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Arkila: A Progressive Web App Car Rental Management System for Kataguan Rides in La Trinidad, Benguet

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Abstract – *This study developed Arkila, a Progressive Web Application (PWA) for Car Rental Management, designed to address the inefficiencies of manual vehicle booking and management processes. Guided by the Feature-Driven Development (FDD) methodology, the project followed a structured approach consisting of six iterative stages: developing an overall model, building a features list, planning by feature, designing by feature, building by feature, and deploying for user acceptance. Functional and non-functional requirements were established through qualitative interviews, forming the basis for the system's overall model, diagrams, and data structures. Subsequent stages involved defining prioritized features through a Feature Breakdown Structure and Milestone Map, followed by process flow designs and UI prototypes to guide development. The system was implemented using Next.js for the frontend and Firebase and Appwrite for backend services, ensuring a scalable, secure, and responsive architecture. Unit tests were conducted which validated that the features function as expected. Quantitative evaluation through a User Acceptance Test (UAT) yielded an overall mean score of 3.72, indicating that users were highly satisfied and fully accepted the platform's functionality and usability. The results confirmed that Arkila successfully achieved its objectives of streamlining booking transactions, improving fleet coordination, and enhancing operational efficiency. Recommendations for further improvement include refining the booking flow, integrating GPS-based fleet tracking, expanding artificial intelligence capabilities, and enabling offline and mobile functionality to improve accessibility and adaptability.*

Keywords – *Car Rental Management, Feature Driven Development, Progressive Web Application*

INTRODUCTION

Transportation is the movement of people, goods, or animals across distances through land, air, or sea, rooted in the Latin words trans (across) and portare (to carry) (Agnihotri & Tripathi, 2023). It enables mobility, which provides access to essential opportunities, services, and daily activities (Abdul Latiff & Mohd, 2023).

Mobility fuels economic activity, especially in developing countries. In 2024, 2.6 million Overseas Filipino Workers (OFWs) (The Global Filipino Magazine, 2024) generated USD 38.34 billion in remittances, about 8.3% of the Philippines' GDP (Fintech News Philippines, 2025). Their constant travel underscores the value of efficient transport systems.

Tourists also heavily depend on mobility, contributing over USD 1.5 trillion to global GDP in 2023 (United Nations World Tourism Organization, 2024), with local transport determining travel satisfaction.

In the Philippines, mobility is supported by modes such as jeepneys, SUVs, buses, railways, private vehicles, taxis, and ride-hailing services (Balita, 2023).

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Students, about 24.8 million in 2024 (Manila Standard, 2024), rely on transport for schooling, while 48.8 million workers (Department of Finance, 2025) depend on it for daily commutes. Families, organizations, and institutions also rely on transport for operations and travel.

Despite its importance, transport reliability and flexibility remain concerns. Crowded, inconsistent public transit struggles to meet diverse mobility needs (Balita, 2023), leading groups such as families, tourists, and business teams to seek alternatives like private rentals or chartered vehicles.

The rise in demand for flexible and comfortable mobility has strengthened the role of transport operators and car owners, fueling growth in the car rental industry. Unlike fixed-route public transport, rentals offer customizable schedules, destinations, and group capacities. In the Philippines, the market reached USD 682.27 million in 2025 and is projected to grow to USD 988.63 million by 2030, offering self-drive, chauffeured, and peer-to-peer services (Mordor Intelligence, 2025). The COVID-19 pandemic further increased preference for private and rental vehicles as safer alternatives (Perez et al., 2021).

Digitalization continues to reshape the sector. Online bookings are expected to surge (Mordor Intelligence, 2025), reflecting how Information Systems drive innovation and workflow optimization (Muntaka et al., 2024). Digital platforms have also improved access and user experience (Adexin, 2024). However, many local operators still rely on word-of-mouth or chat inquiries, despite 81% of customers researching online before contact (Mallory, 2023). Lacking online presence reduces visibility and trust (Sela, 2023).

Manual record-keeping persists among small operators, yet it is highly prone to errors, data loss, and limited historical tracking (Thakur, 2021). Real-time, database-driven fleet systems provide accurate vehicle availability (Flowers, 2023; Chawhan et al., 2023), making them essential as operations scale.

Customer reviews strongly influence trust and service improvement; digital feedback systems help shape consumer decisions (Rachmiani, 2024; Veltri et al., 2020). Likewise, identity verification enhances security and accountability (Tookitaki, 2024; Thakur, 2021). KYC frameworks, widely used across digital industries, employ document-based verification such as full name, birthdate, address, and valid IDs (Financial Crime Academy, 2025; Xiong et al., 2025; Shufti, 2025).

During peak seasons, many small rental companies struggle to meet demand due to limited fleets. Other platforms address this through scalable membership models, for example, GrabRentals allows driver-partners to lease vehicles as needed (Wu, 2025). This reveals an industry gap: integrating independent car owners and drivers into rental platforms can expand fleet capacity without major capital costs (Golo & Encarnacion, 2024; Nansubuga & Kowalkowski, 2021).

In the digital landscape, Progressive Web Applications (PWAs) have become vital, combining the accessibility of web apps with the functionality of native apps. PWAs run directly in the browser and bypass app store downloads (LePage & Richard, 2020). They support push notifications, fast loading, and responsive design (Blessing, 2024), and reduce operational complexity by centralizing development. Companies such as Uber use PWAs to deliver key services without requiring installation (Lee, 2024).

Digital transformation continues to push rental platforms online. In the Philippines, about 60% of rentals were booked digitally in 2022 (Ken Research, 2023), driven by increasing internet and smartphone penetration, which reached roughly 69 million users in 2023 (Mordor Intelligence, 2025). Golo and Encarnacion (2024) emphasized the need for online systems with functions such as booking, digital agreements, customer reviews, and ratings.

Internationally, digital platforms show strong effectiveness. SOCAR in Malaysia has raised over USD 73 million, operates thousands of vehicles, and enables

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real-time booking through its app ecosystem (R-Eed, 2024). In the United States, companies like Hertz and Enterprise streamline rentals through online systems showing real-time vehicle availability and routing users to pick-up locations (Hertz, 2022; Enterprise Fleet Management, 2024).

Locally, digital systems similarly strengthen small operators by enhancing visibility and operational control beyond what basic Facebook pages provide. Platforms such as Baguio Rent a Car (2017) benefit from online presence, while systems like DOON (2025) offer robust fleet management and digitalized booking. Membership-based scalability, as used by GrabRentals, further demonstrates how partnerships can address demand fluctuations (Wu, 2025).

Given the advantages above, this project will focus on developing a Car Rental Management System for Kataguan Rides, a car rental organization based in Pico, La Trinidad, Benguet. The group was formally established in 2019 and operates as a cooperative-style association of private car owners. Kataguan Rides primarily provides vehicle rentals for families, tourists, church groups, student organizations, government field trips, and other social groups traveling within and outside Benguet.

Despite its active operations, Kataguan Rides still relies on a semi-manual process. Inquiries are handled through calls or Facebook Messenger, making communication prone to delays and misinterpretation. Vehicle availability is checked manually by the chief, which slows down coordination and increases the likelihood of scheduling conflicts. Bookings are recorded on a physical whiteboard, resulting in missing customer records, no centralized booking history, and limited accountability. The absence of automated fleet tracking for availability, digital verification, and systematic customer feedback further restricts operational efficiency.

Overall, a dedicated Car Rental Management System is a key innovation that will provide Kataguan Rides with the advantages of a digital and centralized solution for their managerial challenges. It will automate the booking process, minimize human errors, and allow real-time monitoring of vehicle availability. Additionally, integrated user verification and digital record-keeping will enhance security and accountability. Built-in descriptive reports and analytics will support data-driven decision-making for fleet optimization and long-term business growth.

OBJECTIVES OF THE STUDY

The primary objective of this project is to develop Arkila, a web-based car rental management system for Kataguan Rides, envisioned to streamline operations and improve service delivery. Specifically, the project seeks to achieve the following: (1) to identify the functional requirements, non-functional requirements and overall model for Arkila, (2) to determine the features list and plan the development of Arkila, (3) to design and develop the features of Arkila, and (4) to deploy and test the user acceptance of Arkila.

MATERIALS AND METHODS

This study utilized the Feature-Driven Development (FDD), which was an agile methodology that emphasized on building and delivering software by focusing on individual features that were meaningful to the client. It involved domain modeling, listing out functional features, and iterative, short-cycle development driven by those features. This approach ensures both structure and flexibility, making it particularly effective for medium to large-scale projects with precise requirements. (Alsaqqa et al., 2020) For Arkila, FDD is significant because it supports a modular and scalable way to deliver key functionalities and features. Figure 1 plots the developmental process undergone by the FDD model.

Figure 1. *Feature Driven Development Stages Adopted from Alsaqqa et al. (2020)*

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Develop an Overall Model

In the initial stage, developing an overall model was essential to ensure that the system design aligned with both business objectives and user needs (Riady et al., 2022). This began with identifying functional and non-functional requirements, which were translated into use case diagrams, user module diagrams, high-level process flows, and an ERD to define the system's data structure.

The functional and non-functional requirements were gathered through a qualitative approach involving one semi-structured interview that allowed the respondent to elaborate on operational workflows and problems. The interview, conducted at Kataguan Rides in Pico, La Trinidad, lasted 45 minutes, was recorded with consent, and later analyzed using content analysis to extract recurring patterns and key concepts.

Insights from the interview informed the system's requirement specifications, which then guided the creation of user modules outlining responsibilities across the platform. Use case diagrams mapped actor interactions and defined the system's functional boundaries, while high-level process flow diagrams provided an overview of how data and operations move across the system. Finally, the ERD established the structure of Arkila's persistent data model, clarifying entity relationships and ensuring data integrity throughout the system's design.

Build the Features List

Following this was the development of the feature list, wherein the system's scope was defined by decomposing it into small, meaningful, and actionable functionalities based on user needs (Riady et al., 2022). Based on the established models, a Feature Breakdown Structure (FBS) with MoSCoW Prioritization labels were created, mapping high-level features down to lower-level processes. This is essential as it mapped out all the system's major features and their functionalities.

Plan by Feature

The process then advanced to planning by feature, where the abstract feature list is transformed into a concrete development plan. Subsequent to the established features list, each feature development was mapped into a Milestone Map, detailing the sequential steps for each phase of development.

Design by Feature

Next was the designing by feature stage, which focused on creating visual and behavioral representations of how each system function would operate (Riady et al., 2022). For Arkila, feature-level process flow diagrams were meticulously created to map the user journeys through the system. Each diagram visually represented the sequence of actions, decisions, and system responses required for each features' functionalities.

Build by Feature

The subsequent stage, build by feature, involved the actual system construction through feature-based coding and continuous integration (CI). Each feature was developed independently and integrated into the central system incrementally. This modular approach enhances code quality, simplifies debugging, and supports parallel development efforts (Riady et al., 2022).

The development of Arkila utilized key tools and technologies. Next.js serves as the main framework, providing both frontend and backend integration with fast, server-rendered performance. Design consistency is achieved through Hero UI's pre-built components and Tailwind CSS's utility-first styling. Next PWA enables app installability, while Nodemailer manages email notifications. Zustand supports efficient state management for synchronized data flow across the system. For backend services, Firebase Firestore offers a cloud-based NoSQL database with secure Google authentication, and Appwrite Storage handles the reliable storage of verification files and vehicle images.

Meanwhile, Visual Studio Code served as the primary integrated development environment (IDE),

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chosen for its efficiency in coding, debugging, and overall project management.

Conduct Unit Test and Integrate Refinements

Unit tests were executed to verify that each system feature functioned correctly under various conditions, including normal execution, boundary cases, invalid inputs, external failures, and performance-related scenarios. Jest was used as the testing tool to ensure consistent and repeatable evaluation of individual components.

The process followed a three-phase iteration structure. The first unit testing phase assessed the initial implementation of each feature, allowing early detection of functional errors, missing validations, and logical inconsistencies. All identified issues were addressed during the refinement and integration phase, where corrections were applied directly to the codebase and reintegrated into the system. After revisions were completed, the second unit testing phase validated the updated functionalities to confirm that all identified issues had been resolved and that no new errors were introduced. This ensured that each feature met the required operational standards before moving to full integration.

Deploy the System

Deployment of Arkila utilized key tools and technologies. Git handles version control, allowing developers to track and merge changes efficiently, while GitHub serves as the central repository that automates deployment workflows. Vercel is used for production deployment, offering fast hosting, strong performance, and built-in analytics for Arkila's live environment. Post-deployment monitoring is managed through the Firebase Console for backend updates, authentication logs, and real-time database activity, while the Appwrite Console oversees storage operations to ensure continuous data reliability.

Conduct User Acceptance Test

The User Acceptance Test (UAT) employed a quantitative design using purposive sampling to select participants who could provide relevant insights (Campbell et al., 2021). Thirty respondents were targeted, representing Arkila's key user groups such as booking users such as students, employees, organization members, tourists, and parents from La Trinidad and Baguio, as well as membership users including drivers and car owners.

Data were collected using a structured questionnaire, an efficient tool for gathering large amounts of information while minimizing bias, maintaining anonymity, and allowing customization to research needs (Khan et al., 2025). The questionnaire contained four sections: Respondent Identification Data (optional name, category, age, location), an Introduction explaining the UAT purpose, Instructions detailing procedures for various tester types, and an Information Section containing the evaluation items.

The evaluation items were adapted from Baharum et al. (2017) and consisted of 27 statements measuring perceived usefulness (1–3), perceived ease of use (4–6), perceived performance (7–9), expectation (10–14), confirmation (15–16), satisfaction (17–19), continuance intention (20–22), and interface quality (23–27).

Responses used a four-point Likert scale, a widely applied method for assessing attitudes and perceptions (Kusmaryono et al., 2022), enabling participants to rate their agreement with each statement as presented in Table 2.

Table 1. Likert Scale and Rubric Used to Scale the Statements in the Questionnaire

Weight	Scale	Description	Rubric
4	3.50–4.00	Strongly Agree (SA)	I am highly satisfied with the platform and **fully accept** its use.
3	2.50–3.49	Agree (A)	I am satisfied with the platform and **generally accept** its use.

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2	1.50–2.49	Disagree (D)	I am dissatisfied with the platform and **hesitant to accept** its use.
1	1.00–1.49	Strongly Disagree (SD)	I am highly dissatisfied with the platform and **reject its use**.

The procedure began with identifying potential participants, securing their interest, and obtaining informed consent. Researchers briefed each participant on Arkila's purpose, the testing objectives, and the tasks to be performed. Participants then used the deployed system to complete predefined tasks, such as booking services, managing accounts, and navigating the interface, to evaluate usability and functionality. Afterward, they completed the UAT questionnaire. All sessions were conducted in a controlled environment to maintain consistency, and confidentiality and voluntary participation were strictly upheld.

Questionnaire data were analyzed using statistical tools aligned with the study's objectives. The weighted mean was applied to summarize Likert-scale responses, accounting for both scale values and response frequency. The formula used for weighted mean is:

$$WM = \frac{\Sigma fx}{n}$$

Wherein:
WM = Weighted Mean
f = Frequency
x = Scale value
n = Number of cases

Weighted means were computed for the four tester groups: booking clients, drivers, car owners, and manager, and then averaged to determine Arkila's overall UAT score. The final weighted mean was interpreted using the established Likert scale descriptions to assess user acceptance and satisfaction.

Data storage and disposal followed strict ethical standards. Physical questionnaires were digitized, temporarily secured, and later shredded after analysis. Digital copies, stored in an access-controlled Google Drive folder accessible only to the researchers, were deleted after the study's completion to ensure responsible data handling.

RESULTS AND DISCUSSION

This chapter discusses the results acquired on every phase of the development of Arkila.

Overall Model

This section discusses the overall system model and its key components. It is composed of five artefacts: Functional and Non-Functional Requirements, User Modules Diagrams, Use Case Diagrams, High-Level Process Flow Diagram, and Entity Relationship Diagram.

Arkila supports five distinct user roles: Client, Car Owner, Driver, Manager, and Super Admin. The primary functions implemented for each role include profile management, car owner and drivers' memberships management, fleet management, bookings and reviews management, and email notifications. Table 3 presents the functional requirements of Arkila and their descriptions.

Table 2. Functional Requirements of Arkila

Functional Requirements	Descriptions
Profile Management	Users can register and log in with a Google Account. A profile is auto created and can be updated, deleted, or verified through uploaded documents. The super admin can view all users, filter user lists, and check visitation history.
Car Owner and Drivers Memberships Management	Clients can apply as car owners or drivers, update applications, and upload required documents. The Manager reviews, accepts, or rejects applications, with automated email notifications. Car owners/drivers can activate or deactivate profiles, and drivers can manage availability.

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Fleet Management	Car owners can register, update, delete, and submit vehicles for verification. The Manager approves or rejects vehicle submissions. Both see dashboards showing vehicle data and fleet status.
Bookings and Reviews Management	Clients can create, update, or cancel bookings, choose vehicle and rental type, assign drivers, and upload booking fee receipts. Car owners can confirm bookings, change drivers, and mark vehicles as returned. Billing can be recorded, and clients can submit reviews. Email notifications are sent for booking actions.
Notification and Communication	The system sends automated confirmation emails and provides an in-system inbox for messages and alerts.

Alongside the functional requirements, the non-functional requirements have been identified and validated to define the quality attributes of the system as presented in table 4.

Table 3. Non-Functional Requirements of Arkila

Non-Functional Requirements	**Descriptions**
Hosted as Progressive Web Application	The system is deployed as a Progressive Web Application, allowing users to access it through multiple platforms.
Performance	The system is designed to load pages and process actions efficiently under normal usage.
Scalability	The system is designed to support growth in the number of users and operations.
Availability	The system is designed to be available to users consistently with minimal downtime.
Reliability	The system is designed to ensure that important data remains intact during unexpected events.
Security	All data transmissions and authentication processes were secured.
Maintainability	The codebase is designed to be modular, well-structured, and maintainable by developers.

The succeeding user modules that comprise Arkila were designed to address specific roles and responsibilities within the platform. The Client Module in Figure 2 demonstrates how customers or renters interact with the system.

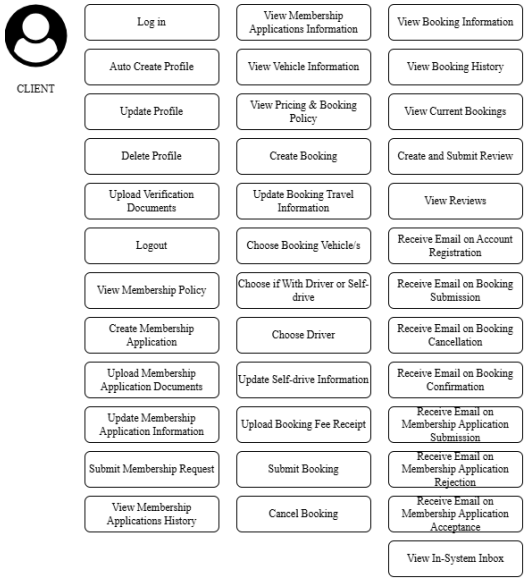

Figure 2. *Client Module*

The Manager Module in Figure 3 focuses on operational oversight. It enables the manager to track bookings, monitor fleet activities, handle membership applications from car owners and drivers, and approve or reject vehicle verification requests.

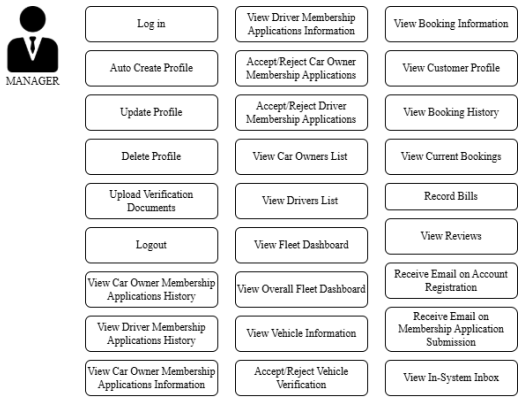

Figure 3. *Manager Module*

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The Car Owner Module in Figure 4 provides tools for vehicle management and monitoring.

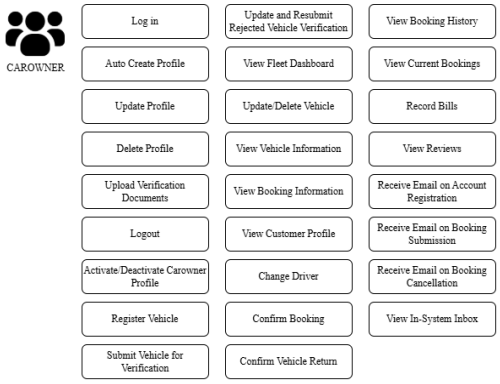

Figure 4. *Car Owner Module*

The Driver Module in Figure 5 highlights the driver's interaction with the platform.

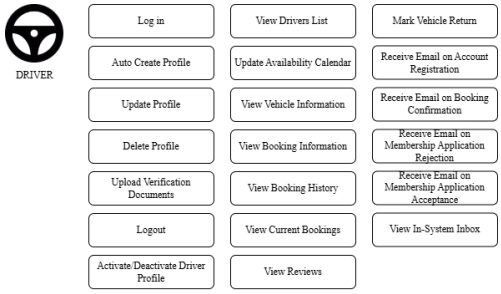

Figure 5. *Driver Module*

The Super Admin Module in Figure 6 represents the core control component of Arkila.

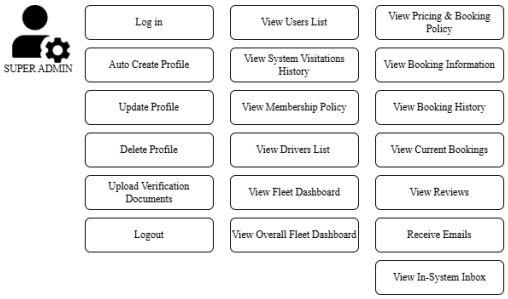

Figure 6. *Super Admin Module*

The Use Case Diagrams illustrate five core functional areas including profile management, driver and car owner memberships management, fleet management, booking management, and notifications, providing a clear, structured representation of how the system's various components support essential rental and management workflows.

Figure 7 outlines how various users manage their profiles, including logging in, updating information, uploading verification documents, and logging out.

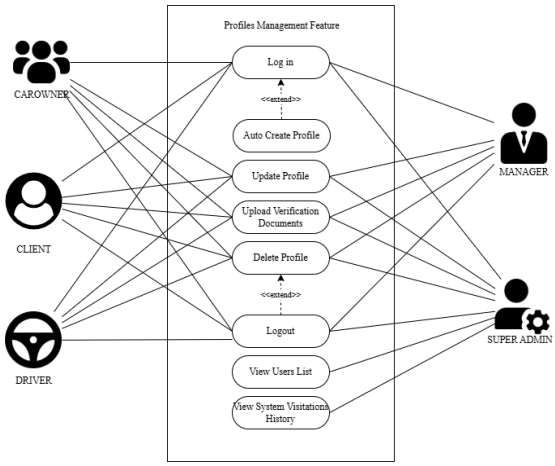

Figure 7. *Use Case Diagram of the Profile Management Feature*

Figure 8 illustrates the membership use cases of both car owners and drivers. It shows how users can submit membership applications, upload required documents, and track approval status, while the manager reviews and decides on these applications.

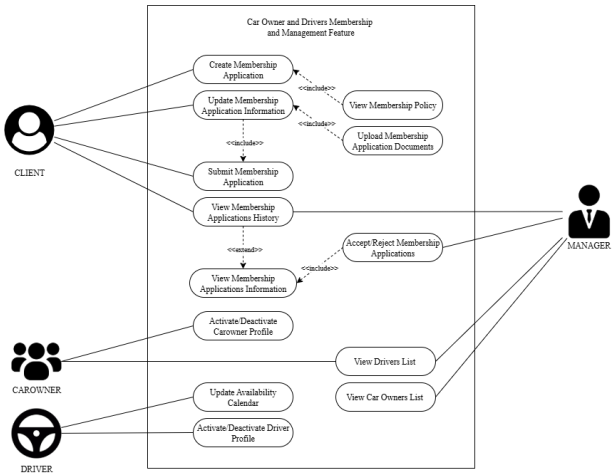

Figure 8. *Use Case Diagram of the Car Owner and Driver Membership Management Features*

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Figure 9 presents how vehicles are registered, verified, and managed. It shows that car owners can add or update vehicle details, while managers review verification requests and monitor overall fleet activity through a centralized dashboard.

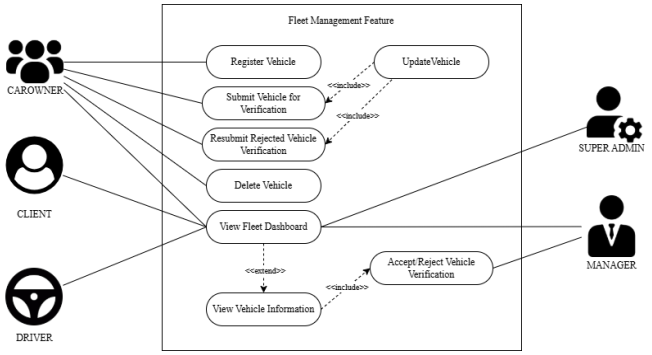

Figure 9. *Use Case Diagram of the Fleet Management Feature*

Figure 10 depicts the booking use cases from different perspectives, including viewing fleet details, creating, updating bookings, and uploading payment receipts for client users. It also highlights how managers, drivers, and car owners interact with bookings by confirming, assigning, or updating booking records.

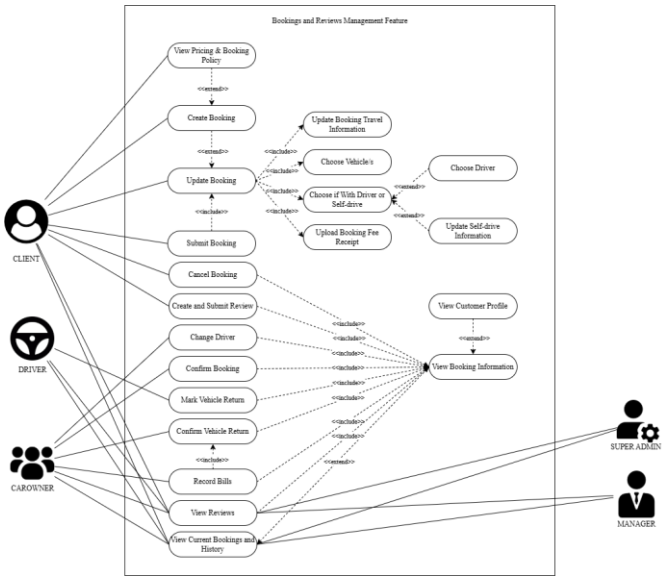

Figure 10. *Use Case Diagram of the Bookings and Reviews Management Feature*

Figure 11 represents how the system automatically sends email alerts and in-system messages to notify users of key activities such as registration, booking confirmations, and membership updates. It ensures users stay informed throughout the rental process.

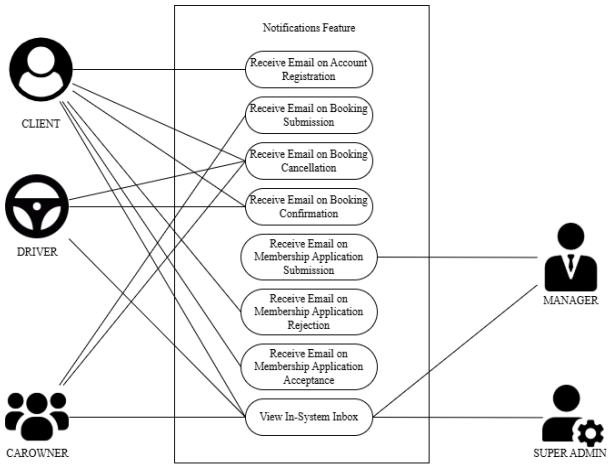

Figure 11. *Use Case Diagram of the Notifications Feature*

The High-level Process Flow Diagram presented in Figure 12 provides a comprehensive overview of the system's operational pathways. The diagram illustrates that after logging in, users select from four primary operational areas: Manage Profile, Manage Bookings, Manage Memberships, and Manage Fleet.

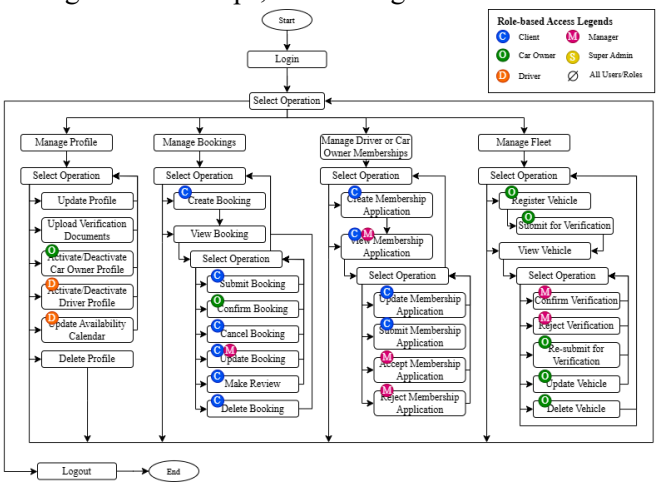

Figure 12. *High-Level Process Flow Diagram of Arkila*

The Entity Relationship Diagram (ERD) presented in Figure 13 illustrates the structural

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relationships among the core entities that define Arkila's database design.

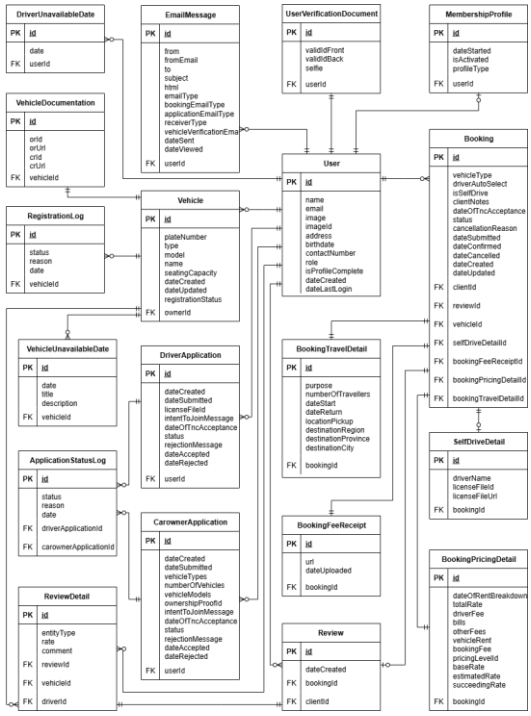

Figure 13. Entity Relationship Diagram of Arkila

Features List

Figure 14 displays the breakdown of Arkila's main features and their prioritization using the MoSCoW model, categorizing them as Must Have, Should Have, Could Have, and Won't Have. It shows that essential features were prioritized to meet project goals efficiently.

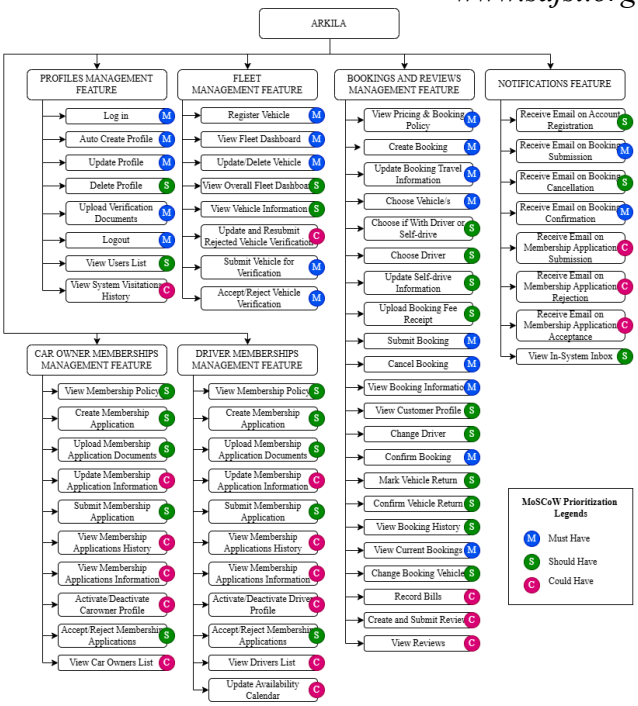

Figure 14. *Feature Breakdown Structure and MoSCoW Prioritization Model of Arkila*

Plan by Feature

This section presents the development roadmap of Arkila, structured according to feature-based milestones. It illustrates how the system's functionalities were strategically planned, prioritized, and implemented in phases to ensure progressive development and stable deployment.

The milestone map presents Arkila's phased development, showing how key features were prioritized across two iterations. As illustrated in Figure 15, the project consists of six milestones. Iteration 1 includes Milestone 1 (Application Foundation), which established the system's technical base; Milestone 2 (Must and Should Have Features), which developed core functionalities; and Milestone 3 (First Unit Test), which validated initial modules. Iteration 2 continues with Milestone 4 (Refinements and Could Have Features), integrating improvements; Milestone 5 (Second Unit Test), confirming refinements; and Milestone 6 (User Acceptance Test), validating user satisfaction. This two-iteration structure ensured organized, gradual, and reliable system development.

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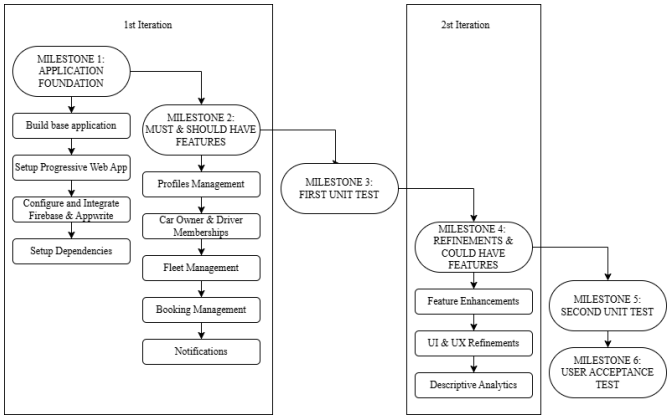

Figure 15. *Milestone Map of Arkila's Features Development*

Design by Feature

This section illustrates the detailed design and operational workflows of Arkila's core features. It focuses on translating the system's planned functionalities into structured process flow diagrams that define how each feature operates within the platform. The following figures presents the flow diagrams which graphically represents the sequence of operations for the key features of Arkila.

Figure 16 illustrates the Profiles Management Feature Process Flow of Arkila, outlining how users interact with their profiles.

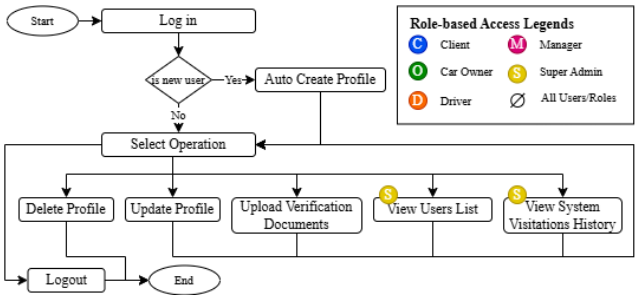

Figure 16. *Profiles Management Feature Process Flow of Arkila*

Figure 17 represents the Car Owner Memberships Management Feature Process Flow of Arkila, detailing how different user roles interact within the system to manage car owner membership processes.

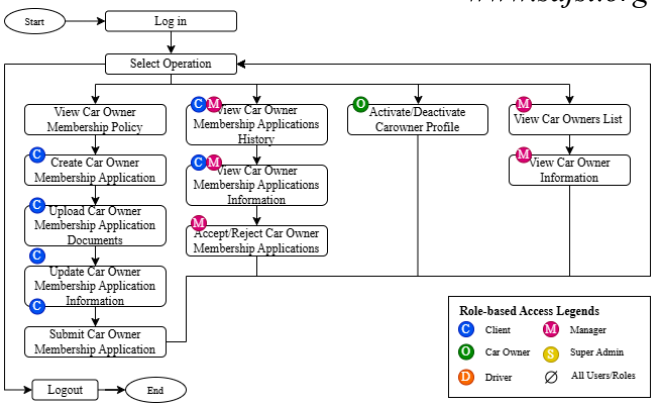

Figure 17. *Car Owner Memberships Management Feature Process Flow of Arkila*

Figure 18 represents the Drivers Memberships Management Feature Process Flow of Arkila, detailing how different user roles interact within the system to manage driver membership processes.

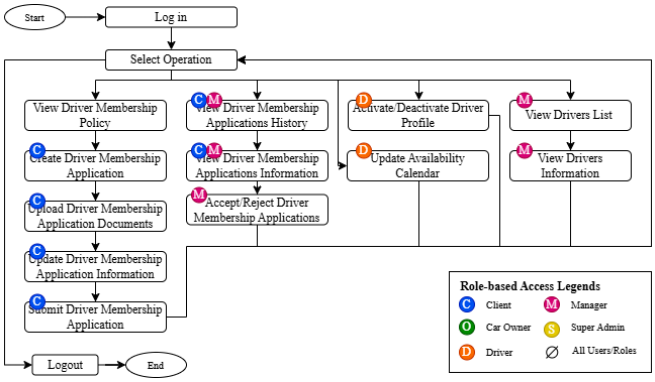

Figure 18. *Drivers Memberships Management Feature Process Flow of Arkila*

Figure 19 represents the Bookings and Reviews Management Feature Process Flow of Arkila, detailing the end-to-end process for managing vehicle bookings and associated reviews within the system.

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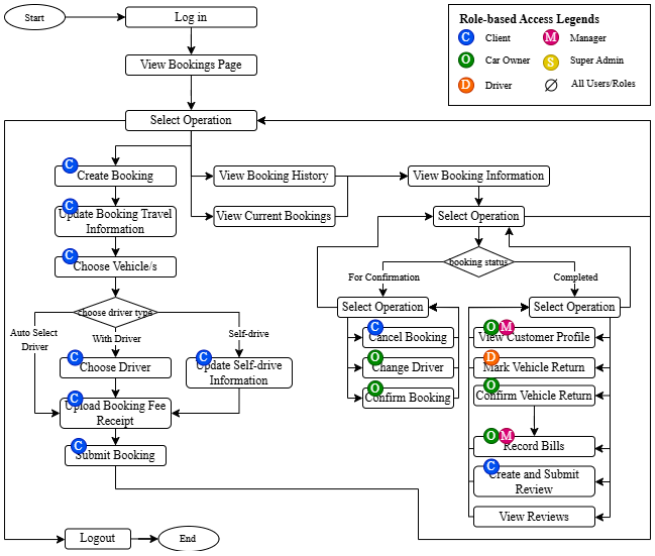

Figure 19. *Bookings and Reviews Management Feature Process Flow of Arkila*

Figure 20 represents the Fleet Management Feature Process Flow of Arkila, outlining the process for registering, verifying, and managing vehicles within the system. The workflow begins when a user logs in and accesses the Fleet Dashboard.

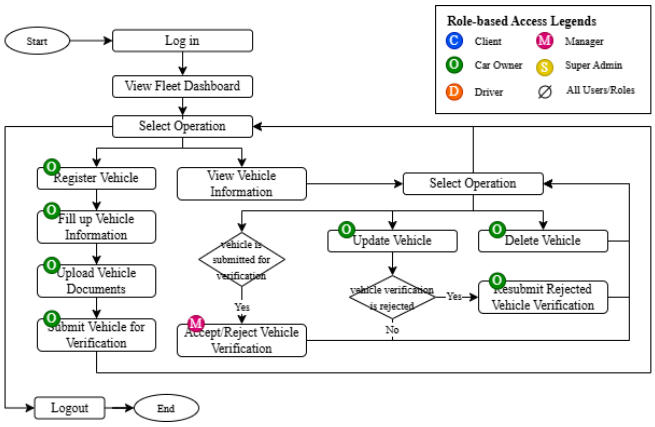

Figure 20. *Fleet Management Feature Process Flow of Arkila*

Build by Feature

Arkila's core system features were designed to streamline car rental operations while ensuring secure and efficient user interactions. The Verified Profiles Management feature allowed users to log in via Google Authentication, manage personal information, and upload verification documents, while administrators could monitor user lists and system visitations. The Bookings and Reviews Management module enabled clients to create, update, cancel, or confirm bookings, select vehicles and drivers, track payment details, and submit feedback, ensuring transparency and a seamless user experience.

The platform also incorporated Car Owner and Driver Membership Management, allowing applicants to submit membership requests, provide necessary documentation, and receive automated approval or rejection notifications. Through Fleet Management, vehicle registration, verification, availability tracking, and historical performance analytics were efficiently handled. Finally, the Notifications feature ensured timely communication through an in-system inbox and email alerts, keeping users informed about account activities, bookings, and approvals. Together, these integrated features provided a centralized, user-friendly, and secure environment for managing all aspects of car rental operations.

Unit Tests

The unit tests conducted in Arkila targeted the core functions that support and interact with multiple micro-functions across the system.

Across all core features of Arkila, the first unit testing cycle consistently revealed failures linked to missing validations, unhandled exceptions, and improper error-handling routines. All features showed similar issues: failures triggered by missing identifiers, Firestore operation errors, invalid inputs, or unmet validation requirements. These initial results indicated that while standard operations were mostly functional, the system lacked sufficient safeguards against edge cases, backend failures, and incorrect user inputs.

After implementing the required refinements, the second unit testing cycle showed complete success across all features. Every test case passed, confirming that the added validation logic, improved exception handling, and corrected workflows resolved the issues identified in the first round. The successful results

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demonstrated that each feature now operated reliably across normal, error, and edge-case scenarios, ensuring stable and consistent system behavior.

System Deployment

Table 5 presents the descriptions of specifications of the platforms used in deploying Arkila. It focused on three platforms mainly Vercel, the main deployment technology, Firebase Firestore, the database platform and Appwrite Storage, which is the storage technology used in Arkila. The specifications presented are all from the Free Plans of the said technologies.

Table 4: Deployment Platforms Technical Specifications

Platform	Specification	Description
Vercel	2 CPUs	Provided enough computing power for Arkila's API routes to respond quickly to requests.
	8 GB RAM	Ensured smooth handling of concurrent requests, helping Arkila's dynamic pages and serverless functions avoid memory throttling.
	23 GB disk space	Supported the build output, logs, and cached assets needed for Arkila's front-end deployment.
	Serverless Deployment	Automatically scales Arkila's backend functions without manual infrastructure management.
Firebase Firestore	50,000 reads/day	Gave Arkila enough query capacity to support frequent client requests.
	20,000 writes/day	Allowed high-volume system actions, updates, and user activity logging.
	20,000 deletes/day	Enabled cleanup of stale data and logs so Arkila maintains a lightweight and optimized database structure.
Appwrite Storage	2 GB storage	Provided adequate space for Arkila's user photos, vehicle images, and documents.
	5 GB bandwidth/month	Supported regular file retrievals needed in various Arkila functionalities.

User Acceptance Test

This subsection presents the results of the User Acceptance Test (UAT) conducted to evaluate the system's usability, functionality, and overall user satisfaction. The evaluation focused on the key users of the system mainly clients or booking testers, driver testers, car owner testers and manager testers. Figure 21 shows the distribution of respondents based on type of tester.

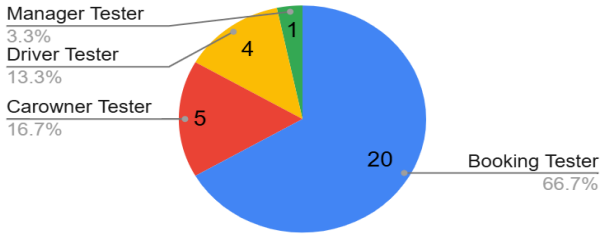

Figure 21. *Distribution of Respondents per Type of Tester*

Figure 22 shows the weighted mean scores of each type of tester which is used to derive the overall user acceptance test score.

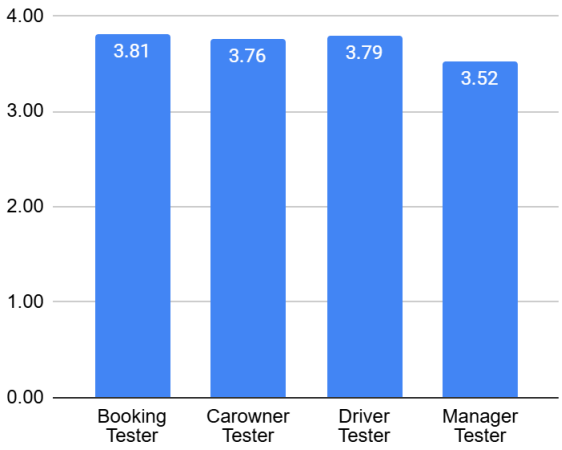

Figure 22. *UAT Scores per Type of Tester*

The consolidated overall User Acceptance Test (UAT) score based on the means of the different types of testers scores was 3.72, which falls within the 3.50 – 4.00 range on the Likert Scale. Based on the established rubric, this rating indicates that users are highly satisfied and fully accept the use of Arkila.

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CONCLUSION AND RECOMMENDATION

Arkila was developed as a Progressive Web Application (PWA) for Car Rental Management to address issues in manual booking, driver coordination, and client transactions. Its development followed four objectives aligned with the Feature-Driven Development (FDD) methodology.

The first objective involved defining functional and non-functional requirements through semi-structured interviews. These insights formed the system model, comprising User Modules, Use Case Diagrams, High-Level Process Flow Diagrams, and an Entity-Relationship Diagram (ERD), providing a comprehensive blueprint for development.

The second objective prioritized system features using a Feature Breakdown Structure (FBS) and the MoSCoW model, ensuring essential functionalities were implemented first. The Milestone Map translated these priorities into a structured development plan.

The third objective focused on system design and construction. Feature-Level Process Flow Diagrams and UI prototypes guided implementation. Arkila was developed using Next.js for the frontend, with Firebase and Appwrite handling backend services such as authentication, database, and storage, ensuring a secure, scalable, and responsive platform.

The fourth objective covered deployment and validation. Arkila was deployed on Vercel, and a User Acceptance Test (UAT) yielded an overall mean score of 3.72, indicating high user satisfaction and acceptance.

In conclusion, the successful completion of all four objectives validates that Arkila has achieved its purpose, to modernize and streamline car rental management processes through an efficient, feature-driven, and user-centered platform.

To further improve Arkila's performance and usability, several enhancements are recommended. Existing features should be refined to create smoother, more intuitive user interactions. The fleet management module may be upgraded with GPS tracking and vehicle monitoring for better transparency. Expanding the platform's AI capabilities, including chatbot access to more features, is also advised. Finally, optimizing the system for mobile use and adding offline functionality would ensure reliability even with unstable internet. These improvements will strengthen Arkila's adaptability, innovation, and user-centered design.

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