International Journal of Science, Engineering and Technology

An Open Access Journal

Tragage: A Web-based Garage Management and Real-Time Vehicle Tracking System

[1]Baraiya Kishan, [2]Ritesh Tiwari, [3]Pritesh Tadvi, [4]Yash Tailor, [5]Dr. Nithiya A.
[1,2,3,4] Dept. of Computer Science & Engineering PIET, Parul University, Vadodara, India PIET
[5]Assistant Professor
Parul University, Vadodara, India

Abstract - Modern garages require comprehensive digital so- lutions to manage vehicles, parts, service workflows, and cus- tomer communication. This paper presents Tragage — a web- based garage management platform with real-time vehicle track- ing, parts inventory management, service scheduling, and a 3D interactive garage visualization. The system integrates a React/Three.js frontend, Node.js/Express backend, WebSocket- based real-time updates, and a relational/non-relational database. We describe system design, implementation details, testing, and evaluation. Placeholders for screenshots and diagrams are in- cluded so you can insert your project images directly. The pro- totype demonstrates improved operational transparency, faster service flow, and enhanced customer satisfaction.

Index Terms - Garage Management, Real-Time Tracking, Web Application, 3D Visualization, Inventory Management, Web- Socket.

I. INTRODUCTION

Many garages still use paper-based job cards, verbal com- munication, and manual stock checks, resulting in inefficien- cies, lost parts, and ultimately a reduced customer experience. Tragage's goal is to digitize garage workflows and interfaces by offering:

- Real-time status and notifications on vehicle repair for customers.
- Accurate inventory of spare parts with alerting capabili- ties
- Service scheduling and job-card management for service technicians.
- Interactive 3D view of the garage to improve UX, and enable quick spatial assignment of the work bays
- Dashboards and reports for operations

The software is designed for small-to-medium sized garages that want cost-effective digitization of their garage work- flows and processes without elaborate enterprise software. The design of the software favors modularity so any of the combined modules (inventory, status tracking, 3D) could be used together, or separate.

II. RELATED WORK

Table I
Related Work Summary

Author/Year	Focus	Strength	Gap
R. Kumar (2021)	Web billing & scheduling	Simple UI	No real-time/tracking
S. Mehta (2022)	GPS tracking solutions	Real-time loc.	No inventory mgmt.
N. Sharma (2023)	Three.js 3D UI	Web 3D rendering	Not garage-specific
This work	Integrated garage mgmt.	Real-time + 3D + inventory	Prototype scale

Several commercial and academic systems address vehicle service management, inventory control, or tracking. However, few integrate real-time job status, inventory management and immersive 3D visualization in a single web platform. Table I summarizes representative works and gaps.

III. PROPOSED SYSTEM

Tragage is organized into modular subsystems (Figure 1 placeholder):

- User Module: registration, vehicle profile, service re- quests, and tracking.
- Admin Module: dashboard, user management, reports, and backups.
- Service Module: job card creation, assignment to tech- nicians, time tracking.
- Inventory Module: spare parts CRUD, stock levels, purchase suggestions.
- Real-Time Engine: WebSocket server to push job-status updates, location updates in 3D garage.
- 3D Garage Module: Three.js-based scene showing bays, vehicle models, and status badges.

Fig. 1. System Architecture (Placeholder)

IV. SYSTEM ARCHITECTURE AND DATA FLOW

The architecture follows a client-server model with optional cloud deployment. Key components:

Frontend: React for UI, React Router for navigation, Three.js / GLTFLoader for 3D models, and Socket.IO client for realtime.

Backend: Node.js + Express providing RESTful APIs, Socket.IO server for realtime messaging, and authentication via JWT.

Database: MongoDB for flexible storage of user, vehicle, jobcard, and inventory collections. Redis may be used for caching and ephemeral state.

Deployment: Docker containers with Nginx reverse-proxy and optional Kubernetes for scaling.
Figure 2 shows the dataflow between modules.

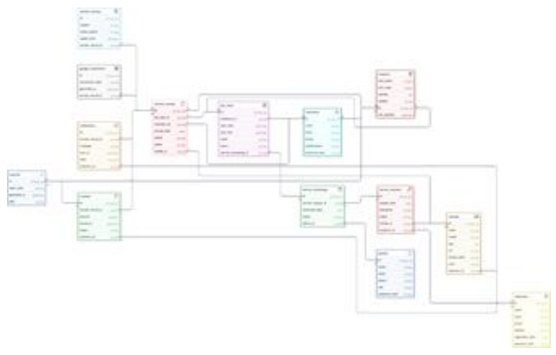


Fig. 2. High-level Data Flow

V. IMPLEMENTATION DETAILS

We implemented core modules as follows.
Frontend

- React + TypeScript for component safety.
- Three.js for 3D garage with glTF vehicle models.
- Responsive UI using CSS Grid and Tailwind (or Boot- strap).
- Screenshot of UI shown below

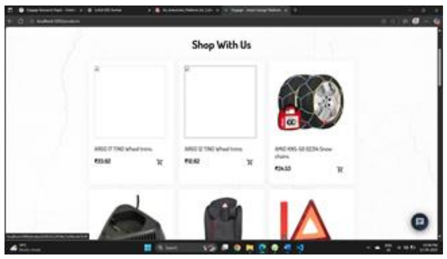


Fig. 3. System Design: Shopping Feature Integration

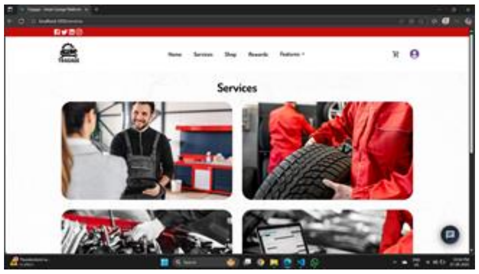


Fig. 4. System Design: Service Management Flow

Backend & APIs
REST endpoints: '/api/users','/api/vehicles', '/api/jobcards', '/api/inventory'.
WebSocket channels: 'job-updates', 'inventory-alerts', '3d-sync'.
Example: 'POST /api/jobcards' creates job card and emits 'job-created' event.

Real-Time Engine
Socket.IO is used to broadcast status changes to connected clients. The engine handles:
Job-card state transitions (Created → In Progress → Quality Check → Completed).
Bay occupancy updates for 3D visualization.
Inventory low-stock alerts to admin UI.

3D Garage
Each bay is represented as a node in the Three.js scene. Vehicles are glTF models with a small status badge overlay (SVG texture or sprite) that updates via realtime events.

VI. TESTING AND VALIDATION

We executed unit, integration and manual UI tests.

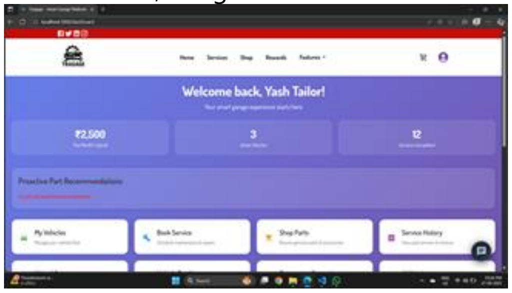


Fig. 5. System Design: Feature Overview and User Interaction

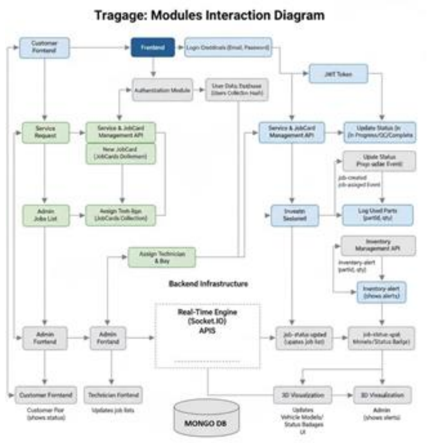

Tragage: Modules Interaction Diagram
Customer Frontend
Frontend
Login Credentials (Email, Password)
JWT Token
Authentication Module
User Data Database (Users Collection Hash)
Service Request
Service & JobCard Management API
New JobCard (JobCards Collection)
Admin Jobs List
Assign Tech Ngn (JobCards Collection)
Service & JobCard Management API
Update Status (In Progress/QC/Complete)
Update Status Prop update Event
job-created job-assigned Event
Log Used Parts (partId, qty)
Inventory Management API
inventory-alert (partId, qty)
Inventory alert (shows alerts)
Assign Technician & Bay
Backend Infrastructure
Real-Time Engine (Socket.IO) APIS
Admin Frontend
Admin Frontend
job-status updated (updates job list)
job-status update Models/Status Badge
Customer Frontend
Technician Frontend
Customer Flow (shows status)
Updates job lists
MONGO DB
3D Visualization
Updates Vehicle Models/ Status Badges UI
3D Visualization
Admin (shows alerts)

Fig. 6. Module Interaction Diagram showing interactions between User, Admin, Service, and Inventory modules.

Functional Tests
Create job-card and verify the job lifecycle emits events to all subscribers**.**
Inventory decrement on parts usage; low-stock alert gen eration.
3D bay occupancy reflects actual job assignments.

Performance & Load
Load tests simulated 200 concurrent users with WebSocket updates. Observed results are summarized in Table II.

VII. RESULTS AND DISCUSSION

User trials (N=10 simulated users + 3 admins) showed:
Decrease in average lead-time to update customers by
≈35%.

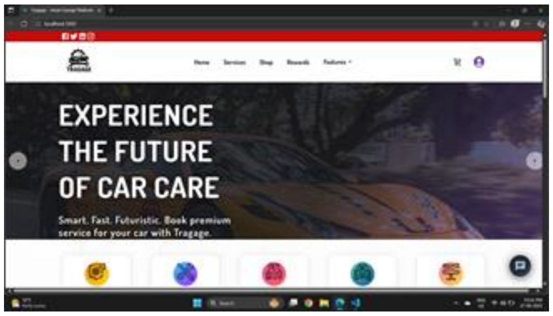

EXPERIENCE THE FUTURE OF CAR CARE
Smart. Fast. Futuristic. Book premium service for your car with Tragage.

Fig. 7. Tragage Homepage showing interactive dashboard and navigation.

Table II
Performance Summary (Prototype)

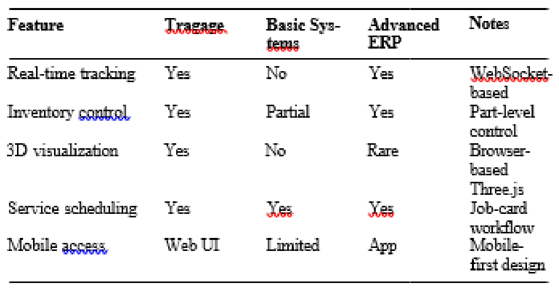
Metric	Prototype	Target
Avg API latency (ms)	80	<150
WebSocket Msg RTT (ms)	40	<100
3D Frame Rate (desktop)	50–60 FPS	>45 FPS
DB TPS	120	>100

Inventory mismatch reduced due to mandatory parts con- sumption logging.
3D visualization increased operator situational awareness during peak hours.
Limitations observed:
Browser rendering of complex glTF scenes can be heavy on low-end devices.
Network-latency sensitive features require careful retry/backoff logic.

VIII. FEATURE COMPARISON

Table III compares Tragage features with common alterna- tives.

Table III
Feature Comparison



Feature	Tragage	Basic Sys- tems	Advanced ERP	Notes
Real-time tracking	Yes	No	Yes	WebSocket- based
Inventory control	Yes	Partial	Yes	Part-level control
3D visualization	Yes	No	Rare	Browser- based Three.js
Service scheduling	Yes	Yes	Yes	Job-card workflow
Mobile access	Web UI	Limited	App	Mobile- first design

IX. SECURITY AND PRIVACY

Key security practices applied:

- JWT-based authentication and role-based access control.
- HTTPS/TLS enforced for all endpoints.
- Input validation and rate-limiting to prevent abuse.
- Optional audit logging for job-card changes and inventory operations.

X. CONCLUSION AND FUTURE WORK

Tragage is a modular, real-time garage management system that includes inventory, tracking, and immersive 3D visualiza- tion. The prototype has demonstrated improved transparency and operational efficiency.

Future enhancements include:

- Mobile native application and offline-first functionality..
- AI-enabled predictive maintenance and parts reorder rec- ommendation.
- Multi-garage cloud deployment with tenant isolation (SaaS).
- Integration into third-party diagnostic tools and OEM part catalogs.

Acknowledgment

We would like to express our sincere gratitude to our guide, Dr. Nithiya A., Assistant Professor, Parul University, for her invaluable guidance, constant encouragement, and continuous support throughout the course of this project. Her expertise, insightful suggestions, and constructive feedback were crucial in shaping our work and helping us overcome technical challenges at every stage of development.

We also extend our heartfelt thanks to the Department of Computer Science & Engineering, PIET, Parul University, for providing us with the necessary infrastructure, laboratory facil- ities, and resources that enabled us to successfully implement and test our system. Their academic environment and technical support have played an important role in the completion of this research work.

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