

ReCarNation: The Ultimate Platform for Buying and Selling Pre-Owned Cars

A Project Report
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ABSTRACT

The increasing demand for cost-effective transportation has pushed the growth of the pre-owned car market. This project gives a lecture by developing a safe and user-friendly web application that simplifies the process of buying and selling used vehicles. Featuring a simple interface, the platform provides secure login options, including OAuth for safe and efficient authentication.

The application offers distinct functionalities for buyers and sellers. Buyers can explore available vehicles through advanced search and filtering tools, with flexible viewing options in grid or list formats. Detailed car listings ensure well-informed purchasing decisions. Sellers benefit from an intuitive listing process to showcase their vehicles, with entries appearing in search results and their personal profiles.

A robust administrative system ensures platform integrity, enabling admins to approve or reject listings, manage user permissions, and oversee sold and unsold vehicles. The application also incorporates a price prediction tool, leveraging market trends and car specifications to help sellers determine competitive prices.

Powered by a secure backend database for storing user data, listings, and the system employs Jenkins for continuous delivery and automated testing, ensuring reliability and seamless updates. This platform aspires to revolutionize the used car market by offering transparency, efficiency and catering to the needs of buyers, sellers, and administrators.

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CHAPTER 1. INTRODUCTION

1.1 Project goals and objectives

The project aims to prioritize the process of buying and selling pre-owned vehicles through use of automation in the automotive marketplace. The main goal is to develop a practical, accessible and user centric platform that facilitates absolute communication between buyers and sellers giving a hassle - free and efficient project. The key feature of the project is to deliver a safe and secure platform that place a high priority on user safety.SSO has been integrated and offers a straightforward process while safeguarding sensitive user information and maintaining data privacy

To empower buyers, the platform includes advanced tools such as a robust search and filtering system. These features enable buyers to find vehicles that align with their preferences while providing comprehensive car details to support well-informed decision-making. The goal is to make the buying process not only easier but also more transparent and insightful.

For sellers, the project simplifies the vehicle listing process through a structured form submission system. This ensures that entering car details is straightforward and efficient. The platform also enhances visibility by showcasing listings prominently in search results and personal profiles, increasing the chances of successful sales.

Scalability and adaptability are key objectives of the project.The platform is built to scale efficiently for an expanding user base and integration for new features as needed.The advanced technologies the system offers exceptional performance and availability ensuring it adapts to change market demands.

The project is developed in response to an increased need for affordable and friendly environment features options. It takes challenges encountered by both buyers and sellers in the pre-owned vehicle market, offering a solution that is secure, efficient, and user-friendly. By prioritizing trust and convenience, the platform addresses the requirements of all stakeholders, creating a dependable and adaptable marketplace.

1.2 Problem and motivation

The growing society for eco-friendly transportation highlights the current systems for buying and selling pre-owned cars. Traditional methods such as in-person dealership visits or classified ads are often time-consuming, inconvenient. Sellers face challenges with cumbersome listing processes and a lack of tools to determine competitive pricing,

often leading to incomplete car listings that undermine trust. Additionally, administrative oversight is often insufficient, resulting in low-quality listings and unregulated user behavior. Current platforms also struggle with integrating secure and seamless authentication mechanisms, leading to privacy concerns and fragmented workflows. Scalability remains another issue, as many systems cannot adapt effectively to growing user demands, causing performance lags and unreliability.

This project is motivated by the need to transform the pre-owned car market through a transparent, efficient, reliable and trustworthy platform. By addressing the main points of traditional and existing digital systems, the aim is to simplify the car buying and selling process. The platform is designed to enhance user experience with intuitive navigation, advanced search and filtering capabilities, and comprehensive car listing details that empower buyers to make informed decisions. For sellers, providing an easy use interface and innovative tools like price prediction features to determine optimal selling prices. Administrative functionalities ensure quality control and marketplace integrity, building trust among users. Emphasis on robust security, including secure Single Sign-On (SSO) authentication, reflects the platform's commitment to user data protection. Finally, leveraging modern technologies ensures scalability, high performance, and adaptability, setting the foundation for future enhancements such as AI-driven analytics and expanded features, meeting evolving user expectations and market demands.

1.3 Project application and impact

The results of this project have significant applications and impacts across academia, industry, and society. Academically, it serves as a practical case study for integrating technologies like Django, PostgreSQL, and secure authentication systems, providing insights into user-centric design, scalable system architectures, and marketplace algorithms while inspiring further research and skill development. In the industry, the project offers a scalable solution for streamlining the used car market, benefiting buyers, sellers, and dealerships by addressing inefficiencies, incorporating advanced tools like price predictions, and ensuring secure, reliable operations, making it a model for similar e-commerce platforms. By leveraging technology to solve real-world challenges, the project not only meets current needs but also lays a foundation for future advancements in digital marketplaces.

1.4 Project results and expected deliverables

The project results consist of a fully designed and user-friendly web application designed to streamline the buying and selling of pre-owned vehicles. The core system features include secure user authentication via SSO, a comprehensive Buy and Sell interface, and

a price prediction tool for sellers. The application allows buyers to browse car listings with detailed specifications and pricing, while sellers can easily submit and manage their listings ensuring transparency and accuracy. Additionally, administrators have full control over the marketplace, including listing approvals, user management, and vehicle status monitoring.

The project deliverables include several key components: the prototype of the web application, the underlying codebase developed using Django for the backend and PostgreSQL for the database, as well as the necessary scripts for deploying and maintaining the application. Documentation has been provided to explain the system architecture, design decisions, and setup instructions. Additionally, a comprehensive report detailing the project's goals, features, challenges, and future enhancements has been included. The report covers technical aspects such as database design, security implementation, and the integration of price prediction algorithms. These deliverables offer a complete solution to the problem of inefficient car buying and selling processes while demonstrating the effectiveness of modern web technologies in creating a scalable, secure platform.

1.5 Market research

The online used car market is managed by several key players, each offering distinct solutions for buying and selling pre-owned vehicles. Carvana offers end-to-end online car purchasing with home delivery has 10% of the market share which has high operational costs as the concern and can expect delay in the delivery with 7 days return policy.

Vroom, which Specializes in reconditioning and delivering vehicles, has 8% market share and faced quality assurance challenges. In addition, Auto trader aggregates listings from dealers and private sellers which have 15% of the market share and has limited buyer - seller communication as the concern.

Finally, Shift Technologies, which holds about 5% of the market, has carved out its niche by offering unique services like home test drives. Shift allows customers to schedule test drives at their convenience, enhancing the car-buying experience. The platform also provides financing options, warranties, and detailed inspection reports for every car listed.

Company	Market Share	Key Features
Carvana	30%	360-degree viewing, home delivery
Vroom	10%	Warranty, nationwide delivery
AutoTrader	15%	Advanced filters, financing tools
CarGurus	8%	Deal ratings, pricing insights, dealer reviews
Shift	5%	Home test drives, financing, warranties

Table 1: Market Share Breakdown

CHAPTER 2. BACKGROUND AND RELATED WORK

2.1 Background and used technologies

This project was developed to meet the demand for a secure, reliable and user-friendly platform which makes it simple for buying and selling of pre-owned vehicles. The expanding of the used car market by the demand for affordable and user friendly transportation options, has exposed limitations in the present platforms . Our project addresses these issues by delivering an absolute, secure, and intuitive solution.

The platform utilizes modern web development principles to create an area where users can list and explore cars for sale. It has both front-end and back-end functionalities to ensure a well defined user experience. The front-end emphasizes a well-designed user interface and intuitive user experience to make navigation simple for all users. Meanwhile, the back-end manages critical aspects like user authentication, secure data and storage ensuring a reliable system.

The application integrates OAuth 2.0 to simplify the authentication process while enhancing security. Users can log in using their credentials from other platforms who can directly login with gmail using sign on with google. The Data Privacy and Protection which provides the security of user data and privacy is crucial.

A RDBMS, such as PostgreSQL, is used to secure data, car listings and details. correct database design ensures data consistency, integrity, and easy retrieval for both front-end and back-end processes for the project.

Technologies Used

Frontend: HTML, CSS, JavaScript, Bootstrap

Backend : Python Django

Database :PostgreSQL

Machine Learning Model: Pandas, Numpy, Matplotlib

Authentication: OAuth 2.0

Messaging: SMTP

Version Control: GitHub

CI/CD : Jenkins

2.2 State-of-the-art

The key points in the used car market are to be in favour of the new technologies to enhance user experience and the growth of transparency, and streamline the buying process. Artificial intelligence also plays a crucial role in price optimization, offering more accurate pricing models based on real-time data.

The integration of financing tools and warranties by companies like AutoTrader, and Shift provides added value for users, simplifying the decision-making process for buyers. Additionally, platforms are increasingly using machine learning and data analytics to offer insights into car valuations, help sellers optimize their pricing, and predict the future value of vehicles.

As online buying and selling continue to dominate the market, the convenience of home delivery test drives is driving demand, with companies like Carvana leading the way. These innovations are not only improving the customer experience but are also reshaping the overall used car market.

In the end, the state-of-the-art in the used car marketplace is noted by the integration of latest technologies, enhanced user interfaces, and a customer-first approach. The market is increasingly shifting towards a fully online experience, are key to gaining a competitive edge. The companies mentioned above, with their diverse features and strong market presence, are setting new standards for what consumers can expect from their used car buying and selling experiences.

RecarNation can differentiate itself in the competitive used car marketplace by combining advanced features like 360-degree car views (as seen on Carvana) with the direct buyer-seller interaction seen on platforms like Facebook Marketplace. This blend of technology and flexibility can offer users a unique experience. To build trust and transparency, RecarNation can introduce detailed, structured listings and a verification process for both sellers and vehicles, addressing concerns seen on platforms like Craigslist. Focusing on a user-friendly interface will resolve usability issues present in sites like Autotrader. RecarNation can also ensure scalability by optimizing its back-end infrastructure to handle an expanding inventory, similar to industry leaders. Finally, targeting eco-friendly and pre-owned vehicles can carve out a unique niche, attracting sustainability-conscious buyers in a growing market.

2.3 Literature survey

The literature survey explores key research and projects related to online automotive marketplaces, focusing on areas such as user behavior, trust mechanisms, scalability, and technological advancements. Existing research highlights the factors that influence user satisfaction in these platforms. For instance, a study by Doe and Smith (2020) on consumer preferences in e-commerce automotive platforms identifies transparency, ease of use, and reliability as critical elements for user satisfaction. The study emphasizes the importance of advanced search options, high-quality images, and clear pricing structures in enhancing the user experience. Similarly, Lee and Tan (2019) explored trust mechanisms in peer-to-peer car dealerships, finding that verification processes, user reviews, and secure payment gateways help build trust. Platforms like Carvana and TrueCar leverage return policies and certification programs to reduce buyer hesitation. In terms of scalability, Chen and Kumar (2021) discuss the importance of scalable backend architectures in e-commerce platforms, with cloud services such as AWS and Google Cloud being integral to managing high traffic and dynamic content delivery. Their research underscores the need for caching and database optimization to maintain performance during peak usage periods. Furthermore, Patel and Jones (2022) demonstrate how artificial intelligence tools, such as recommendation engines and predictive analytics, can personalize user experiences, tailoring suggestions based on user behavior.

In addition to academic studies, several research projects have contributed significantly to the field. One such project, developed by the MIT Media Lab, is the Next-Generation Car Marketplace (NGCM), which explored the use of blockchain technology to ensure data integrity and trust without intermediaries. The project showcased how decentralized systems could revolutionize online automotive marketplaces (Brown & Li, 2020). Another important contribution comes from the Stanford HCI Group's project on Enhancing Usability in Automotive E-Commerce. This project focused on UX strategies to simplify complex tasks like advanced search and filtering, showing that clean interfaces and guided workflows improve user retention (Wong & Zhao, 2018). Additionally, the GreenCar Initiative by the University of Cambridge aimed to promote sustainability in automotive marketplaces by encouraging the reuse and recycling of pre-owned vehicles. The project highlighted the environmental benefits and user incentives for choosing pre-owned vehicles, thus contributing to sustainable practices in online automotive sales (Taylor & Singh, 2021). These studies and projects play a significant role in advancing the understanding and development of online automotive marketplaces.

CHAPTER 3. SYSTEM REQUIREMENTS AND ANALYSIS

3.1. Domain and business Requirements

3.1.1. Domain Requirements

The domain requirements define the specific functionalities and features the system must implement to address the unique needs of the pre-owned automobile marketplace.

1. User Management:

- Implement Single Sign-On (SSO) for secure authentication.
- Allow users to create and manage profiles for buyers, sellers, and admins.
- Provide account recovery mechanisms for forgotten passwords or locked accounts.

2. Vehicle Listings:

- Enable sellers to create comprehensive listings with vehicle specifications, images, and price predictions.
- Offer intuitive tools for editing and managing listings post-creation.
- Archive expired or inactive listings automatically.

3. Search and Filtering:

- Provide advanced search options to filter vehicles by price, make, model, mileage, year..
- Allow users to save and revisit their favorite searches for convenience.

4. Communication Tools:

- Integrate secure messaging to facilitate buyer-seller negotiations.
- Enable notifications for new messages, offers, or status changes on listings.

5. Administrative Oversight:

- Implement workflows for approving or rejecting listings to maintain marketplace integrity.
- Include reporting mechanisms for resolving disputes and addressing flagged content.

6. Scalability and Performance:

- Design the platform to support rapid growth in user base and concurrent usage.
- Ensure a responsive and seamless user experience across devices.



Fig1: Process Summary Activity Diagram

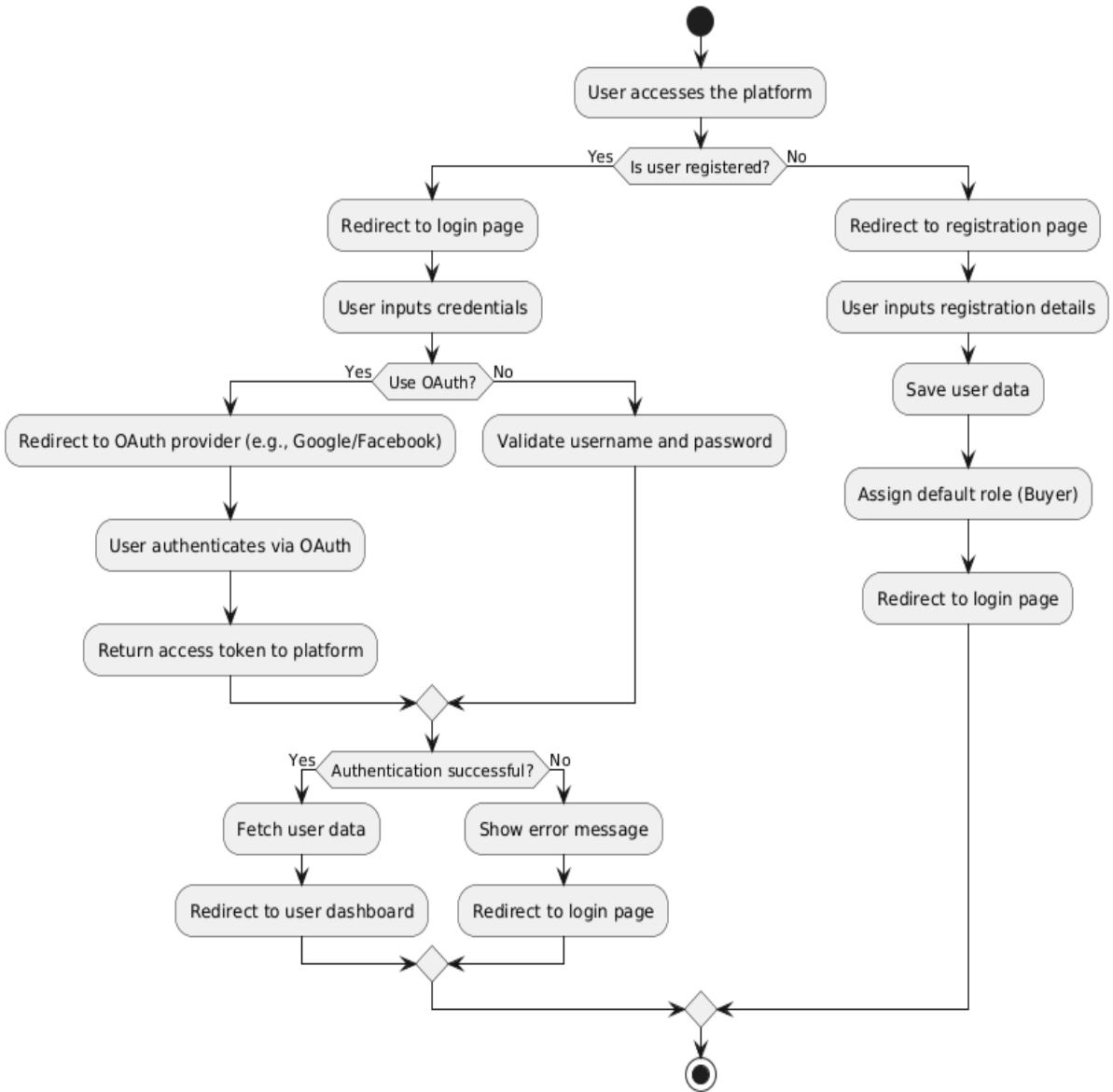


Fig 2: Activity diagram for User Registration and Login

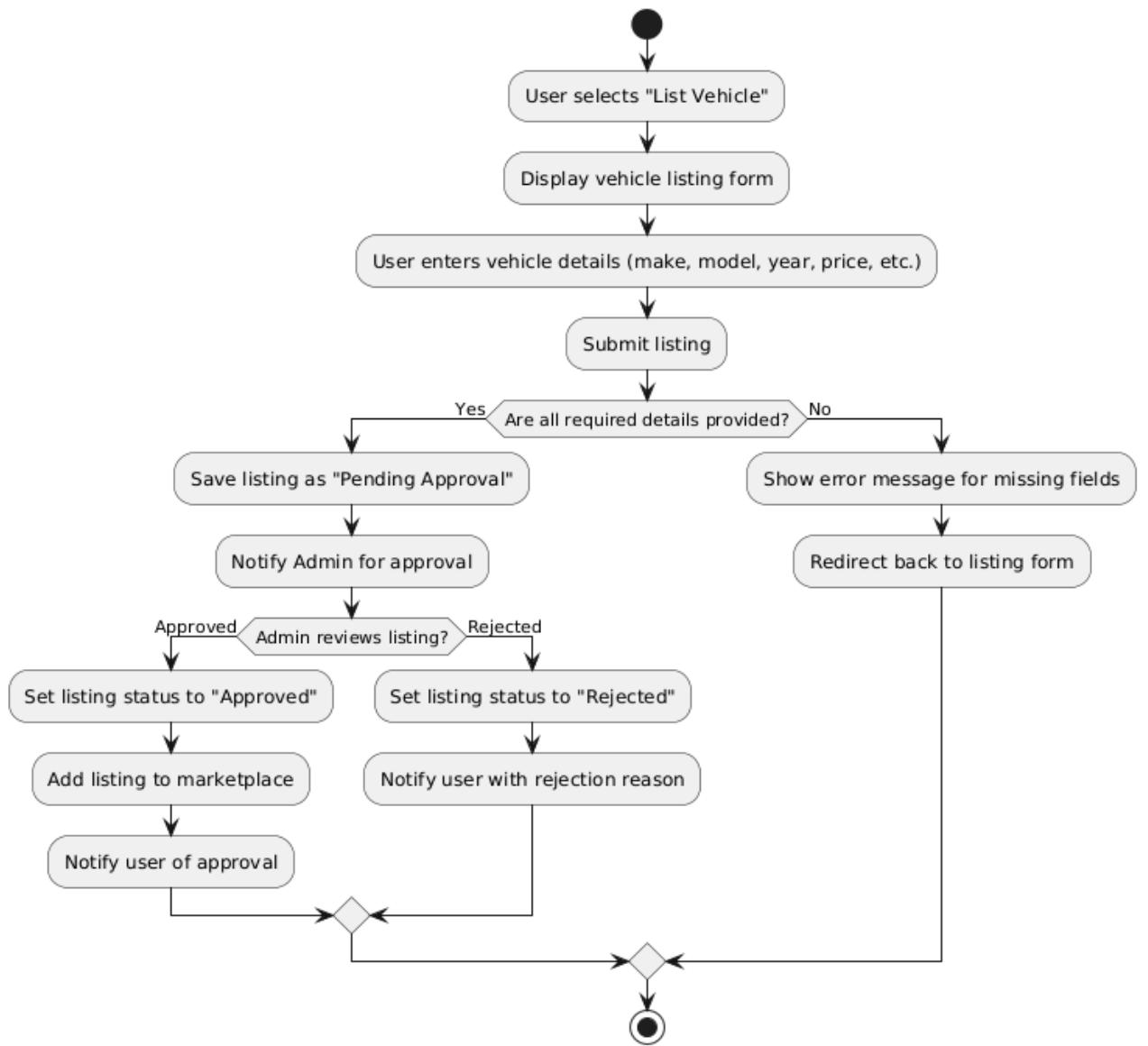


Fig 3: Activity diagram of Vehicle Listing Process

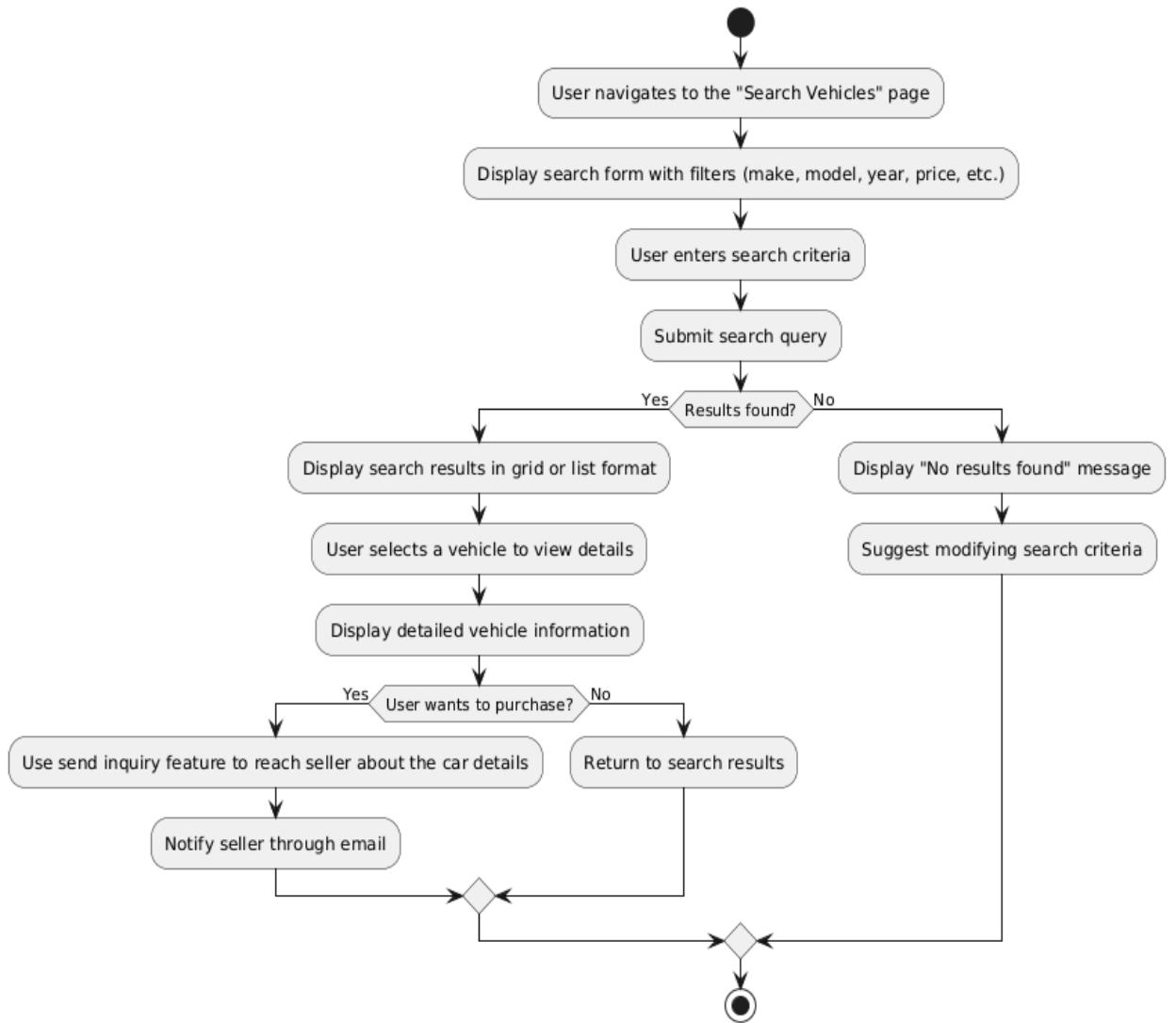


Fig 4: Activity diagram of Vehicle Search and Purchase process

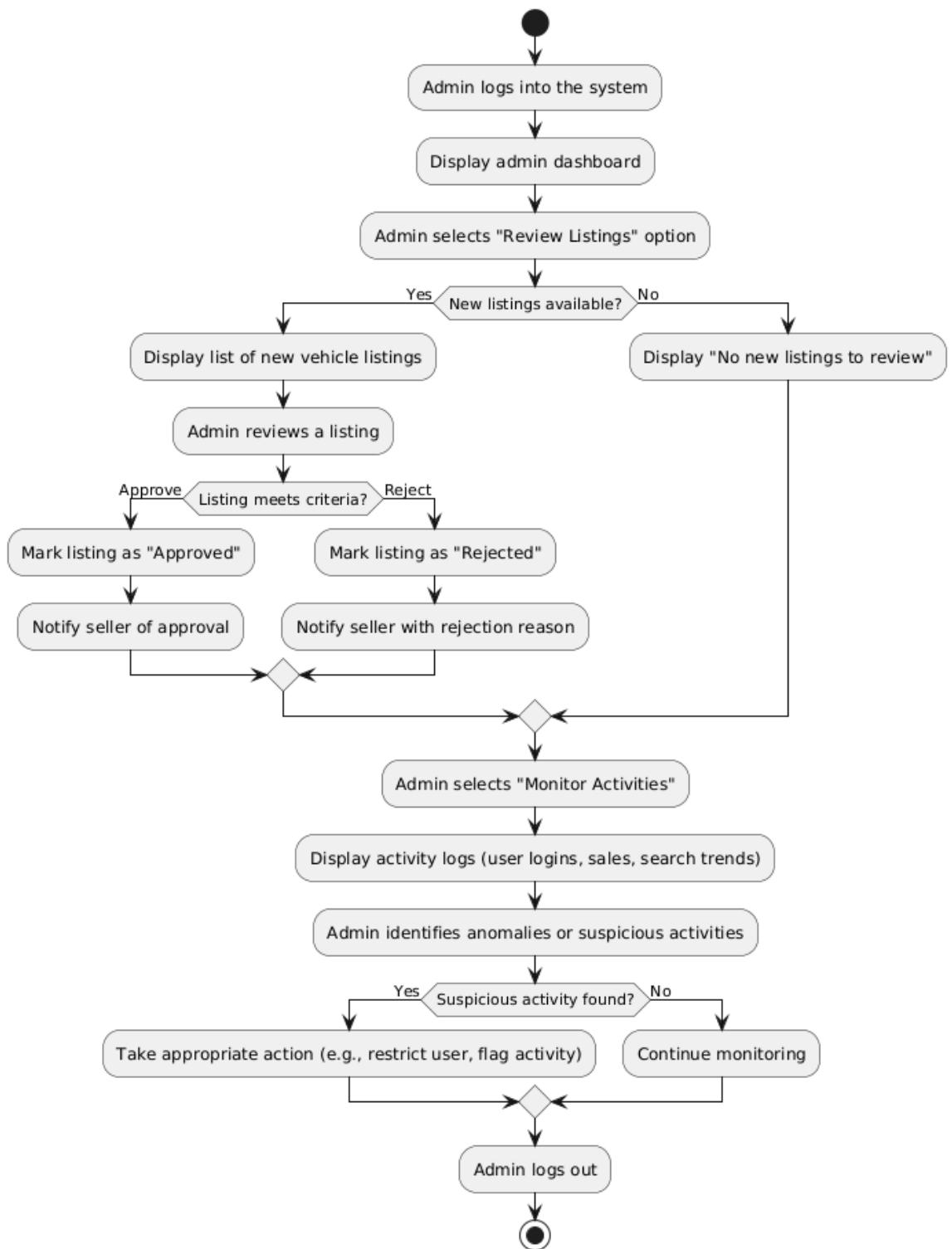


Fig 5: Activity diagram of Administrative Management

3.1.2. Business Requirements

The business requirements focus on aligning the project with the organizational objectives to achieve market success and user satisfaction.

- 1. Customer Acquisition and Retention:**
 - Simplify the registration to attract a wide user base.
 - Enhance user experience with an intuitive design and absolute navigation.
- 2. Revenue Generation:**
 - Introduce a freemium model where basic features are free.
 - Allow dealerships to advertise and promote inventory for a fee.
- 3. Trust and Transparency:**
 - Foster user trust by providing accurate car information, verified listings, and secure transactions.
 - Display price insights using historical and market trends to assist both buyers and sellers.
- 4. Compliance and Security:**
 - Ensure compliance with data protection laws like GDPR and CCPA.
 - Implement robust encryption for all user data and transactions.
- 5. Market Differentiation:**
 - Introduce innovative features like price prediction, AI-driven recommendations, and detailed car history reports.
 - Build partnerships with insurance and financing companies for added user convenience.
- 6. Scalability and Adaptability:**
 - Design a flexible architecture to accommodate future features and integrations, such as AI analytics or expanded payment options.

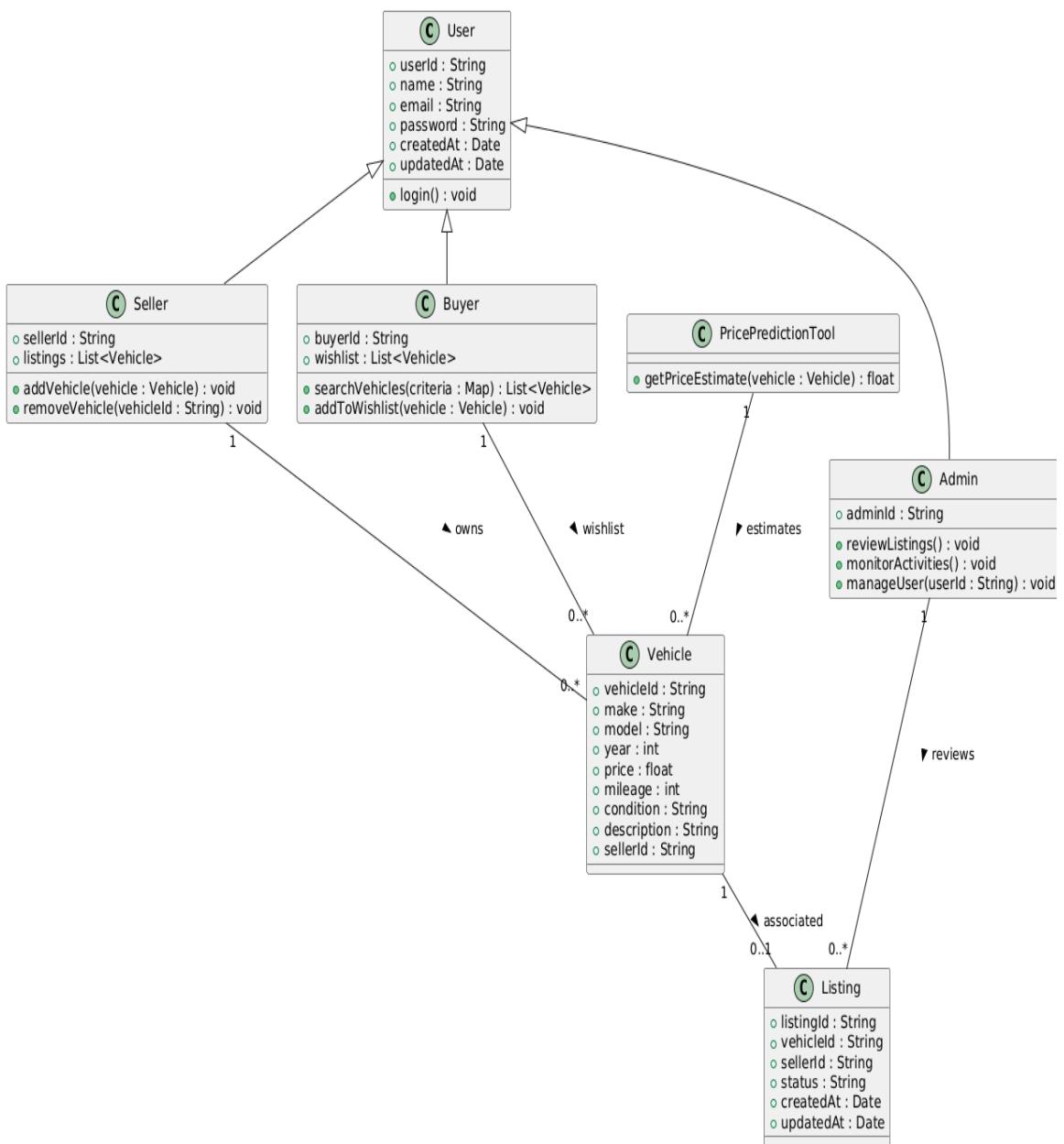


Fig 6: Class diagram

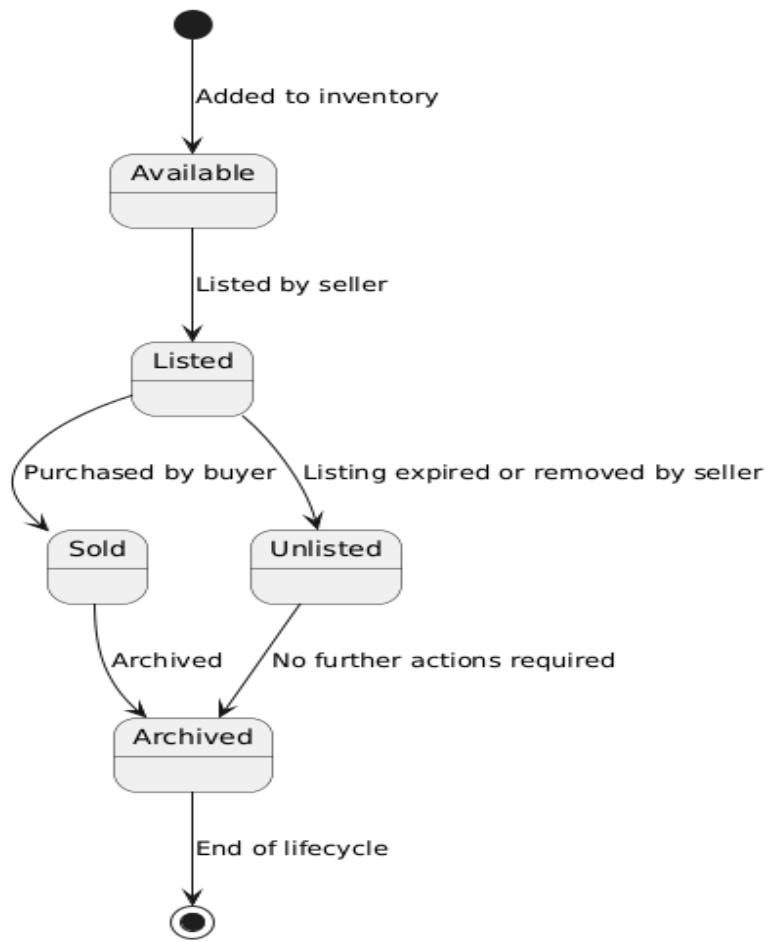


Fig 7: State Machine Diagram for vehicle

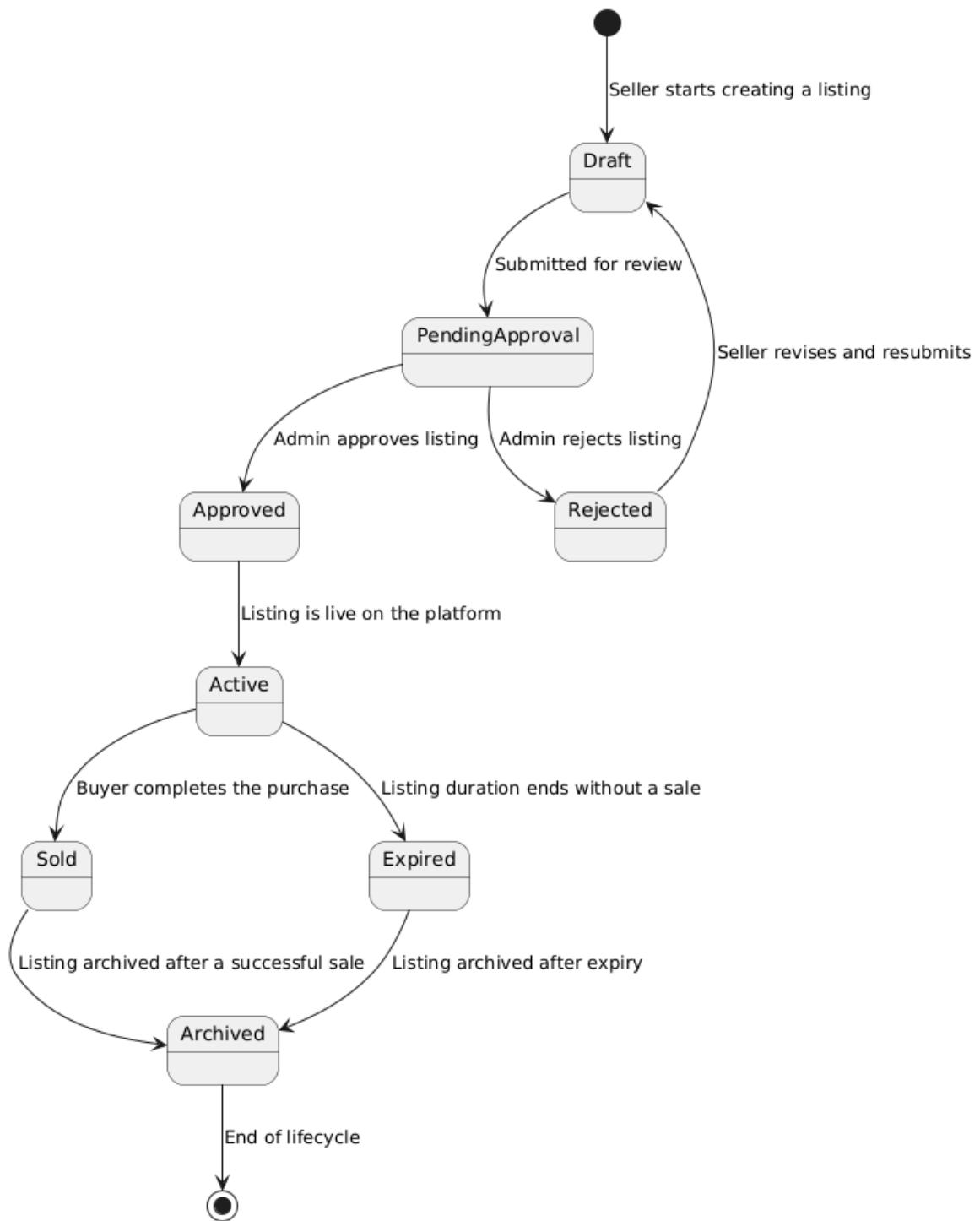


Fig 8: State Machine Diagram for Listing

3.2. Customer-oriented requirements

The customer-oriented requirements for the RecarNation project focus on identifying the primary user groups and defining their respective use cases. This section includes a textual description and a table summarizing the details.

Expected User Groups

1. Buyers:

Individuals looking to purchase used cars on the platform. They require advanced search, filtering, and communication features to evaluate and contact sellers effectively.

Buyers can filter cars by specific attributes such as make, model, year, mileage, price range, color, fuel type, transmission type, and location. This feature ensures they find vehicles tailored to their preferences.

Each car listing should include comprehensive information, such as photos, specifications, seller contact details, and inspection history.

2. Sellers:

Individuals or dealerships wishing to sell cars. They need a straightforward interface for listing their vehicles, managing existing listings, and monitoring buyer inquiries.

A step-by-step guide to list a vehicle, including fields for photos, descriptions, specifications (make, model, mileage, condition), and pricing.

A feature that provides sellers with an estimated market value of their vehicle based on data such as make, model, and condition.

3. Administrators:

Platform managers are responsible for moderating content, verifying listings, handling disputes, and ensuring smooth platform operations.

Administrators must have the ability to review and approve or reject vehicle listings based on platform guidelines.

Systems to verify the identities of sellers and validate vehicle details, ensuring authenticity and reducing fraudulent activities

User Group	Use Case	Description
BUYERS	Search for vehicles	Use advanced filters (e.g., price, brand, mileage) to find vehicles matching preferences.
	Contact sellers	Secure messaging system to negotiate pricing and finalize transactions.
	Bookmark listings	Save favorite listings for future reference.
SELLERS	List vehicles for sale	Input vehicle details, upload photos, and specify pricing.
	Manage listings	Edit, update, or delete active vehicle listings.
	Track performance	View listing views and engagement metrics.
ADMINISTRATOR	Approve/reject listings	Review vehicle details and approve or reject listings.
	User management	Manage user accounts and resolve disputes.
	System monitoring	Oversee platform performance and flag potential issues.

Table 2: User Groups and Related Use Cases

3.3. System (or component) function requirements

The functional requirements define the core system features of the RecarNation platform. These requirements outline the system's expected functionality by specifying inputs, behavior, and outputs.

Functional Requirements

1. User Authentication and Profile Management
 - o Input: User-provided credentials or Single Sign-On (SSO) details.
 - o Behavior: Validate user credentials and create/update user profiles.
 - o Output: Grant or deny access and provide personalized user dashboards.
2. Advanced Search and Filtering
 - o Input: Search queries and filter criteria such as make, model, year, and price range.
 - o Behavior: Process the query and apply filters to the database.
 - o Output: Display relevant car listings matching the search criteria.
3. Car Listing Creation and Management
 - o Input: Seller-provided details, including car specifications, condition, and images.
 - o Behavior: Validate and store the submitted data in the system.
 - o Output: Publish the listing or return errors for corrections.
4. Buyer-Seller Communication
 - o Input: Messages sent by buyers or sellers via the platform.
 - o Behavior: Facilitate direct and secure communication between users.
 - o Output: Deliver messages and maintain a chat history for reference.
5. Content Moderation
 - o Input: Car listings and reports submitted by users.
 - o Behavior: Review and approve listings or take actions on reported issues.
 - o Output: Approved, flagged, or removed listings.
6. Transaction Support
 - o Input: Buyer and seller agreement to proceed with a transaction.
 - o Behavior: Generate transaction details and maintain a record of the transaction.
 - o Output: Confirm transaction completion and update car listing status.

FEATURE	INPUTS	BEHAVIOR	OUTPUTS
User Authentication	Login credentials, SSO token	Verify user identity and provide access.	User is logged in and redirected to dashboard.
Vehicle Search and Filter	Search query, filter criteria	Search database for matching vehicles.	List of vehicles meeting criteria.
Create Listings	Vehicle details, images	Validate and store listing information in the database.	Confirmation of successful listing.
Messaging System	Message content, recipient details	Send and display messages between users.	Notification of sent/received messages.

Table 3: Functional Requirements table

3.4. System performance and non-functional requirements

This section defines the key performance and nonfunctional requirements for the RecarNation project. Non-functional requirements refer to the system overall characteristics, ensuring the system operates optimally, securely, and in compliance with standards.

Performance Requirements

1. System Response Time
 - o Requirement: The system should respond to user actions, such as searching or submitting forms, within 2 seconds under normal load conditions.
 - o Description: Ensuring fast and responsive interactions will improve user experience.
2. System Throughput
 - o Requirement: The system should be able to handle at least hundred concurrent users performing operations like browsing, searching, messaging, etc.
 - o Description: The system should support a minimum of 100 users concurrently without significant performance disturbance.

3. Database Query Performance
 - o Requirement: Database queries should return results within 1 second for searches or car listings, and 3 seconds for more complex queries.
 - o Description: Optimized database queries will improve the speed of fetching listings, performing advanced searches, and displaying detailed pages.

Capacity Requirements

1. Scalability
 - o Requirement: The system should scale horizontally to accommodate an increasing number of users.
 - o Description: The system must be capable of scaling out to support higher demand during peak times.
2. Data Storage Capacity
 - o Requirement: The system should support up to 10TB of user and transaction data.
 - o Description: The database should be able to accommodate a growing volume of user profiles, car listings, and transaction records.

Availability Requirements

1. Uptime
 - o Requirement: The system should have an availability of 99.9% uptime per month, allowing for maintenance windows.
 - o Description: The platform should be reliably available for users, with minimal downtime for updates or maintenance.
2. Disaster Recovery
 - o Requirement: The system should have automatic backups with a recovery time objective (RTO) of 1 hour and a recovery point objective (RPO) of 15 minutes.
 - o Description: In case of failure, the system should be able to recover quickly with minimal data loss.

Compliance to Standards

1. Legal and Regulatory Compliance
 - o Requirement: The system should comply with applicable data protection laws when handling personal user information.
 - o Description: Personal data should be processed in accordance with industry regulations to ensure user privacy and security.
2. Accessibility Compliance
 - o Requirement: The system should be comfortable with WCAG 2.1 accessibility standards for users with disabilities.

- o Description: The platform should be usable by people with various disabilities, providing features like keyboard navigation, screen reader support, and color contrast adjustments.

Security Requirements

1. Data Encryption
 - o Requirement: All sensitive data, including user passwords, and personal details, should be encrypted.
 - o Description: Encryption of sensitive information ensures that even if data is intercepted, it remains unreadable where as secure..
2. Secure Authentication
 - o Requirement: The system should implement multi-factor authentication for users logging in to their profiles.
 - o Description: Adding an extra layer of security makes unauthorized users cannot access accounts even if they know the password.
3. Security Auditing and Logging
 - o Requirement: The system must maintain audit trail of key actions such as logins, and updates.
 - o Description: Logging and auditing are important for identifying and investigating any unauthorized access.

REQUIREMENT TYPE	REQUIREMENT DESCRIPTION	PRIORITY	MEASUREMENT
System Response Time	User actions, including searching and form submissions, should complete within 2 seconds.	High	< 2 seconds for 95% of operations
System Throughput	Support up to 100 concurrent users performing operations like browsing and messaging.	High	< 100 users simultaneously without significant lag
Database Query Performance	Query results for listings and search actions should return within 1 second.	High	< 1 second for most queries
Scalability	Must support scaling to handle up to 10,000 active users concurrently.	High	Horizontal scaling for large numbers of users
Data Storage Capacity	Database should handle up to 10TB of data.	Medium	Scalable storage for user data and transactions
Uptime	The system should be available 99.9% of the time.	High	99.9% availability per month
Disaster Recovery	RTO of 1 hour, RPO of 15 minutes.	High	System restores with minimal data loss
Legal Compliance	Must comply with GDPR or CCPA regulations for user privacy.	High	Regular compliance checks

Accessibility Compliance	Compliant with WCAG 2.1 standards to ensure usability for users with disabilities.	Medium	Accessibility testing and audit
Data Encryption	Encrypt sensitive data with AES-256 to protect user and transaction information.	High	AES-256 encryption for sensitive data
Secure Authentication	Implement multi-factor authentication for user login.	High	MFA implementation

Table 4: Non Functional Requirements table

3.5. System behavior requirements

System behavior requirements describe how the system should respond to various inputs and states over time. These behaviors are important for understanding the sequence of actions that the system must follow in different scenarios.

In this section, we will use UML state diagrams to visually represent the system's behavior. These diagrams will focus on key processes such as user authentication, car listing creation, and the transaction process.

Key System Behaviors and State Transitions

1. User Authentication Behavior

o State Description:

- Initial State: The user is on the login page.
- Logged Out: The user is not authenticated and must log in to proceed.
- Logged In: After a successful login, the user is authenticated and redirected to their profile or homepage.
- Failed Login: If the login credentials are incorrect, the system transitions to this state to prompt the user to try again.

o State Transitions:

- From Logged Out to Logged In: When the user enters valid credentials or uses Single Sign-On (SSO).
- From Logged Out to Failed Login: If the login credentials are invalid.
- From Failed Login to Logged Out: After the user corrects credentials and tries again.

2. Car Listing Creation Behavior

o State Description:

- Initial State: The seller is on the "Create Listing" page.
- Draft State: The user has filled out the car details but has not yet submitted the listing.
- Submitted State: The car listing has been submitted successfully.
- Approval Pending: The listing is awaiting admin approval (if applicable).
- Active Listing: The listing is live and visible to buyers.
- Deactivated Listing: If the seller decides to remove the listing or if it is flagged by an admin.

o State Transitions:

- From Initial State to Draft State: When the seller begins entering car details.
- From Draft State to Submitted State: Once the seller submits the listing.
- From Submitted State to Approval Pending: If the listing requires admin review.
- From Approval Pending to Active Listing: If the listing is approved.
- From Active Listing to Deactivated Listing: If the seller removes or deactivates the listing.

3. Transaction Behavior

o State Description:

- Initial State: Buyer views the car details.
- Transaction Started: The buyer expresses interest and agrees to the transaction terms.
- Transaction Pending: The system processes the transaction, verifies details, and finalizes the agreement.
- Transaction Complete: The transaction is confirmed, and both the buyer and seller are notified.

- Transaction Cancelled: Either party can cancel the transaction before completion.
- o State Transitions:
 - From Initial State to Transaction Started: When the buyer expresses interest in the car.
 - From Transaction Started to Transaction Pending: When the buyer and seller agree to the terms.
 - From Transaction Pending to Transaction Complete: Once the transaction is successfully processed.
 - From Transaction Started to Transaction Cancelled: If either the buyer or seller cancels the transaction.

State	Trigger	Next State	Action/Description
Logged Out	User enters credentials	Logged In	Validate login and grant access to dashboard or homepage.
Logged In	User logs out	Logged Out	End session and prompt user to log in again.
Failed Login	User enters incorrect credentials	Logged Out	Display error message and prompt user to try again.
Logged In	User navigates away or logs out	Logged Out	End session and log out user.

Table 5: State Diagram Table for User Authentication

State	Trigger	Next State	Action/Description
Initial	User fills out car listing details	Draft State	Car details are entered but not yet submitted.
Draft State	User submits car listing	Submitted State	Validate and store car listing.
Submitted State	Admin reviews listing	Approval Pending	The listing is waiting for admin approval.
Approval Pending	Admin approves listing	Active Listing	Listing is visible to buyers.
Active Listing	Seller or admin deactivates listing	Deactivated Listing	Remove or deactivate the listing.

Table 6: State Diagram Table for Car Listing Creation

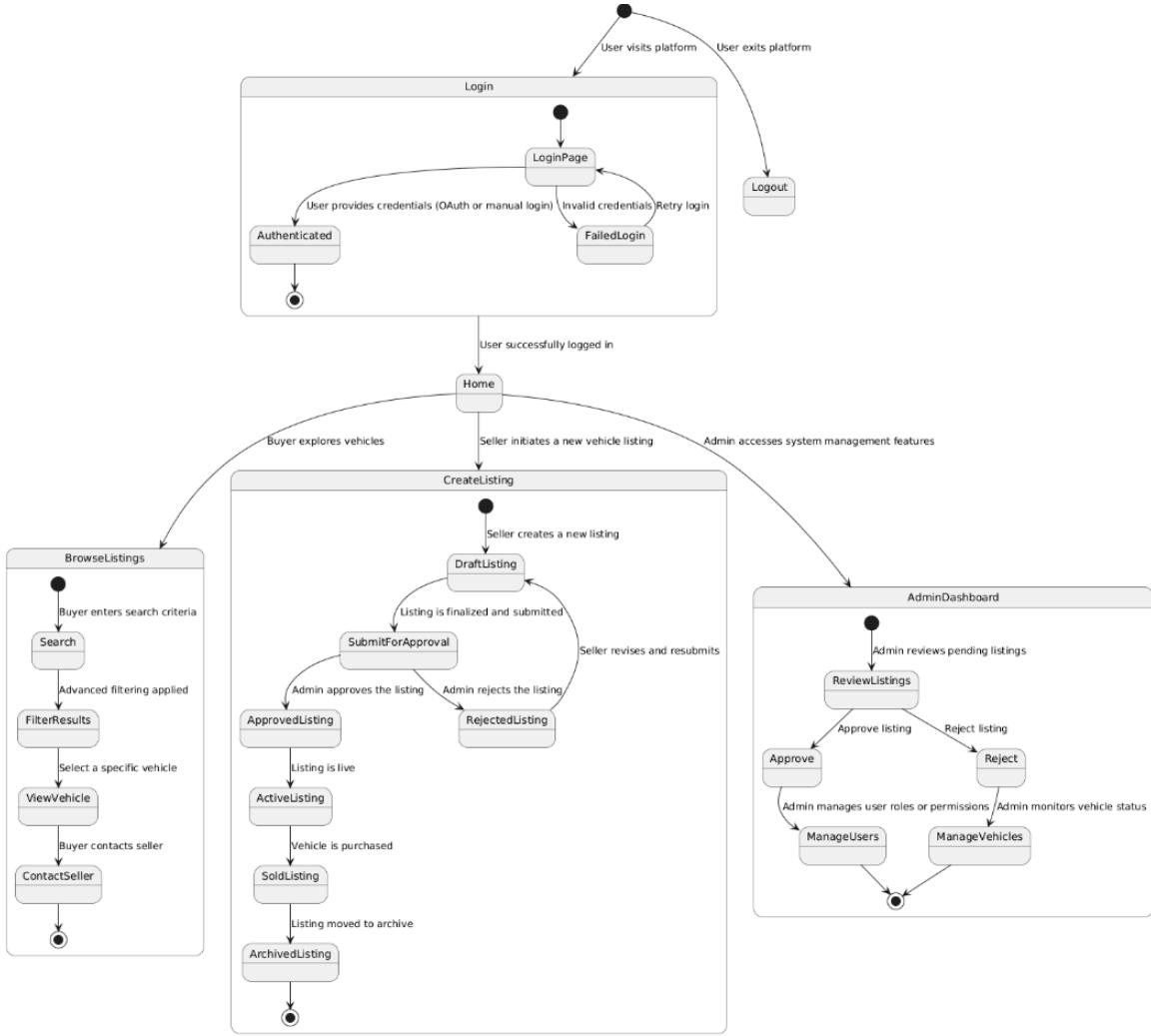


Fig 9 : state diagram for system-level behaviors

3.6. Context and interface requirements

This section specifies the environments and systems necessary to support the development, testing, and deployment of the RecarNation project. Additionally, it covers the system interface requirements, including the user interface structure and design.

Context Environment Requirements

The RecarNation project requires specific environments and tools to function effectively during development, testing, and deployment. These environments include both software and hardware configurations required to run the project successfully.

1. Development Environment

- Software:

- Backend Framework: Django (Python-based)

- Frontend Framework: HTML5 with CSS for basic structures

- Database: PostgreSQL (used for storing user data, car listings, transactions, etc.)

- Version Control: Git (GitHub repository for collaboration and source control)

- Integrated Development Environment (IDE): Visual Studio Code, PyCharm, or IntelliJ IDEA

- Python Version: 3.8 or above

- Hardware:

- Local Development Machine: A MacBook, Windows, or Linux machine with sufficient RAM (8GB or more) and CPU power (minimum 2 cores).

2. Testing Environment

- Software:

- Testing Frameworks:

- Backend Testing: Pytest or Django's built-in testing tools for unit and integration testing.
 - Frontend Testing: Selenium for testing components and interactions.

- Continuous Integration (CI)/Continuous Deployment (CD): GitHub Actions Jenkins for automating testing and deployment.

- Load Testing Tools: Apache JMeter or Locust for load and performance testing.

- Hardware:

- Test Servers: Staging servers replicating production environments where automated and manual tests are conducted.

3. Deployment Environment

- Web Server: Django web server for deploying.
- Database Service: PostgreSQL running on Django framework.

System Interface Requirements

This section describes the system interfaces required to interact with external systems and the interface requirements for internal components (such as database, authentication service, etc.).

1. User Interface (UI) Requirements

The RecarNation platform's user interface is designed to provide an intuitive experience for both buyers and sellers. The UI is optimized for simplicity and responsiveness, ensuring accessibility across various devices, including desktop and mobile platforms.

Key UI Features:

1. Homepage Layout

- Components:
 - Navigation Bar: Links to "Home," "Buy Cars," "Sell Cars," "Login/Signup," and "Contact Us."
 - Search Bar: For searching cars based on make, model, price range, and other filters.
 - Car Categories Section: Display categories like "Sedans," "SUVs," and "Trucks."
 - Featured Listings: A section showcasing popular or featured cars.
- User Flow:
 - Users can view the homepage, search for cars, or navigate to specific car listings.

2. Buy Page

- Components:
 - Filter Sidebar: Filters for price, make, model, year, mileage, etc.
 - Car Listings Grid: A grid or list view to display cars based on search criteria.
 - Pagination: For browsing large numbers of listings.
- User Flow:
 - Users can refine their search and view car details by clicking on individual listings.

3. Sell Page

- Components:
 - Car Details Form: Sellers can enter car details such as make, model, year, price, and mileage.

Submit Button: To submit the listing for review and approval.

- User Flow:

Sellers fill in car details and submit the listing, which will be displayed after admin approval.

4. Login/Signup Pages

- Components:

SSO (Single Sign-On): Integration with Google or Facebook for easier login.

User Credentials Form: For users to enter username and password for traditional login.

Error Message: If login fails, display an appropriate error message.

- User Flow:

New users can sign up, and existing users can log in to access their profiles.

5. Car Detail Page

- Components:

Car Specifications: Showcasing detailed information like make, model, year, mileage, price, and condition.

Seller Contact Info: Information about the seller for direct messaging or calls.

- User Flow:

Buyers can review the car details and decide whether to make a purchase.

6. Price Prediction page

- Components:

Car Details Form: Sellers can enter car details such as make, model, year, price, and mileage.

- Submit Button: To submit the listing for review and approval.

- User Flow:

Buyers/Sellers can review the predicted price and decide whether to make a purchase.

Page	Description	Components	User Action
Homepage	Displays general information, featured cars, and search bar for buyers.	Navigation, Search Bar, Featured Listings	View cars, search cars, navigate to other pages.
Buy Page	Allows users to browse cars based on filters.	Car Grid/List, Filter Sidebar, Pagination	Filter and view cars, click for details.
Sell Page	Sellers can submit their car listings.	Form for Car Details, Submit Button	Fill details and submit listings.
Login	For user authentication through SSO or credentials.	Login Form, SSO Buttons, Error Message	Login or sign up, retry on failure.
Car Detail Page	Provides detailed information on a specific car listing.	Car Specs, Contact Info, Image Gallery	View details, contact the seller, or initiate purchase.
Price Predictor Page	Provides the predicted price of the car details provided.	Form for Car Details, Submit Button	Fill details and submit listings.

Table 7 : Interface design table

3. External System Interfaces.

- Third-Party Authentication:
 - System: Google OAuth Login for Single Sign-On (SSO).
 - Data Flow: The system communicates with Google/Facebook to verify the user's identity, enabling smooth login/signup processes.
- Email and SMS Notification Service:
 - System: SMTP for sending email notifications.

3.7 Technology and resource requirements

This section outlines the technologies and resources necessary to develop, test, deploy, and maintain the RecarNation project. The requirements are classified into various categories to provide a clear understanding of the tools, platforms, and resources utilized.

1. Software Requirements

The following software tools and platforms are necessary for the development and operation of the RecarNation application:

Development Frameworks and Tools

- Backend Framework: Django (Python-based)
 - Handles business logic, database interactions, and APIs.
- Frontend Framework: Plain HTML/CSS (depending on implementation)
 - Enables a responsive and dynamic user interface.
- Database Management System (DBMS): PostgreSQL
 - Stores user accounts, car listings, and transaction data securely.
- Authentication Service: OAuth 2.0 (via Google SSO)
 - Provides secure and seamless login/signup processes.
- API Tools: Django Rest Framework (DRF)
 - Allows interaction between the frontend and backend.
- Version Control System: Git
 - Tracks code changes and supports collaboration.
- Package Managers:
 - Python: pip (for managing Python dependencies)

Testing Tools

- Unit Testing: Pytest, Django's built-in testing framework
- Integration Testing: Postman API testing
- Performance Testing: Apache JMeter or Locust
- UI Testing: Selenium

Deployment Tools

- Hosting Platform:
Web Servers: Django

2. Hardware Requirements

Development Machines

- Minimum Specifications:
 - CPU: Quad-core processor
 - RAM: 8GB
 - Storage: 256GB SSD
 - OS: macOS or Windows

Local Testing Machines:

- Devices for testing UI compatibility:
 - Desktop: Windows and macOS

4. Resource Requirements

Third-party Services

- Notification Service: SMTP (email notifications).

CHAPTER 4. SYSTEM DESIGN

4.1 System architecture design

The architecture of the used car marketplace web application is designed to be scalable, secure, and efficient. It involves multiple components that interact with each other to deliver a smooth user experience. Below is a breakdown of the system architecture and the relationships between various components:

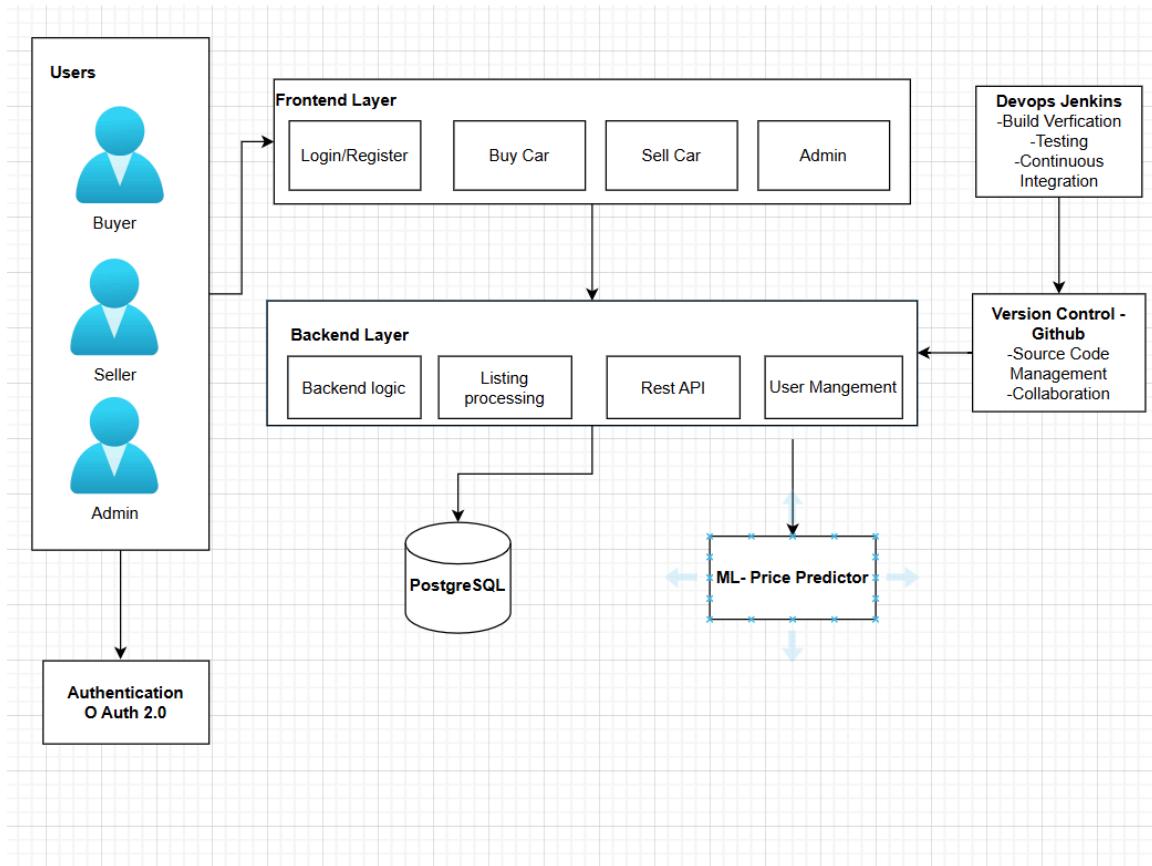


Fig 10 : System Architecture Diagram

Client-Side (Frontend)

Web Interface application is developed using modern web technologies Javascript, HTML, CSS and bootstrap to provide an interactive, friendly experience for buyers, sellers, and administrators. The frontend integrates with OAuth for secure user login and registration, enabling users to authenticate using their email credentials. Buyers can filter and search

for cars, view car details, and interact with the price prediction feature. Sellers can submit car listings and manage their profiles. Admins can access the admin panel to manage users and listings.

Application Layer (Backend)

The backend is powered by Django web server. It serves as the intermediary between the frontend and the database. This layer handles all the core functionalities of the platform, such as:

- Car listing management (adding, updating, and deleting listings)
- Price prediction algorithm (analyzes market data and car attributes to predict optimal pricing)
- User management (authentication, permissions, and user profiles)
- Administrative tasks (approving/rejecting listings, managing user access)

RESTful APIs endpoints are exposed to interact with the frontend and allow data exchange between the client-side and the backend.

Database Layer

The application uses PostgreSQL, a relational database to store data about users, car listings, transaction history, and other related data. Sensitive data such as user credentials, transaction details, and car specifications are encrypted and stored securely. A secure database connection with encryption in transit ensures that user data is kept private. The database maintains data integrity with constraints (e.g., foreign keys) and ensures consistency across transactions.

Price Prediction Engine

The price prediction feature leverages linear regression machine learning model to analyze historical pricing data, car specifications (e.g., make, model, year, mileage), and current market trends to provide an estimated price for the vehicle. This component is integrated into the backend, where it fetches car attributes from the database and returns a recommended price that is displayed to the seller.

Admin Panel

This is a secured interface that allows administrators to manage users, approve/reject car listings, and monitor the overall health and performance of the platform. Admins have full access to manage user accounts, monitor listing quality, and remove inappropriate content.

Third-Party Integrations

OAuth authentication can be integrated with social media platforms Google to ease the login process for users.

Continuous Integration and Delivery (CI/CD)

Jenkins is used for continuous integration Jenkins automates the process of integrating code changes into the shared repository. It ensures that code is compiled, built, and deployed to production seamlessly after each update, providing a more efficient and streamlined deployment process.

4.2 System data and database design

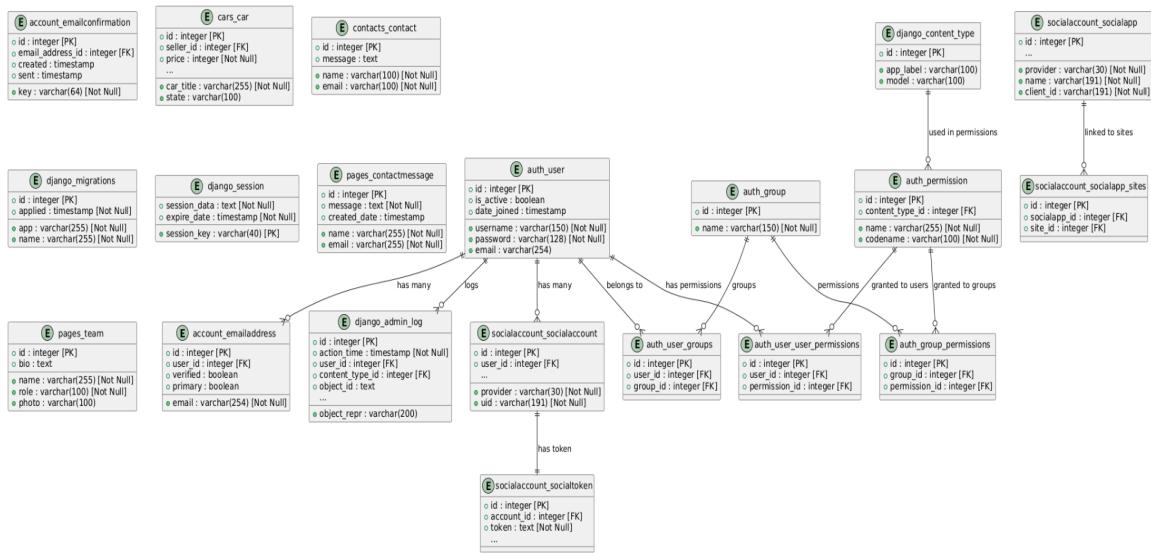


Fig 11: ER Diagram for the system data and database

The cardealer_db database is designed to support a car dealership platform by organizing user accounts, car listings, contact management, and social account integrations. Its modular structure ensures logical separation of responsibilities. Authentication and authorization functionalities are managed through tables like auth_user, auth_group, and auth_permission, which also facilitate role-based access control. Car listings are central to the database, with the cars_car table capturing essential details such as car title, price, model, year, and seller information. Optional multimedia fields for photos allow the

inclusion of rich content for each listing. Contact management is handled through contacts_contact and pages_contactmessage tables, which store inquiries and messages sent by users, enabling communication between buyers and sellers. Social account integration tables under the socialaccount prefix provide modern login mechanisms, supporting third-party logins from platforms like Google.

The database design is normalized to eliminate redundancy and ensure data consistency. For instance, user details are centralized in the auth_user table and referenced across related tables like account_emailaddress and socialaccount_socialaccount. Similarly, permissions and roles are structured into dedicated tables (auth_permission, auth_group) and linked through many-to-many relationships for flexible role management. Relationships between entities are clearly defined, such as the one-to-many relationship where a user can own multiple cars, or the many-to-many relationship between users and groups for role assignments.

This design is highly scalable, allowing the system to handle increasing data volumes efficiently. It supports multiple car listings per seller, manages growing contact inquiries independently, and integrates seamlessly with third-party login providers. By organizing data into distinct modules, the database ensures ease of maintenance, consistency, and adaptability for future requirements, making it well-suited for the demands of a modern online car dealership platform.

4.3 System interface and connectivity design

a) the external interfaces to third-party systems/components, and system user interfaces

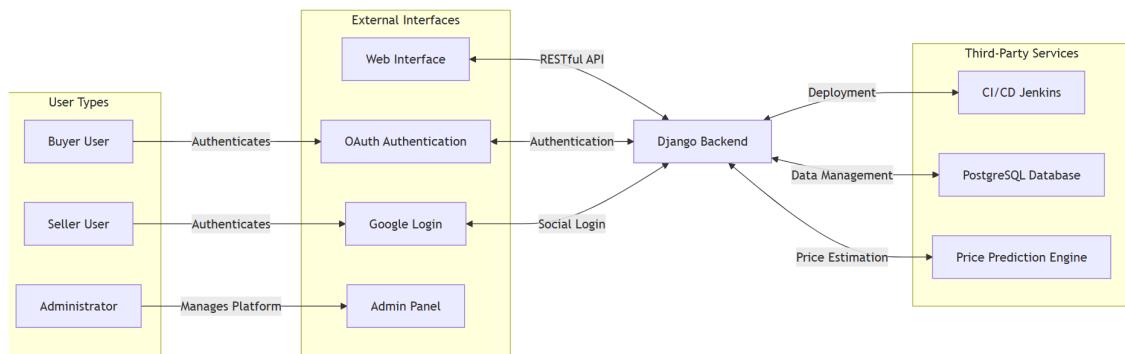


Fig 12: External interfaces and System User Interfaces

b) System connectivity protocols.

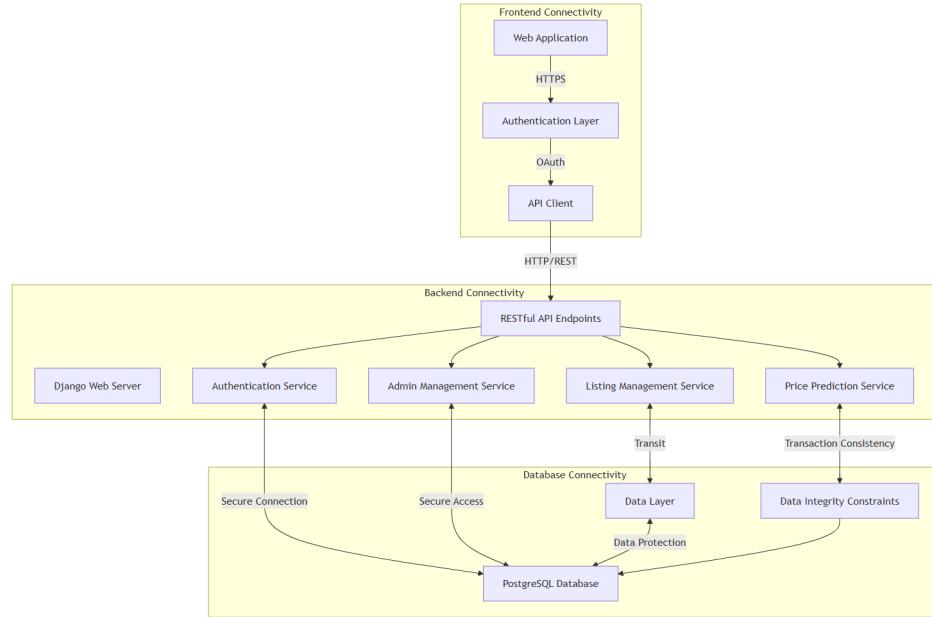


Fig 13: System Connectivity Protocol

Component Connectivity and Flow

- User Access:** Users interact with the frontend interface, which communicates with the backend through RESTful APIs. The frontend sends requests for car listings, user data, and transaction details, while the backend processes these requests, interacts with the database, and returns appropriate responses.
- Authentication:** The authentication process involves the frontend sending authentication requests to the backend, which verifies credentials using OAuth and issues a secure token for session management.
- Price Prediction:** When a seller submits a listing, the backend triggers the price prediction engine to provide an estimated selling price, which is then displayed to the seller.
- Admin Controls:** Admins interact with the admin panel to review and manage users and listings. The admin interface communicates directly with the backend to retrieve and update data.

4.4 System user interface design

This section includes the initial draft of the intended user interface (UI) for the system, which has been designed to be simple and efficient, yet user friendly. The objective here is to present an essential navigational platform for buyers and sellers and administrators alike in their efforts to provide a smooth, clean, and easily accessible site.

Graphical User Interface (GUI) Structure

The platform comprises such important pages designed and tailored to the different specific requirements:

- **Landing Page**

The landing page puts login and signup on the front screen.

- **Dashboard**

The dashboard now personalizes itself as a buyer, seller, administrator, and notification for important actions, plus quick-link features with a user-by-user perspective.

- **Vehicle Listings Page**

Buyers can browse cars in grid or list view, and they can also make use of the advanced filters based on the price, model, mileage, and year attributes, as well as sorting mechanisms attached to it, to make searching a lot easier.

- **Create a Listing**

A simple step-by-step process will be followed for sellers to create a listing for their vehicle. They are expected to put in their car specifications, upload images alongside it, and even offer pricing suggestions to make a competitive listing.

- **Admin Control Panel**

An admin panel where all management of roles given to users with reviewing and approving or rejecting listings of vehicles can be expressed to oversee all activities on the platform.

Operation Flow

In fact, the interaction flow is designed to be simple and efficient for every category of users:

- **Buyers**

Start with logging in.

Browse vehicle listings using search and filtering tools.

View and access information regarding selected vehicles.

- **Sellers**

Login to access the dashboard

Commences with creating a vehicle listing entry

Posted for admin approval once completed

Check the status of the listing and edit if necessary

- **Administrators**

Log in to visit the control panel.

Checks all pending listings and either approves or disapproves it.

Manages user rights and ensures healthy operation of the platform.

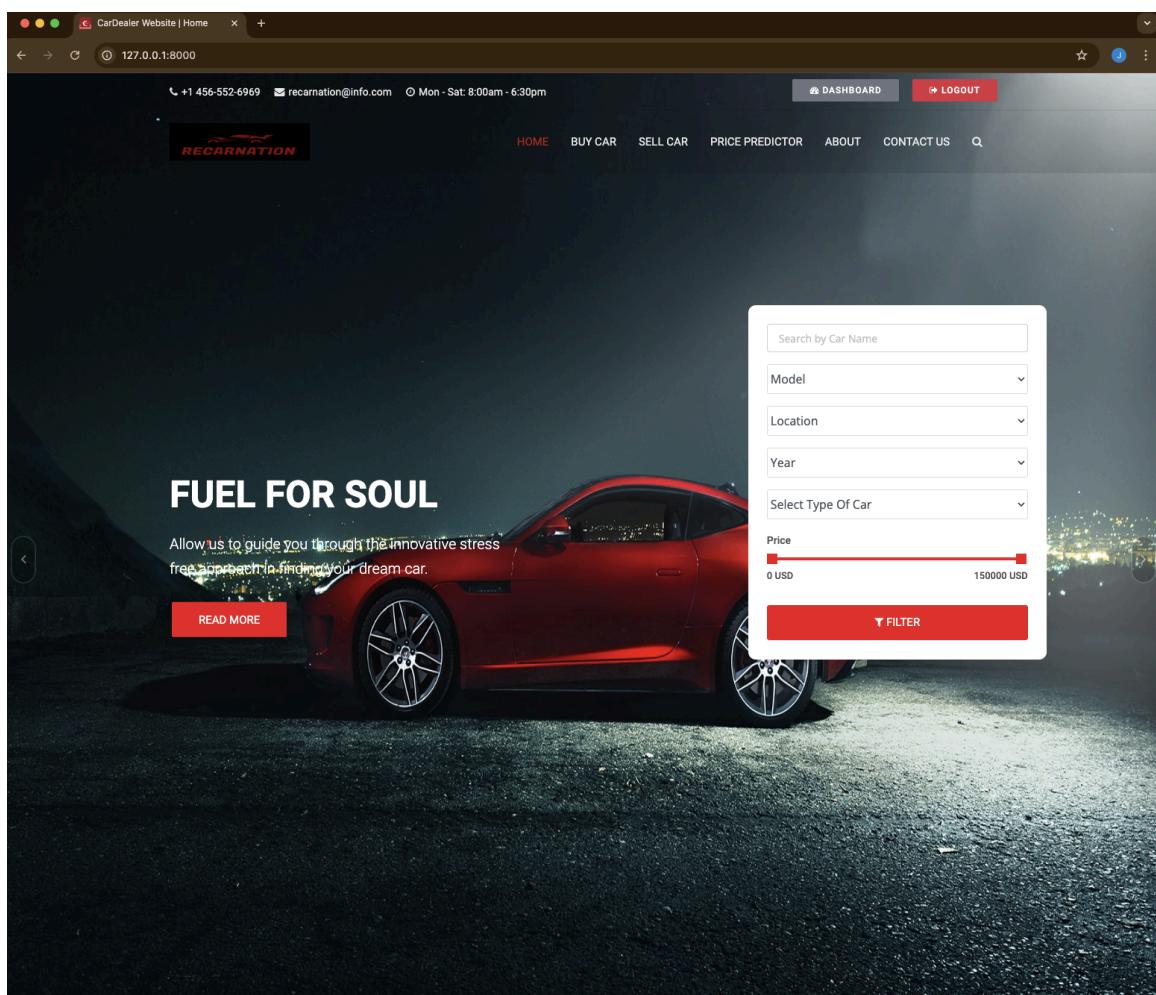


Figure 14: Home Page

Figure15: Register Page

Figure16: Login Page

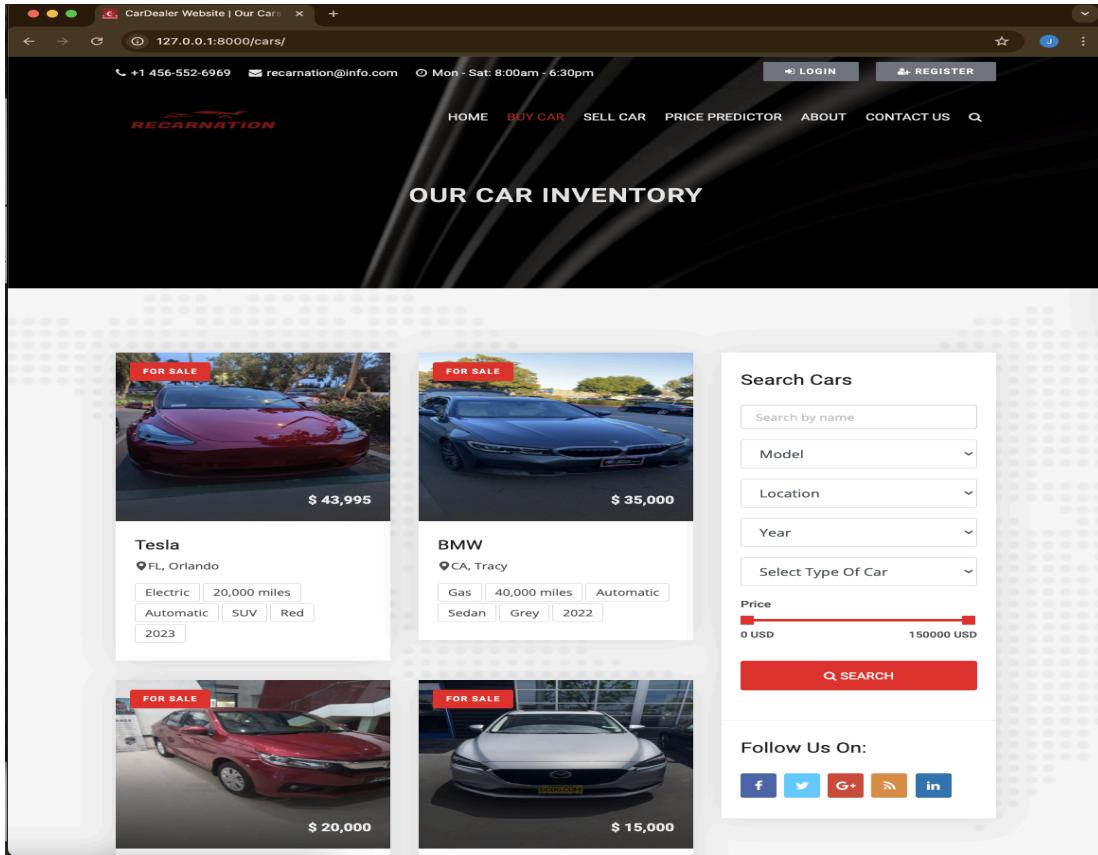


Figure 17: Buy Car Page

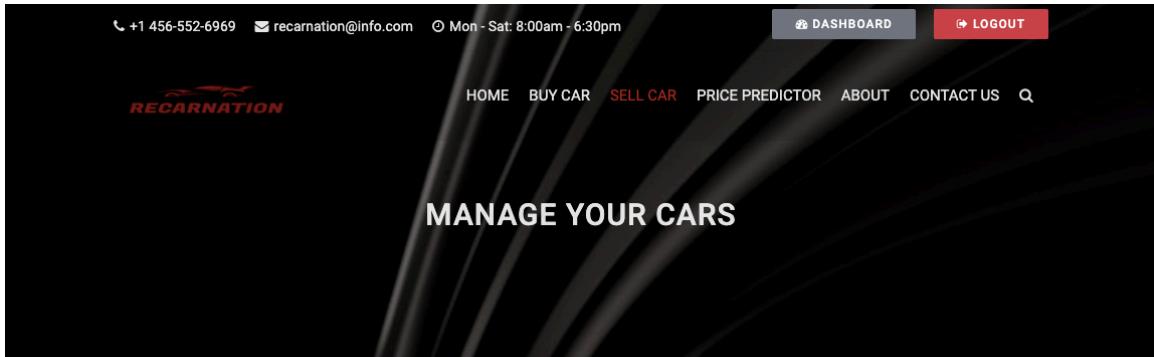
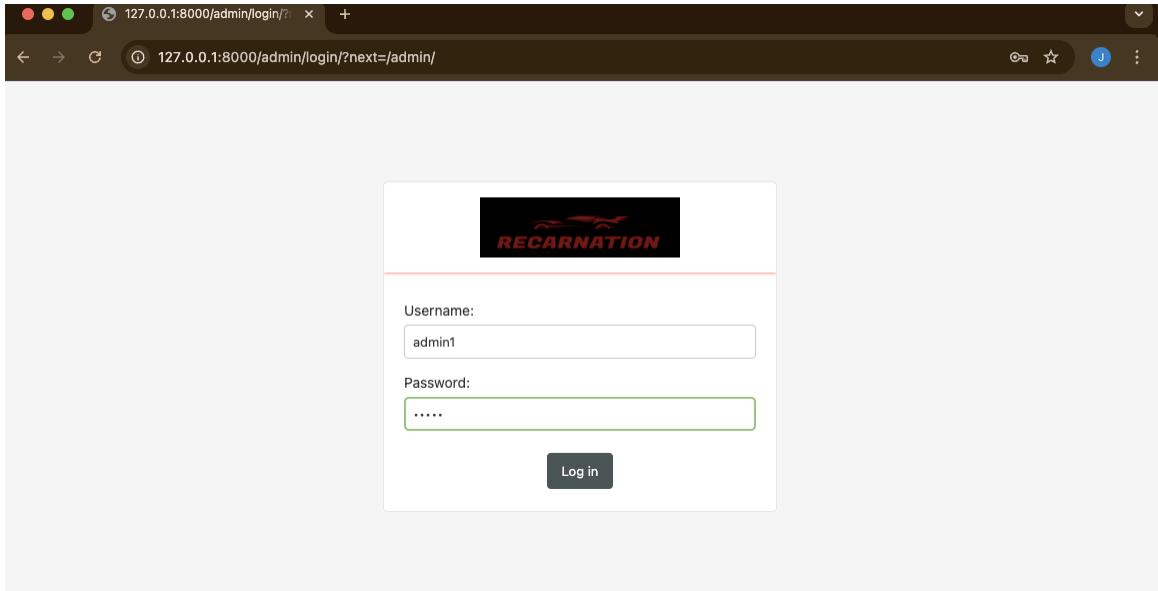


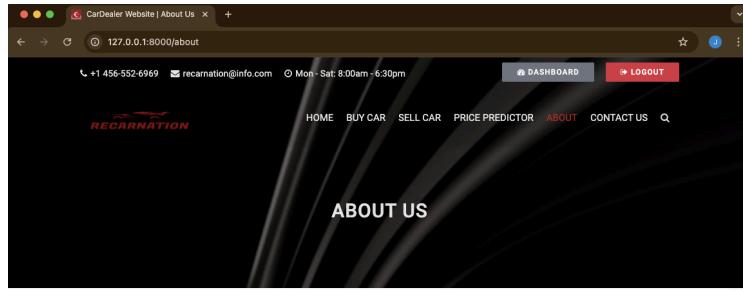
Figure18: Sell Car Page

Figure 19: Price Predictor Page



A screenshot of the RECARNATION site administration dashboard. The title bar shows the URL 127.0.0.1:8000/admin/. The top right corner displays a welcome message: "WELCOME, ADMIN1. VIEW SITE / CHANGE PASSWORD /". The left side of the screen contains several navigation sections: "ACCOUNTS" (Email addresses), "AUTHENTICATION AND AUTHORIZATION" (Groups, Users), "CARS" (Cars), "CONTACTS" (Contacts), and "PAGES" (Contact messages). Each section has "Add" and "Change" buttons. On the right side, there are two panels: "Recent actions" (empty) and "My actions" (a list of recent operations involving contacts and cars).

Figure 20: Admin Page



WELCOME TO RECARNATION

Welcome to ReCarnation, a platform designed to revolutionize the way people buy and sell pre-owned vehicles. Our mission is to create a seamless, transparent, and trustworthy experience for both sellers and buyers, making car ownership accessible and hassle-free.

At ReCarnation, we believe that every car has a story and a second chance at life. By connecting car owners with potential buyers, we aim to promote sustainability and reduce waste, while helping individuals find their perfect vehicle match. Whether you're looking to sell your beloved car or searching for a reliable ride, ReCarnation is here to make the process as simple and rewarding as possible.

With user-friendly tools, advanced filters, and a secure platform, we ensure a smooth experience for all our users. Our dedicated team works tirelessly to verify listings, ensure quality, and provide exceptional customer support. Join us today and become a part of the ReCarnation community, where every journey begins with trust and reliability.

Let's drive the change, together.

Figure 21: About Page

CONTACT US

Contact Us

Full Name Email
 Subject Number
 Write message

Phone: +1 456-552-6969

Email: recarnation@info.com

Web: recarnation.com

Fax: +1 456-622-0110

Figure 22: Contact Us Page

4.5 System component API and logic design

This section outlines different software components, their APIs, and the logic design behind them. The design ensures modularity, scalability, and seamless communication between components while maintaining security and efficiency.

Component Overview

The main modules of the platform, with other components interacting through RESTful APIs, take care of the buying, selling, and administrative functions. A summary of the main modules is given below:

- **Authentication Service**

Handles user authentication using OAuth or classical logins.

Key Features: User Login, Signup, Token-based Authentication.

- **Vehicle Listing Service**

Provides creation, search, filtering, and management of listings of vehicles.

Key Features: Listing creation, advanced searches, and status updates.

- **User Management Service**

Manages user roles, profiles, and permissions.

Key Features Role-based access control, profile update.

- **Admin service**

It allows the administrator to moderate approved and rejected listings, manage users, and monitor the performance of the platform.

Key Features Listing approvals/rejections and user management.

- **Price Prediction Service**

It predicts the best price depending on the specification of a car and market trends.

Key Features Price suggestion to sellers.

- **Notification Service**

Send alerts/updates to users on listings, approvals, and purchases.

Key Features Email as well as in-app notifications.

Logical Design

The internal logic is meant for secure and efficient operations:

- **Authentication Logic**

Validates user credentials and issues tokens.

OAuth tokens are validated with the provider before allocating internal session tokens

- **Vehicle Listing Logic**

When sellers create listings, they will be flagged as "Pending Approval" and thus will be kept pending for review by an admin.

Therefore, the buyers can apply filters and sorting to quickly find their desired vehicles.

- **Admin Moderation Logic**

The Admins can approve or reject listings based on predefined rules. Thus, these approved listings will be made visible for viewing by buyers, while the rejected ones can be revised by the seller.

- **Price Prediction Logic**

Inputs include car specifications, condition, and market data. A competitive price using machine learning algorithms is calculated by using the algorithm.

API Design

Each component exposes RESTful APIs, ensuring a standardized approach to communication between the frontend and backend. Below is a description of key API endpoints:

1. Authentication API

Endpoint	Method	Description	Parameters
/accounts/login	POST	Authenticates the user and issues a token	Email, Password
/accounts/register	POST	Registers a new user	User details
/accounts/login	GET	Handles OAuth-based login	Provider, Token

Table 8: Authentication API Table

2. Vehicle Listing API

Endpoint	Method	Description	Parameters
/cars	GET	Fetches all active listings	Filters (optional)
/cars/:id	GET	Fetches details of a specific car	Listing ID
/sell	POST	Creates a new vehicle listing	Listing data
/sell/:id	PUT	Updates an existing listing	Listing ID, Updates

Table 9: Vehicle Listing API

3. Admin API

Endpoint	Method	Description	Parameters
/admin/cars/car	GET	Fetches all pending listings	None
/admin/cars/:id	POST	Approves or rejects a listing	Listing ID, Action
/admin/auth/users	GET	Fetches all registered users	None

Table 10: Admin API table

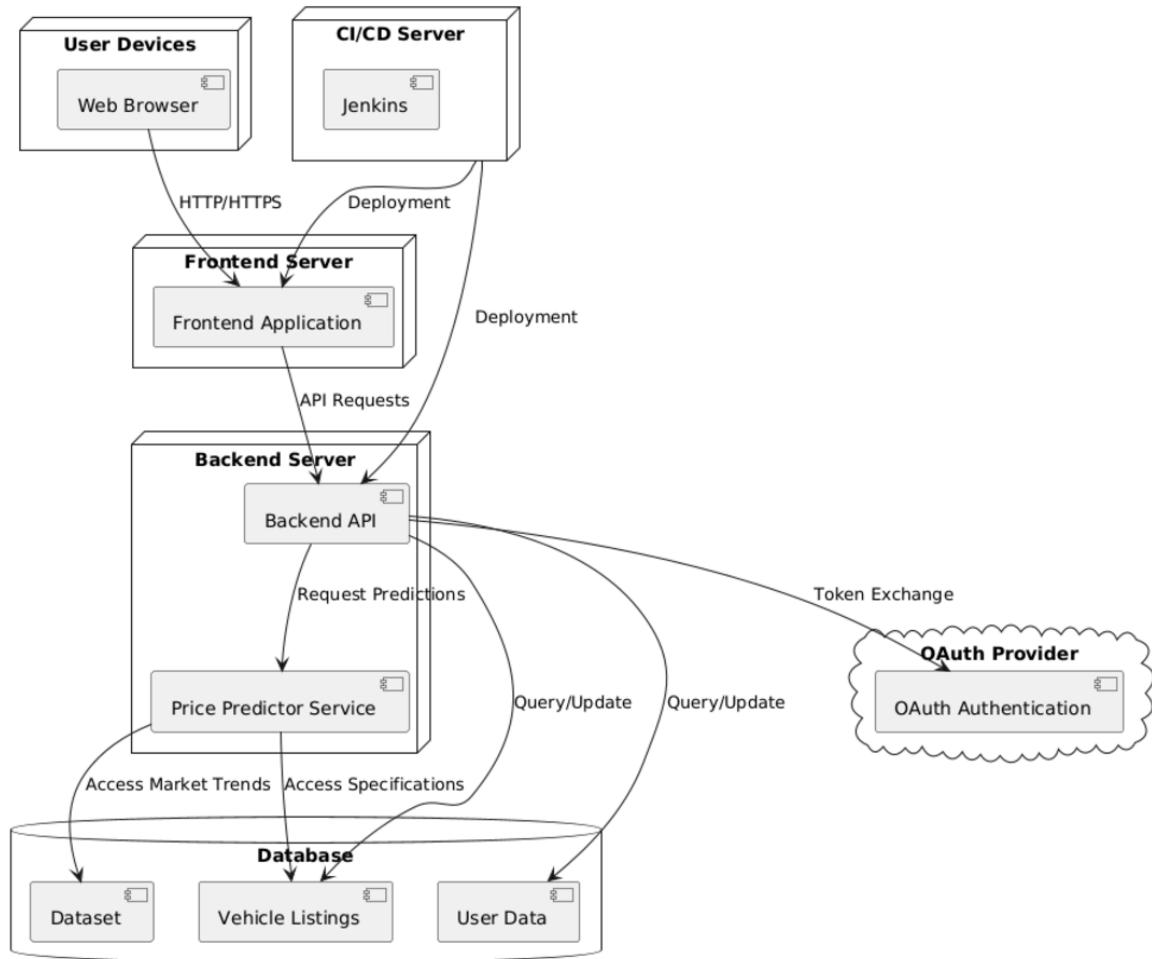


Figure 23: Deployment Architecture of the system

CHAPTER 5. SYSTEM IMPLEMENTATION

5.1. System implementation summary

The implementation of the pre-owned car marketplace application was planned with a focus on security, and scalability. The system features a user-friendly front-end, built using Angular, and a robust back-end developed in Django, which handles sso, data storage, and business logic. Key features include a secure login mechanism supporting both OAuth and standard credentials, a streamlined car listing process for sellers, and advanced search functionality for buyers, complete with filters and options. The application also employs a touch friendly design, ensuring accessibility across various appliances..

A notable key feature of the platform is its ml-based price predictor, which analyzes market trends, car specifications, and other to provide sellers with optimal pricing suggestions. This ensures sellers achieve competitive prices while maximizing value. Additionally, the application includes a comprehensive admin panel that allows administrators to review, approve, or reject car listings, manage user accounts, and ensure marketplace quality. Admins can also block users when necessary to maintain security and trustworthiness.

The database is implemented using PostgreSQL, efficiently managing user data, car listings, transaction histories, and admin actions. The application is hosted on cloud services, ensuring scalability to accommodate a growing number of users. Continuous integration and delivery are facilitated through Jenkins, streamlining the deployment process and ensuring that updates are integrated into the environment.

While automated testing has not yet been implemented, the system has undergone rigorous manual testing to validate functionality and performance across all modules. These efforts collectively aim to deliver a seamless, secure, and reliable platform for buying and selling pre-owned vehicles, while maintaining high marketplace standards through administrative oversight and advanced pricing capabilities.

5.2. System implementation issues and resolutions

The implementation of the pre-owned car marketplace application faced several challenges, which were carefully addressed to ensure the development of a functional and user-friendly platform. One major challenge involved integrating the machine learning-based price predictor into the backend. The issue was resolved by creating a dedicated API endpoint in Django, enabling efficient communication between the

backend and the prediction model. Rigorous testing was conducted to ensure that the price estimates aligned with real-world market trends, offering valuable insights to users.

The front-end, developed using HTML, CSS, and JavaScript, required significant effort to achieve a responsive and user-friendly interface. Ensuring compatibility across devices and browsers posed challenges that were overcome by using modern CSS frameworks and thorough testing on multiple platforms. The admin panel, a critical component for managing user accounts, car listings, and approvals, required careful planning to implement secure role-based access controls. Django's built-in authentication system provided a robust foundation for developing these functionalities.

Database performance issues emerged as the volume of stored data increased, affecting query execution times. These issues were resolved by optimizing database queries, implementing indexing on frequently accessed columns, and revising the database schema to enhance efficiency. Setting up secure login mechanisms, supporting both OAuth-based single sign-on (SSO) and standard credentials, required a meticulous integration process, which was successfully achieved using Django's authentication libraries.

While the application has not been deployed yet, hosting preparations were made with AWS in mind for scalability and reliability. The focus during implementation remained on building the core functionalities while keeping the deployment process simple and seamless for future scaling.

Despite the absence of automated testing, extensive manual testing was performed using tools like Postman for API validation and browser-based debugging for the front-end. These efforts ensured that the application functioned as intended, paving the way for further enhancements, including automated testing and eventual deployment.

5.3. Used technologies and tools

The development of the pre-owned car marketplace application employed a range of technologies and tools to ensure simplicity, functionality, and scalability. Each tool was carefully selected to address specific needs in the system's development and operation.

Front-End Development

The front end was developed using HTML, CSS, and JavaScript, providing the user interface with sensitivity and interactivity. These technologies were chosen for their simplicity, unity, compatibility, and ease of use. Their lightweight nature ensures quick

rendering on various devices and browsers, making the application accessible to an audience.

Back-End Development

The Django framework, built on Python, was selected for the server-side implementation. Django efficiently manages server-side logic, handles API endpoints, and ensures secure user interactions. Its robust features, including built-in authentication and scalability, made it an excellent choice for the back end of this application.

Database Management

PostgreSQL was used to handle the application's relational data storage needs, including user profiles, car listings, and many more. PostgreSQL was chosen for its reliability, scalability, and ability to perform complex queries efficiently, ensuring quick data retrieval across the platform.

Machine Learning Integration

Python-based machine learning libraries were utilized to develop the price prediction feature. This model analyzes car specifications, market trends, and other key factors to provide sellers with accurate pricing suggestions. Python's rich ecosystem of machine learning libraries ensures precision, efficiency, and ease of implementation in developing such predictive tools.

Security Measures

The application incorporated OAuth2 for secure Single Sign-On (SSO) and Django's authentication framework for user and admin role-based access control. These tools were chosen for their reliability in protecting sensitive user data and for providing a secure login mechanism, ensuring trust and safety for all users.

Testing and Debugging

Manual testing was performed using Postman for API verification and browser debugging tools for front-end testing. These tools were selected for their ease of use and comprehensive features, allowing the team to validate functionality, detect bugs, and optimize user experience across different modules of the application.

Version Control

Git was used for tracking changes in the codebase, and GitHub served as the collaborative platform for hosting repositories and managing version control. These tools were chosen because of their industry-standard status, enabling efficient team collaboration and code management.

The combination of these tools and technologies ensured a seamless development workflow and laid the foundation for creating a secure, efficient, and user-friendly platform for the pre-owned car marketplace.

CHAPTER 6. SYSTEM TESTING AND EXPERIMENT

6.1 Testing and experiment scope

In our application, we have implemented a combination of automated functional tests and manual testing to ensure the reliability and correctness of the core features. The tests focus on key features such as user authentication, car management (including approval and rejection processes), and the integrity of the database. Below is a detailed breakdown of the automated test cases implemented, alongside the manual testing process for other parts of the application.

1. User Authentication & Registration Tests

- Login with Valid Credentials: We tested whether a user can log in successfully using valid credentials. A valid login should redirect the user to the dashboard page.
- Login with Invalid Credentials: This test checks if the system correctly handles invalid login attempts, providing appropriate error messages.
- Registration Success: We tested if a user can successfully register with valid data and a matching password confirmation. The registration should redirect the user to the dashboard.
- Password Mismatch: This test verifies that the registration form returns an error when the password and confirmation do not match.
- Duplicate Username: We tested the registration process when a user attempts to register with an already existing username. The form should return an appropriate error message.
- Duplicate Email: This test checks if the system properly handles duplicate email registrations by showing an error message when the email is already associated with another account.
- Authenticated Dashboard View: This test ensures that only authenticated users can access the dashboard. Unauthenticated users should be redirected to the login page.
- Unauthenticated Dashboard Access: We tested that unauthenticated users trying to access the dashboard are redirected to the login page.
- Logout Functionality: We tested the logout view to ensure that authenticated users can log out successfully and are redirected to the homepage.

2. Car Model Tests

- Car Creation: We tested whether a car instance can be created successfully with the expected attributes (e.g., title, city, status, etc.). This ensures that the system handles car data correctly when a new car is added.
- Car String Representation: We verified that the string representation of the Car model returns the car title as expected, making it easier to identify cars in the admin panel or when displayed elsewhere.

3. Approve Cars View Tests

- Approve Cars View (Staff User): We tested whether a staff user can access the car approval view, where they can approve or reject cars. This view is restricted to staff users, and the test verifies that a staff user can view cars pending approval.
- Approve Car Action: We simulated the action of approving a car. This test verifies that when a staff user approves a car, its status is updated from "Pending" to "Approved" in the database.
- Reject Car Action: Similar to the approved action, we tested the process of rejecting a car. The car's status should change from "Pending" to "Rejected" when a staff user selects the 'reject' option.

While the tests above cover the core functionalities of the application, other features were tested manually. These include:

- Car Listing and Search: The functionality of listing all cars and searching for cars by different attributes (e.g., city, make, model, etc.) was manually tested to ensure proper functionality.
- Admin Views and Permissions: Additional admin-specific workflows, such as managing car listings, editing car information, and reviewing submitted inquiries, were manually tested to verify that the correct permissions are enforced.
- User Interactions: Various user interactions, such as editing profiles, updating contact information, and submitting inquiries, were manually tested to ensure smooth and error-free user experiences.

6.2 Testing and experiment approaches

The primary goal of this test plan is to ensure the robustness, security, usability, and performance of the application. This includes testing critical features such as user authentication, car management, and approval/rejection workflows. To achieve this, we have devised a comprehensive strategy that involves a combination of unit testing,

functional testing, integration testing, and manual testing. Each of these testing methods addresses different aspects of the system, ensuring that all key features and components are thoroughly validated before deployment.

1. Test Methods

a. Unit Testing

Unit testing is an essential part of the test plan, aimed at validating individual components of the application. It ensures that each part of the system—such as models, views, and form validations—functions correctly in isolation. Unit tests are automated and run frequently during the development process to detect errors early. These tests are primarily written for smaller units of functionality, for instance:

- Model Tests: Ensuring that data objects, such as car and user models, are created and saved correctly in the database.
- View Tests: Verifying that views return the expected status codes and templates based on different inputs.

The unit tests are already implemented and tested, as seen in the CarModelTest and ApproveCarsViewTest classes. These tests cover key scenarios, such as car creation and approval/rejection workflows.

b. Functional Testing

Functional testing focuses on verifying the core user workflows of the application, ensuring that each flow behaves as expected from the user's perspective. This includes testing user authentication (login and registration), car creation, and managing the approval or rejection of cars.

- Login and Registration Testing: Ensuring that users can register successfully and log in with correct credentials while being appropriately redirected.
- Car Management Testing: Testing the process of creating and editing cars, as well as verifying that users with the appropriate permissions can approve or reject cars.

Functional testing helps validate the user interface and overall behavior of the system when interacting with it through a browser or API.

c. Integration Testing

Integration testing ensures that different components of the application interact as expected. This involves testing the interactions between the front end and the back end, ensuring that the system behaves correctly when components are combined. For example:

- Car Approval Workflow: Testing the approval action triggers both the correct status change in the database and appropriate notifications to the user.
- User Authentication and Permissions: Ensuring that actions like car approval or rejection are only accessible to users with the correct permissions (e.g., staff members).

Integration tests help identify any issues that arise when multiple components are combined, ensuring smooth operation when the system is in use.

d. Manual Testing

Manual testing plays a critical role in identifying issues that may be difficult to capture through automated tests. This testing is primarily focused on:

- UI/UX Testing: Manually verifying the layout, responsiveness, and user-friendliness of the user interface.
- Exploratory Testing: Actively exploring the application to uncover edge cases, usability issues, or other unforeseen problems that might not be covered by automated test cases.

While unit, functional, and integration tests cover most of the application's functionality, manual testing is essential for assessing the user experience, especially with respect to UI design and permission handling.

2. Test Criteria

The success of the testing process is based on several key criteria, which are used to evaluate the system's performance and behavior. These criteria include:

a. Correctness

Correctness refers to the application's ability to meet functional requirements and deliver the expected results. For example:

- Verifying that a car is correctly created and saved in the database with the right details.
- Ensuring that when a car is approved, its status is correctly updated to "Approved".

Automated tests already cover many of these correctness checks, but additional manual tests will be written to check for edge cases and unexpected inputs.

b. Usability

Usability ensures that the application is user-friendly and intuitive. The registration, login, car creation, and approval processes should all be straightforward and easy to navigate. Testing will focus on the following:

- Navigation: Ensuring that users can easily navigate through pages and understand the next steps.
- Error Messages: Ensuring that informative and helpful error messages are displayed when users make mistakes.

c. Security

Security testing ensures that sensitive parts of the system are properly secured and that unauthorized users cannot perform sensitive actions like approving or rejecting cars. Key areas for security testing include:

- Authentication: Ensuring that only registered and authorized users can access their accounts.
- Permissions: Verifying that only staff members can approve or reject cars.
- Data Protection: Ensuring that sensitive information, such as passwords, is stored securely and is not accessible to unauthorized users.

d. Performance

Performance testing evaluates how well the application performs under various loads. The system should be able to handle multiple concurrent users and operate efficiently without delays. Testing will focus on:

- Response Times: Ensuring that page load times remain reasonable under different loads.
- Concurrent Users: Simulating multiple users performing tasks like login or car approval and evaluating the system's response.

e. Edge Case Handling

Edge cases involve scenarios that are rare or extreme, such as inputting invalid data or performing actions in an unusual order. The system should gracefully handle these situations and provide appropriate feedback to the user. Tests will focus on:

- Boundary Conditions: Verifying that the system correctly handles large or small inputs.
- Invalid Input: Ensuring that users cannot submit incomplete or incorrect forms.

3. Test Coverage

Test coverage includes both automated and manual tests, ensuring that all critical functionality is tested and validated.

A test coverage chart will be provided to highlight the percentage of coverage for each category (unit tests, functional tests, integration tests, and manual tests). The chart will show:

- Automated Tests: Which portions of the system are covered by unit, functional, and integration tests.
- Manual Tests: Areas like UI/UX and exploratory tests that are not covered by automation.

4. Future Testing Plans

While unit tests are already written and executed, future plans include the development of the following test cases:

- Functional Tests: Writing more detailed functional tests to cover different user flows, such as car approval/rejection, and testing various edge cases related to data input.
- Integration Tests: Testing complex workflows, like the interaction between user authentication, car management, and approval actions, to ensure that all system components interact as expected.
- Performance Testing: Conducting load testing to assess the application's responsiveness and performance under heavy traffic.

Manual testing will continue to focus on usability, user interface, and exploratory testing to ensure a seamless user experience.

The test plan is designed to ensure that the application is functional, secure, usable, and performs well under various conditions. It uses a combination of automated tests and manual testing to comprehensively cover all critical features, including user authentication, car management, and approval workflows. As the project progresses, additional test cases for performance, security, and edge cases will be written to provide further coverage and ensure the system is ready for deployment.

6.3 Testing and experiment

The test scripts developed for this project are designed to cover all critical system functionality, including user authentication, car management, approval/rejection workflows, and security validation. The following test scripts were executed:

Test Category	Test Script	Purpose	Scope	Outcome
Unit Testing	CarModelTest	To test that the car model correctly handles car creation and updates	Creating cars with valid inputs, validating required fields, and updating car status.	All tests passed, with correct car creation and status updates.
Unit Testing	ApproveCarsViewTest	To verify the car approval functionality.	Ensuring only authorized users (admin) can approve cars and update car status.	All tests passed, with successful status updates and restricted access for unauthorized users.
Functional Testing	UserLoginTest	To validate the login functionality for registered users.	Tests valid and invalid login attempts, ensuring proper error messages are displayed.	All scenarios passed, error messages displayed correctly, and successful login leads to the correct dashboard.
Functional Testing	CarCreationTest	To validate that the car creation process works smoothly.	Tests form submission for car details and ensures the car is added to the database	Passed, with the car appearing in the admin's dashboard upon

				successful creation.
Integration Testing	UserAuthenticationAndCarApprovalTest	To test that a user can login and approve/reject cars.	Testing the integration of login functionality with car approval actions.	Integration passed with no errors, users with appropriate roles can approve/reject cars.
Integration Testing	CarApprovalAndNotificationTest	To validate that a car's approval triggers the correct status update and notification.	Verifying that the approval workflow updates car status and sends notifications.	All steps passed successfully, with accurate status updates and notifications sent.
Manual Testing		To cover edge cases, UI/UX, and unusual user flows.	Testing different user roles, input data variations, and UI responsiveness.	Majority of manual test scenarios passed, though UI responsiveness issues identified for further refinement.

Table 11: System Test Scripts Summary and Outcomes

```

(myenv) rohan@junie Recarnation-TechTitans % python manage.py test
Logged in successfully!
Found 10 tests(s)
Creating test database for alias 'default'...
System check identified some issues:

WARNINGs:
cars.Car (models.W042) Auto-created primary key used when not defining a primary key type, by default 'django.db.models.AutoField'.
    HINT: Configure the DEFAULT_AUTO_FIELD setting or the CarsConfig.default_auto_field attribute to point to a subclass of AutoField, e.g. 'django.db.models.BigAutoField'.
contacts.Contact (models.W042) Auto-created primary key used when not defining a primary key type, by default 'django.db.models.AutoField'.
    HINT: Configure the DEFAULT_AUTO_FIELD setting or the ContactsConfig.default_auto_field attribute to point to a subclass of AutoField, e.g. 'django.db.models.BigAutoField'.
pages.ContactMessage (models.W042) Auto-created primary key used when not defining a primary key type, by default 'django.db.models.AutoField'.
    HINT: Configure the DEFAULT_AUTO_FIELD setting or the PagesConfig.default_auto_field attribute to point to a subclass of AutoField, e.g. 'django.db.models.BigAutoField'.
pages.Thing (models.W042) Auto-created primary key used when not defining a primary key type, by default 'django.db.models.AutoField'.
    HINT: Configure the DEFAULT_AUTO_FIELD setting or the PagesConfig.default_auto_field attribute to point to a subclass of AutoField, e.g. 'django.db.models.BigAutoField'.

System check identified 4 issues (0 silenced).
.../Users/rohan/Downloads/CarDealerWeb-Django/myenv/lib/python3.11/site-packages/django/db/models/fields/_init_.py:1595: RuntimeWarning: DateTimeField Car.created_date received a naive datetime (2024-12-07 20:55:31.480999) while time zone support is active.
.warnings.warn(
./Users/rohan/Downloads/CarDealerWeb-Django/myenv/lib/python3.11/site-packages/django/db/models/fields/_init_.py:1595: RuntimeWarning: DateTimeField Car.created_date received a naive datetime (2024-12-07 20:55:31.831699) while time zone support is active.
.warnings.warn(
./Users/rohan/Downloads/CarDealerWeb-Django/myenv/lib/python3.11/site-packages/django/db/models/fields/_init_.py:1595: RuntimeWarning: DateTimeField Car.created_date received a naive datetime (2024-12-07 20:55:31.174499) while time zone support is active.
.warnings.warn(
./Users/rohan/Downloads/CarDealerWeb-Django/myenv/lib/python3.11/site-packages/django/db/models/fields/_init_.py:1595: RuntimeWarning: DateTimeField Car.created_date received a naive datetime (2024-12-07 20:55:32.591499) while time zone support is active.
.warnings.warn(
./Users/rohan/Downloads/CarDealerWeb-Django/myenv/lib/python3.11/site-packages/django/db/models/fields/_init_.py:1595: RuntimeWarning: DateTimeField Car.created_date received a naive datetime (2024-12-07 20:55:32.691489) while time zone support is active.
.warnings.warn(
.

Ran 15 tests in 3.323s

OK
Destroying test database for alias 'default'...

```

Figure 24 :Test Run Output for Recarnation Web Application

Overall, the system's testing phase revealed several critical issues, most of which were promptly addressed. The test coverage was extensive, including unit, functional, integration, and manual testing, ensuring that all critical features function as expected. The bug report analysis highlights a few remaining moderate issues, which are being actively worked on. The experimental case study showed the core workflows functioning as intended, with some minor UI and performance adjustments still required. Future testing will focus on edge cases, further performance optimization, and additional validation on user permissions.

CHAPTER 7. CONCLUSION AND FUTURE WORK

7.1 Project summary

The project successfully created a secure web application designed to modernize the buying and selling of pre-owned vehicles. The platform gives a clean, intuitive interface that caters to both buyers and sellers. Buyers benefit from an advanced search and filtering system, enabling them to browse cars based on personal preferences, and sellers can easily submit their vehicles for sale with detailed specifications. Key features are the price predictor, administrative controls, and secure user authentication, further enhancing the platform's value, ensuring users have a seamless and trustworthy experience.

The backend system is built with a robust database to manage car listings, user data, and transaction history securely. By incorporating continuous integration and automated testing through Jenkins, the project ensures regular updates and reliability. Overall, the platform addresses the growing demand for cost-effective transportation while offering a transparent, and secure solution for the pre-owned car market.

7.2 Future work

Future development of the platform will focus on personalization and customization. One main point of improvement is the implementation of AI-driven features, such as personalized recommendations for buyers based on browsing history and preferences. This would optimize the user experience, making it easier for buyers to find cars that meet their needs further .

Another important area is the introduction of more robust trust mechanisms. While the platform already incorporates basic verification processes, future work will include features like vehicle history reports and third-party certifications to provide greater transparency and reduce buyer hesitation. In addition, expanding the platform's scalability and optimizing performance under high traffic will be a first step to accommodate a growing user base.

The platform will also focus on mobile improving to ensure accessibility for users on-the-go. A mobile-friendly version of the platform, will allow users to browse listings and manage their profiles more easily.

Moreover, there is potential for expanding into new geographic markets, particularly those with high demand for used vehicles, and incorporating electric or hybrid vehicles into the platform as these become more popular. To promote sustainability, future

enhancements may include initiatives to encourage the reuse and recycling of cars, further aligning the platform with eco-friendly practices.

In summary, the future direction of the project will be focused on improving personalization, and transparency, scalability, and promoting sustainability to keep pace with the evolving automotive market.

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10. All the listed car images used in this application were taken by the authors for the purpose of this project.
11. All the figures and diagrams were created using Mermaid Diagramming Tool, PlantUML and draw.io Diagramming Software.