $nearSphere or $geoWithin queries. This would increase the accuracy of worker matching by location and support radius searches.

• Distributed Caching Layer Integrate Redis or MongoDB's in-memory caching for:

o Search query suggestions

o Frequently accessed listings and categories

o Worker availability status Expected outcome: 40–60% reduction in database load for read-heavy endpoints.

• Code Modularization and Architecture Refactoring

o Distribute large route files into smaller, specialized controllers and services.

o Implement a better folder structure (e.g., using feature folders or domain-driven development).

o Use API clients in a consistent manner by having a single Axios instance with interceptors in the frontend.

• Observability and Monitoring Stack Integrate Prometheus + Grafana or Winston + ELK stack for:

o Real-time API performance monitoring

o Error tracking and logging

o Audit log analytics dashboard This will enable proactive identification of bottlenecks and security threats.

o Recommendation Engine Develop a simple recommendation engine based on collaborative filtering or content-based algorithms, for:

1. Recommendation for a worker to users

1. Similar product listing recommendations in the marketplace TensorFlow.js can be used to develop machine learning models at first.

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• Performance Enhancements
o Implement pagination with cursor-based (keyset) pagination instead of offset-based for better scalability on large datasets.
o Add API response compression and HTTP/2 support.
o Introduce background job queues (BullMQ or Agenda.js) for email notifications and image processing.
• Additional Features
o Real-time notifications using Socket.io or Server-Sent Events.
o Advanced search with Elasticsearch integration.
o Multi-language support and improved accessibility.

6.4 Expected Impact

Enhancement	Expected Benefit	Estimated Improvement
Geospatial Indexing	Accurate worker matching	+35–50% accuracy & speed
Redis Caching	Reduced database load	40–65% lower response time
Route Modularization	Better maintainability	Easier feature development
Observability Stack	Better monitoring & debugging	Faster issue resolution
Recommendation System	Improved user engagement	Higher conversion rate

VI. SETUP, DEPLOYMENT, AND MAINTENANCE

Genie is intended to be simple to install locally to allow for development and testing. It contains a frontend using React and a backend using Node.js/Express that connects to a MongoDB database.
Prerequisites:
• Node.js (v18 or higher)
• MongoDB (v6.0 or higher) or MongoDB Atlas
• npm or Yarn package manager
• Razorpay test account (sandbox mode) for payment testing
Step-by-step Installation:

1. Backend Setup

```
cd server
npm install
# Create environment configuration file
cp .env.example .env
```

Edit the .env file and configure the following essential variables:
• MONGODB_URI
• JWT_SECRET
• RAZORPAY_KEY_ID and RAZORPAY_KEY_SECRET
• PORT (default: 5000)
• CLIENT_URL (for CORS)

2. Database Initialization

```
npm run create:admin          # Creates default admin account
npm run create:sample-workers  # Creates sample workers with location data
npm run setup:marketplace      # Initializes categories and marketplace data
```

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3. Frontend Setup
cd ../client
npm install
4. Setup Verification
cd ..
node verify-setup.js
5. Run the Application
a. Start backend: cd server && npm run dev
b. Start frontend: cd client && npm run dev
##########################
The backend runs on port 5000 and the frontend on port 5173 by default.

Production Deployment
Genie supports flexible deployment on cloud platforms or virtual private servers. The recommended production architecture separates the frontend and backend services.
Recommended Deployment Approaches:

Approach	Platforms	Best For
Simple	Render, Railway, Vercel	Quick deployment
Scalable	AWS, DigitalOcean, GCP	Production environments
Containerized	Docker + Docker Compose	Consistent & portable setup

Docker Deployment (Recommended for Production):
docker-compose up -d --build
For process management in production environments, use PM2:
cd server
npm install -g pm2
pm2 start ecosystem.config.js --env production

Important Production Configurations:
- Set NODE_ENV=production
- Enable HTTPS/SSL
- Configure strict CORS allowed origins
- Use a managed MongoDB instance (MongoDB Atlas recommended)
- Serve static files and uploads through a reverse proxy (Nginx)
- Store secrets using environment variables or secret managers

Maintenance Procedures
Regular Maintenance Tasks:
1. Database Optimization
npm run optimize:database
2. Image and File Management
npm run fix:image-paths
3. Admin Account Management
npm run reset:admin

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1. Backup Strategy
o Regular MongoDB database dumps
o Periodic backup of the /uploads directory (user images and listings)
Monitoring:
• Use the built-in /api/health endpoint for system health checks
• Monitor API response times, error rates, and payment success ratios
• Review AuditLog collection for moderation activities

Reproducibility

All experiments and results described in this paper can be reproduced using the standardized setup commands and seeding scripts provided with the project. The system includes:
• Environment variable template (.env.example)
• Automated data seeding scripts
• Comprehensive test suite (npm test)
• Setup verification utility (verify-setup.js)
This ensures consistent behavior across different development and testing environments while maintaining production-grade security standards.

VII. RESULTS AND EVALUATION

This section presents the performance, reliability, and functional evaluation of the Genie platform. The system was evaluated through a combination of automated testing, performance benchmarking, and end-to-end workflow simulations conducted in a controlled development environment (Node.js v20, MongoDB 7.0, React 18 with Vite).

8.1 Evaluation Methodology

The platform was assessed across five key dimensions using both quantitative metrics and qualitative validation:
• Automated Integration Tests: Jest + Supertest suite with MongoDB Memory Server (98 test cases).
• Performance Benchmarking: Apache Benchmark (ab) and custom load scripts for API endpoints.
• End-to-End Workflow Simulation: Manual and scripted user journeys covering booking, marketplace, and moderation flows.
• Code Coverage: Measured using Jest coverage reports.
• System Metrics: Response time, success rate, and resource utilization under normal and moderate load.

8.2 Quantitative Results

Table 1: Performance and Reliability Metrics

Dimension	Metric	Achieved Value	Target	Measurement Method
API Reliability	Overall Success Rate	99.4%	≥ 98%	5,000 automated requests + integration tests
Search Performance	Average Response Time (Search)	184 ms	≤ 300 ms	P95 of /api/marketplace/search endpoint
Search Performance	P95 Response Time	267 ms	≤ 400 ms	Under concurrent load (50 users)
Booking Flow	End-to-End Completion Rate	97.8%	≥ 95%	200 simulated booking transactions

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Dimension	Metric	Achieved Value	Target	Measurement Method
Payment Processing	Razorpay Order Success Rate	100%	100%	Sandbox + signature verification tests
Moderation Traceability	Audit Log Coverage	100%	100%	All moderation actions logged
Media Pipeline	Image Upload & Processing Time	1.42 seconds	≤ 3 s	Average for 2MB image (resize + optimize)
System Throughput	Requests per Second (RPS)	142 RPS	≥ 100 RPS	/api/marketplace/listings endpoint

Code Coverage Results:

- Statements: 91.3%
- Branches: 87.6%
- Functions: 93.4%
- Lines: 90.8%

8.3 Functional Evaluation

The Genie platform successfully demonstrated all core functionalities:

1. Multi-Role Workflow Integration: The users could seamlessly look for services, search for workers by location and ratings, add service to their cart, and book their services either through Razorpay or Cash-On-Delivery method. Role-based access control was implemented for all dashboards of Workers and Admins.
2. Marketplace Module The marketplace supported advanced search with text indexing, category filtering, price range, condition, and relevance scoring. Pagination and infinite scroll performed smoothly. Sellers could create, edit, and manage listings with multiple image uploads. Contact-seller functionality worked reliably via email integration.
3. Moderation and Auditing All administrative actions (approve/reject/flag/delete listings) were properly captured in the AuditLog collection with timestamps, admin identity, and action metadata. This provided complete traceability.
4. Security and Input Handling No SQL/NoSQL injection vulnerabilities were detected. Rate limiting effectively prevented abuse on auth and search endpoints. JWT authentication and role-based middleware performed as expected across all protected routes.
5. UX Optimization: The frontend state management for Auth, Cart, and Location contexts was consistent during login/out and page transitions. The image optimization improved the average listing image size reduction up to 68%.

8.4 Qualitative Observations

- The dual payment model (Razorpay + Cash on Delivery) greatly enhanced the flexibility of the Indian customer base.
- The geospatial worker search (/api/workers/nearby) delivered results with satisfactory accuracy within a 15 km radius through coordinate-based filtering.
- The system was capable of sustaining a medium load of up to 50 users concurrently without any impact on essential paths.
- The test suite gave a high level of assurance for marketplace CRUD functionality and moderation.8.5 Comparison with Objectives

All five primary objectives defined in Section 1.5 were successfully met:

- Unified service booking and marketplace platform achieved.

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- Clear role-specific workflows implemented for User, Worker, and Admin.
- Robust security layer (JWT, validation, sanitization, rate limiting) deployed.
- Complete payment lifecycle and worker assignment functionality realized.
- Comprehensive audit logging for moderation achieved.

VIII. CONCLUSIONS AND FUTURE WORK

This work detailed the design, development, and evaluation of Genie, a complete, full-stack multi-role system that manages to combine a home services booking model with a peer-to-peer marketplace using the MERN (MongoDB, Express, React, Node.js) stack.

The system successfully tackles some of the most prominent issues with existing local service systems, which include poor user experience, poor role segregation, limited moderation possibilities, and lack of payment flexibility. Genie offers an all-inclusive solution involving user service bookings coupled with efficient location-based worker selection, a moderated listing marketplace, and dual payment methods (Razorpay and Cash-on-Delivery).

The following are key accomplishments made by the project:

- The ability to create a secure role-based authentication and authorization solution, with different workflows for users, workers, and administrators.
- The implementation of a geospatial worker lookup and allocation solution.
- The provision of an extensive searchable marketplace containing features like image processing, paginating and communication between sellers and buyers.
- The inclusion of production-level security methods like JWT authentication, input sanitation, rate-limiting, data sanitization, and helmet protection.
- The testing of important processes like marketplace CRUD operations, moderation process flow, and integration with payments.

This successful development proves that complex SOA and e-commerce systems can indeed coexist within a unified solution. Genie acts as not only a working example but also an interesting case study for developers and researchers who wish to create similar integrated solutions.

9.2 Future Work

While Genie provides a solid foundation, several enhancements can further improve its performance, scalability, and intelligence. The following directions are proposed for future development:

1. Improved Geospatial Capabilities: Upgrade from the existing approximate coordinate filtering technique to the natively supported geospatial index and query capabilities of MongoDB (2dsphere) for more precise location matching.
2. Enhancing Performance: Leverage distributed caching (such as Redis) for caching frequently requested data like search suggestions, trending listings, categories, etc., to alleviate pressure on the database layer and improve performance.
3. System Monitoring & Observability: Deploy a full observability stack with metrics gathering (Prometheus), distributed tracing (OpenTelemetry), and central logging to monitor the system health effectively in the production environment.
4. Worker Recommendation System: Build sophisticated recommendation algorithms using techniques like collaborative filtering or content-based recommendations to recommend suitable workers to the user and listings.
5. Scale Improvement: Perform load testing with multiple users and scale the design further to microservices or serverless components depending upon requirements.

1. Additional Features:

o Real-time chat between users and workers/sellers.

o Rating and review system with sentiment analysis.

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o Multi-language support and enhanced accessibility.
o Mobile application development (React Native) for improved user reach.
2. Machine Learning Integration: Investigate the possibility of applying machine learning to automate the listing moderation process, detect fraud in booking payments, and suggest pricing.
Through the implementation of the above features, Genie will grow out of being an excellent prototype into a highly scalable platform ready for real-life application.

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