جـــامـعـــة الـــشرق الأوســط
MIDDLE EAST UNIVERSITY

Faculty of Information Technology

Computer Science Department

Computer Science

Urban Parking Solutions Mobile Application"ParkEase"

Graduation Project 2 Report

Prepared by

Student ID	Student Name
202020345	Mais Zahran

Supervised By

Dr. Adi Maaita

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Faculty of Information Technology

Graduation Project 2 Report

Declaration

We hereby acknowledge that the work presented in this document report and the ideas based upon are the group members own unless stated otherwise and properly cited in the text and referenced at the end of the document.

Student ID	Student Name	Signature	Date
202020345	Mais Zahran		

Faculty of Information Technology

Graduation Project 2 Report

Supervisor Approval موافقة المشرف

Approval For Submission

I certify that this project report entitled “**Urban Parking Solutions Mobile Application”ParkEase**” was prepared by **Mais Zahran** has met the required standard fro submission in partial fulfillment of the requirements for the degree of Bachelor of science in Computer Science at MEU

Approved by

Signature : ....

Supervisor : Dr ....

Date:..

Acknowledgements الشكر و العرفان

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Abstract (English) (إنجليزي) المستخلص

Urban Parking Solutions Mobile Application"ParkEase"

This project introduces a mobile application designed to revolutionize urban parking, with a special emphasis on supporting electric vehicles (EVs). As cities grow and EV adoption increases, finding parking and charging stations becomes a significant challenge. This application addresses these issues by offering real-time information on available parking spaces and specific functionalities for EV owners, such as locating EV charging stations and facilitating reservation and payment for parking and charging. Employing Agile methodologies, the project aims to enhance urban mobility, promote environmental sustainability by encouraging EV use, and contribute to reducing urban congestion. Through innovative technology, it sets a new standard for smart, EV-friendly urban parking solutions, simplifying the parking experience in the modern urban landscape.

Abstract (Arabic) (عربي) المستخلص

Urban Parking Solutions Mobile Application"ParkEase"

يقدم هذا المشروع تطبيقًا جوالًا مصممًا لتحويل تجربة البحث عن مواقف في المناطق الحضرية، مع تركيز
مع نمو المدن وزيادة تبني السيارات الكهربائية، يصبح إيجاد .(EVs) خاص على دعم السيارات الكهربائية
مواقف ومحطات شحن تحديًا كبيرًا. يتناول هذا التطبيق هذه المشكلات من خلال تقديم معلومات فورية عن
أماكن الركن المتاحة ووظائف محددة لمالكي السيارات الكهربائية، مثل تحديد مواقع محطات الشحن
الكهربائي وتسهيل الحجز والدفع للموقف والشحن. باستخدام منهجيات الأجايل، يهدف المشروع إلى
تحسين التنقل الحضري، وتعزيز الاستدامة البيئية من خلال تشجيع استخدام السيارات الكهربائية،
والمساهمة في تقليل الازدحام الحضري. من خلال التكنولوجيا المبتكرة، يضع المشروع معيارًا جديدًا لحلول
مواقف السيارات الحضرية الذكية والصديقة للسيارات الكهربائية، مبسطًا تجربة البحث عن مواقف في
المشهد الحضري الحديث

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Chapter 1 : Introduction

This chapter is about illustrating the description of the challenge of Solving the absence of a Urban Parking Solutions Mobile Application "ParkEase" , related work to be done and the technology and tools that were going to use later so we can implement our website

1.1 Background and Context

The "**ParkEase**" project emerges as a solution to the persistent challenges in urban parking management, especially within densely populated areas. With the ever-increasing number of vehicles, cities worldwide are facing critical shortages of parking spaces, contributing to traffic congestion and environmental issues. "**ParkEase**" aims to transform the way parking is accessed and managed in urban environments by harnessing advanced mobile application technologies.

1.2 Description of the Problem

Urban areas globally struggle with a scarcity of available parking spaces, resulting in heightened traffic congestion, driver frustration, and environmental pollution. *"Conventional parking management systems often lack real-time information on parking spot availability"*, leading to inefficient use of existing spaces and compounding the issue. Moreover, the absence of integration with emerging technologies, such as electric vehicle (EV) charging infrastructure, poses additional hurdles for both drivers and parking facility operators.

1.3 Description of the Suggested Solution

The proposed solution, ParkEase, is designed to streamline urban parking management by leveraging a combination of IoT technology, real-time data analytics, and user-centric features. This solution aims to address key issues such as prolonged search times for parking, traffic congestion, and environmental impact, providing an efficient and user-friendly parking experience.

1. IoT-Enabled Parking Sensors:

ParkEase employs a network of IoT-enabled sensors installed in parking lots and on-street parking spaces. These sensors detect vehicle presence in real-time and transmit this information to a central server. This setup ensures accurate, up-to-date data on parking availability.

2. Real-Time Parking Availability:

The real-time data collected by the IoT sensors is processed and displayed through the ParkEase mobile application. Users can access current parking space availability in their vicinity, which helps in reducing the time spent searching for parking and minimizing traffic congestion.

3. User-Friendly Mobile Application:

The ParkEase mobile app serves as the primary interface for users. It provides an intuitive and user-friendly design, offering real-time updates on parking availability, navigation assistance to the nearest available spaces, and the ability to report parking space occupancy, contributing to the crowdsourced data pool.

4. Reservation System:

ParkEase includes a reservation feature that allows users to book parking spaces in advance. This ensures drivers have a guaranteed parking spot upon arrival, reducing stress and further decreasing the time spent searching for parking. This feature is particularly useful during peak hours and special events.

5. Payment Integration:

To streamline the parking experience, ParkEase integrates a secure, cashless payment system within the mobile app. Users can pay for parking directly through the app using various payment methods, such as credit/debit cards and digital wallets. This feature eliminates the need for physical payment at parking meters and enhances user convenience.

6. Environmental Impact Reduction:

By providing real-time parking information and reservation capabilities, ParkEase significantly reduces the amount of time drivers spend circling in search of parking. This leads to a decrease in vehicle emissions and fuel consumption, contributing to a cleaner and more sustainable urban environment.

7. Data Analytics and Reporting:

ParkEase offers comprehensive data analytics and reporting tools for city planners and parking authorities. The system collects and analyzes data on parking patterns, peak usage times, and occupancy rates. These insights help optimize parking management strategies, plan for future infrastructure needs, and make informed decisions to improve urban mobility.

1.4 Literature Review (related work)

Smart parking systems have emerged as a pivotal solution to mitigate the issues related to urban parking, traffic congestion, and environmental impact. Various studies and implementations have demonstrated the effectiveness of technology-driven solutions in optimizing parking space utilization and reducing the time spent searching for parking spots. This literature review explores several key studies and projects that have contributed to the development and advancement of smart parking systems.

1. Technology-Driven Smart Parking Solutions

Khan Aftab et al. (2020) present a comprehensive case study on reducing parking space search time and environmental impacts through a technology-driven smart parking solution. Their study highlights the increasing urbanization and the resultant demand for efficient transportation and parking solutions. The ParkUs solution proposed in the study leverages crowdsourced data and advanced infrastructure management to provide significant benefits for citizens, businesses, and cities (Aftab et al., 2020). This approach is indicative of the broader trend towards integrating IoT and AI in urban planning to enhance the efficiency of public services.

2. Sensor-Based Parking Systems

The use of sensors in smart parking systems has been extensively researched. An early study by Abbas and Gabriel (1998) introduced a differential global positioning system (DGPS) combined with a fuzzy logic Kalman filter for accurate positioning of vehicles in parking facilities. This innovative use of sensor fusion techniques set the stage for future developments in the field, emphasizing the importance of precise location tracking in parking management systems (Abbas & Gabriel, 1998).

3. Optimization of Traffic and Parking Management

Further advancements in traffic and parking optimization have been explored by Cheng et al. (2010), who focused on optimizing freeway traffic sensor locations through clustering GPS-derived speed patterns. Their research aimed to enhance the accuracy and efficiency of traffic monitoring systems, which are crucial for real-time parking management and the reduction of traffic congestion in urban areas (Cheng et al., 2010).

4. Crowdsourced Smart Parking Solutions

The promise of crowdsourced data in smart parking solutions has been demonstrated in several studies. Crowdsourcing provides a cost-effective method to collect real-time data on parking space availability, which can be integrated with smart parking applications to guide drivers to available spots. This approach not only reduces the time spent searching for parking but also helps in reducing fuel consumption and emissions.

5. Integration of AI in Parking Management

The integration of artificial intelligence in parking management has opened new avenues for developing intelligent and adaptive systems. AI algorithms can analyze vast amounts of data to predict parking space availability and optimize the allocation of parking resources. These systems can learn from patterns and trends, continuously improving their performance over time.

1.5 Technology and tools to be used

The development and deployment of the urban parking solutions mobile application, especially designed to accommodate electric vehicles (EVs), necessitates the use of modern technologies and tools. This comprehensive approach ensures the application is robust, user-friendly, and scalable, addressing the diverse needs of urban drivers and EV owners. The selection of technologies and tools for this project includes:

Frontend (Client Application)

- Flutter: Remains the best choice for a cross-platform mobile application, enabling a unified codebase for both iOS and Android.
- Figma: For UI/UX design, essential for crafting an intuitive and appealing user interface.

Backend Services

- Node.js: Provides the runtime environment for your server-side logic, known for its efficiency and scalability.
- Express.js: A web application framework for Node.js that simplifies API development with its robust set of features.
- MongoDB Atlas: A cloud-based database service that offers scalability and flexibility, perfect for storing user data, parking information, and reservations.
- Mongoose: Enhances MongoDB usage with schema definitions, data validation, and query building.

Payment Integration

- 2CheckOut: For processing global payments, supporting multiple payment methods and currencies, integrated into your application to handle transactions securely.

Deployment and Hosting

- Railway: To deploy and manage your application's backend services, providing an easy path to scaling and monitoring.
- MongoDB Atlas: For the database, leveraging its cloud infrastructure for high availability and performance.

DevOps and Version Control

- GitHub: For source code management, collaboration, and version control.

Authentication

- JWT (JSON Web Tokens): For authentication and session management, ensuring secure and scalable user authentication within your application.
- Rapid SMS API: For sending OTPs to users' phone numbers, enhancing security by verifying user identity during sign-up and login processes.

Development and Testing Tools

- Postman: For API testing, ensuring that your backend services are correctly implemented before they go live.
- Jest: For writing unit and integration tests, particularly for your Node.js backend, ensuring code reliability and functionality.

Monitoring and Analytics

- MongoDB Atlas Monitoring: For insights into database performance, helping identify and resolve potential issues quickly.
- Railway Metrics and Logs: For real-time monitoring of your application's health and performance.

Other Tools

- Google Maps API: Essential for integrating map and location services, crucial for navigating to parking spots.

- SSL/TLS Certificates: To secure communications between the client and server, protecting user data during transmission.

1.6 Organization of the Report

- **Chapter 1: Introduction**

This chapter sets the stage for the report, presenting the problem statement around the lack of a centralized academic resource platform. It provides a thorough description of the problem, outlining the challenges students face in accessing up-to-date and relevant academic materials. The suggested solution, the **ParkEase**, is introduced as a digital platform tailored to the needs of university students and faculty. This chapter also reviews related literature and details the technologies and tools utilized in the development of **ParkEase**.

- **Chapter 2: Project Plan**

The project plan chapter outlines the objectives, scope, and the software process model of the **ParkEase** project. It details the strategic plan for achieving the project's goals, defining the limits of the project scope, and describing the Waterfall methodology adopted for structured development. The project schedule, including Gantt charts, and the roles and responsibilities within the team are also presented, providing a comprehensive roadmap for the project's execution.

- **Chapter 3: Requirements and Analysis**

Chapter 3 delves into the functional and non-functional requirements that frame the development of **ParkEase**. It lists the essential features and specifications that the system must meet, such as user authentication, resource cataloging, and search functionality. The chapter also defines performance, security, and usability requirements, ensuring the system's reliability and efficiency.

- **Chapter 4: Architecture and Design**

The architecture and design chapter describes the structural blueprint of the **ParkEase**, highlighting the layered approach consisting of the presentation, application, and data layers. It includes detailed design components like use case diagrams, sequence diagrams, activity diagrams, class diagrams, and the entity-relationship diagram, illustrating the system's design considerations and database schema.

- **Chapter 5: System Implementation**

In this chapter, the implementation details are discussed, covering the development environment, database implementation, user interface construction, and functionality implementation. The integration of external services/APIs, security measures, and performance optimization techniques are also elaborated upon, showcasing the practical application of the proposed design and architecture.

- **Chapter 6: System Testing and Installation**

Chapter 6 addresses the testing and installation processes of the ParkEase. It describes the various testing strategies employed, such as unit, integration, system, and user acceptance testing, as well as security and performance testing. The installation process is detailed to ensure the correct deployment of the system, and a thorough validation of requirements is conducted to confirm that the system fulfills the established criteria.

- **Chapter 7: Conclusion and Future Work**

The final chapter wraps up the report with a summary of the project's achievements and an evaluation of how the project goals were met. It acknowledges the limitations and challenges encountered during the project and proposes recommendations for future enhancements. The concluding remarks reflect on the project's contribution to academic resource

Chapter 2 : Project Plan

2.1 Project Objectives

The mission of the ParkEase project is to create a mobile application that simplifies parking in urban areas. The app aims to provide real-time information on available parking spots, allow users to reserve and pay for these spots, and cater to electric vehicle (EV) users by including spots with EV chargers. The following are the specific objectives of the ParkEase project:

1. Provide Real-Time Parking Information:

- Implement a system that continuously updates the availability of parking spots, including those with EV chargers, to provide users with the most accurate and current data.

2. Enable Reservation and Payment:

- Develop features that allow users to reserve parking spots in advance and make secure payments directly through the mobile app, enhancing convenience and user experience.

3. Promote Electric Vehicle (EV) Usage:

- Include dedicated parking spots with EV chargers in the app to encourage the adoption and use of electric vehicles by providing easy access to charging infrastructure.

4. Reduce Parking Search Time:

- Minimize the time drivers spend searching for parking by providing up-to-date information and navigation assistance to the nearest available parking spots.

5. Offer Subscription Levels:

- Create different subscription tiers with added benefits to cater to various user needs and preferences, such as priority reservations, discounted rates, and premium support services.

6. Ensure Scalability:

- Design the app to be easily scalable, capable of handling a growing number of users and expanding to new cities without compromising performance.

7. Maintain Security:

- Implement robust security measures to protect user data and transactions from digital threats, ensuring a safe and secure experience for all users.

8. Enhance Reliability:

- Develop a reliable system that remains operational and efficient regardless of the number of users, providing consistent service even during peak usage times.

9. Promote Eco-Friendly Urban Driving:

- Support environmentally friendly urban driving by reducing emissions through optimized parking solutions and encouraging the use of electric vehicles.

10. Foster User Engagement and Satisfaction:

Create a user-friendly interface that simplifies the process of finding, reserving, and paying for parking, resulting in a positive user experience and high satisfaction levels.

2.2 Project Scope

The scope encompasses the development of a cross-platform application accessible on both iOS and Android, featuring:

- Real-time parking and EV charging spot availability.
- A subscription model.
- Secure in-app payment and reservation system.
- User-friendly design and navigation facilitated by Figma and Google Maps API.

Exclusions include global coverage at launch, direct involvement in parking enforcement, and the development of physical parking infrastructure

2.3 Software Process Model

The project will adopt the Agile development methodology, specifically utilizing the Scrum framework to allow for flexibility, rapid iteration, and continuous feedback throughout the development process. This approach supports the dynamic nature of the project and enables the team to adapt to user needs and technological advancements efficiently.

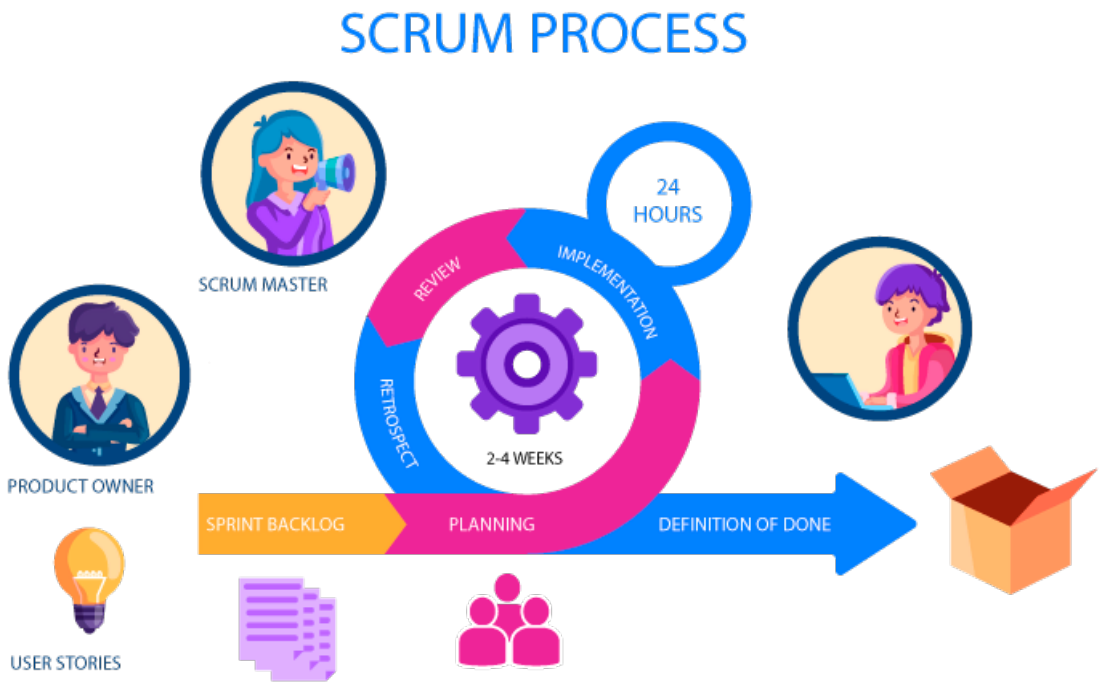
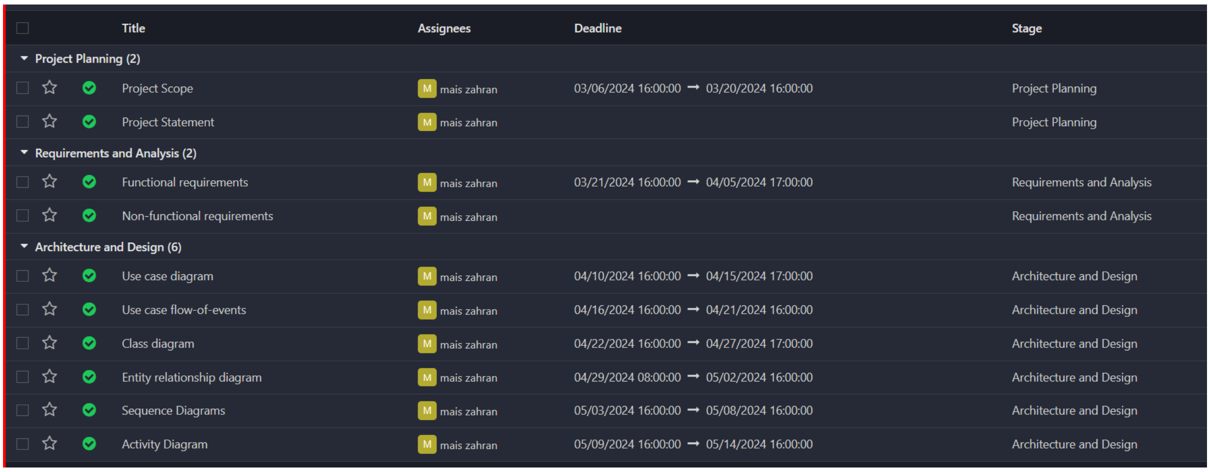


Figure 2.1.1 Methodology

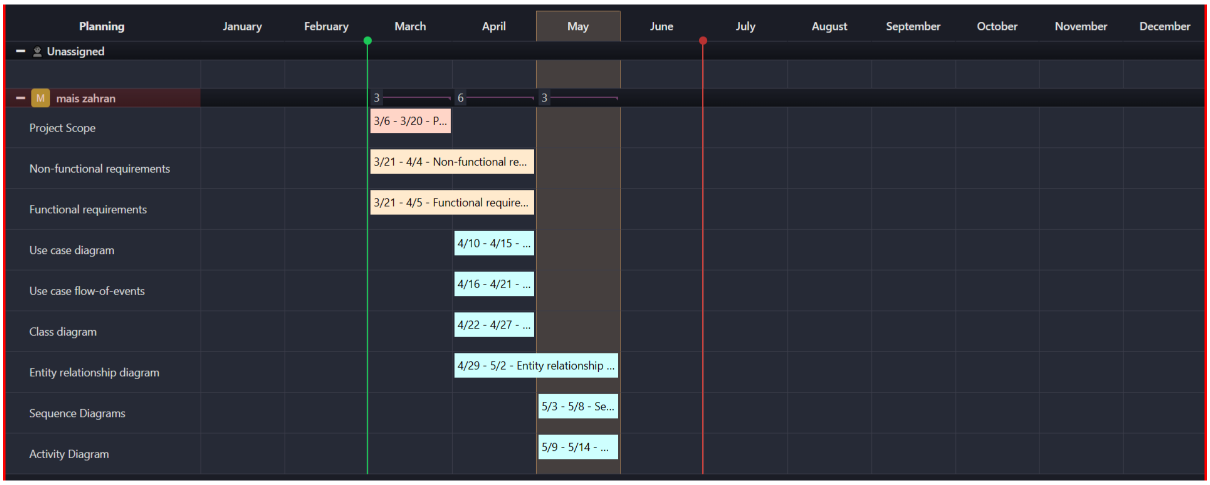
2.4 Project Schedule



☐	Title	Assignees	Deadline	Stage
	▾ Project Planning (2)			
☐ ☆ ✓	Project Scope	M mais zahran	03/06/2024 16:00:00 → 03/20/2024 16:00:00	Project Planning
☐ ☆ ✓	Project Statement	M mais zahran		Project Planning
	▾ Requirements and Analysis (2)			
☐ ☆ ✓	Functional requirements	M mais zahran	03/21/2024 16:00:00 → 04/05/2024 17:00:00	Requirements and Analysis
☐ ☆ ✓	Non-functional requirements	M mais zahran		Requirements and Analysis
	▾ Architecture and Design (6)			
☐ ☆ ✓	Use case diagram	M mais zahran	04/10/2024 16:00:00 → 04/15/2024 17:00:00	Architecture and Design
☐ ☆ ✓	Use case flow-of-events	M mais zahran	04/16/2024 16:00:00 → 04/21/2024 16:00:00	Architecture and Design
☐ ☆ ✓	Class diagram	M mais zahran	04/22/2024 16:00:00 → 04/27/2024 17:00:00	Architecture and Design
☐ ☆ ✓	Entity relationship diagram	M mais zahran	04/29/2024 08:00:00 → 05/02/2024 16:00:00	Architecture and Design
☐ ☆ ✓	Sequence Diagrams	M mais zahran	05/03/2024 16:00:00 → 05/08/2024 16:00:00	Architecture and Design
☐ ☆ ✓	Activity Diagram	M mais zahran	05/09/2024 16:00:00 → 05/14/2024 16:00:00	Architecture and Design

Figure 2.4.1 Project Schedule

2.5 Team Structure and Roles



Planning	January	February	March	April	May	June	July	August	September	October	November	December
− Unassigned												
− M mais zahran			3	6	3							
Project Scope			3/6 - 3/20 - P...									
Non-functional requirements			3/21 - 4/4 - Non-functional re...									
Functional requirements			3/21 - 4/5 - Functional require...									
Use case diagram				4/10 - 4/15 - ...								
Use case flow-of-events				4/16 - 4/21 - ...								
Class diagram				4/22 - 4/27 - ...								
Entity relationship diagram				4/29 - 5/2 - Entity relationship ...								
Sequence Diagrams					5/3 - 5/8 - Se...							
Activity Diagram					5/9 - 5/14 - ...							

Figure 2.5.1 Team Structure and roles

Chapter 3 : Requirements and analysis

3.1 Functional Requirements

Functional requirements specify the essential behaviors and functionalities the application must support to meet user needs and project objectives:

User Authentication:

- Users must be able to log in and sign up using there number or username.
- Authentication should be secure and comply with OAuth 2.0 standards.

Parking Spot Reservation:

- Users must be able to view the availability of parking spots in real-time.
- The app should allow users to reserve a parking spot.
- Reservation includes spots with EV chargers where applicable.

Subscription Service:

- Users should be able to subscribe to the app for reservation features.
- Payment processing for subscriptions must be secure and support major credit/debit cards.

Navigation Integration:

- Once a parking spot is reserved, the app must provide an option to navigate to the spot using Google Maps.

EV Charging Spot Feature:

- The app must allow filtering of parking spots to show only those with EV charging facilities.

Profile Management:

- Users must be able to manage personal details and payment methods.

Admin Management:

- Admins should be able to add, modify, or delete parking spot information.

3.2 Non-functional Requirements

Non-functional requirements describe the standards the application must adhere to regarding performance, security, usability, and scalability:

Performance:

- The app should load parking availability within 3 seconds.
- Reservation transactions should not take more than 5 seconds to process.

Usability:

- The app interface must be user-friendly and accessible to users with no technical background.
- It should be intuitive to navigate within the app.

Reliability:

- The app should have an uptime of 99.9%.
- Real-time data should have a 98% accuracy rate.

Scalability:

- The system should be scalable to accommodate a growing number of users and parking spots.
- It must handle at least 1000 concurrent users.

Security:

- Data encryption for personal and payment information must adhere to industry standards.
- The app must comply with GDPR and other relevant privacy regulations.

Compatibility:

- The app must be compatible with both iOS and Android platforms.
- It should support the latest and two previous versions of the operating systems.

Maintainability:

- The app should be easy to maintain and update without significant downtime.

Localization:

- The app should support multiple languages, starting with English and expanding as per the user base.

Chapter 4 : Architecture and Design

4.1 Architecture

Overview

This section delineates the layered architecture of the **ParkEase** , ensuring a seamless user experience and robust system functionality. The architecture is composed of three primary layers—Presentation Layer, Application Layer (inclusive of Business Logic), and Data Layer.

Architecture Diagram

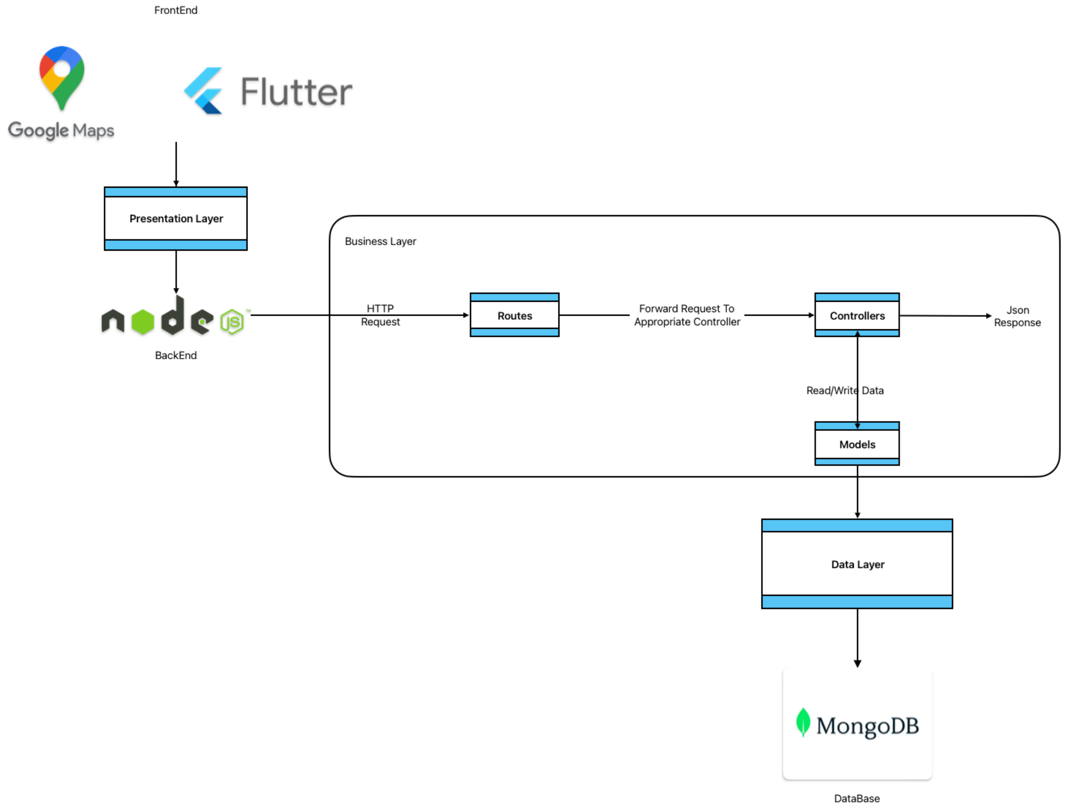


Figure 4.1.1 Architecture Diagram

High-Level Architecture of ParkEase

The application's architecture is designed to be modular and scalable, comprising several key components:

1. Presentation Layer:

- Technology: Flutter for cross-platform mobile development; Figma for UI/UX design.
- Features: Native performance on iOS and Android, intuitive design for ease of use, secure data handling and transmission.

2. Application Layer:

- Core Technologies: Node.js with Express.js for backend services; JWT for authentication; Rapid SMS API for OTP verification.
- Design Principles: Microservices architecture for modular, scalable development and deployment; API Gateway for centralized request handling and security enhancements.
- Integration: Google Maps API for real-time navigation and mapping; 2CheckOut for secure payment processing.

3. Data Layer:

- Database: MongoDB Atlas for a flexible, scalable NoSQL database solution; Mongoose for data modeling and validation.
- Security: Encryption of sensitive data, secure access controls, regular data backups.

4. Deployment & Monitoring:

- Deployment: Railway for backend hosting with CI/CD pipelines via GitHub Actions for automated testing and deployment.
- Monitoring: Railway Metrics and Logs for real-time application performance monitoring; integration with third-party tools for in-depth analysis.

5. Security & Compliance:

- Approach: Implement SSL/TLS for secure communication; adhere to PCI DSS standards for payment processing; GDPR compliance for data protection.
- Authentication: Stateless authentication using JWT for a secure and efficient user login process; Rapid SMS API integration for OTP-based phone verification.

4.2 Use Case Diagram

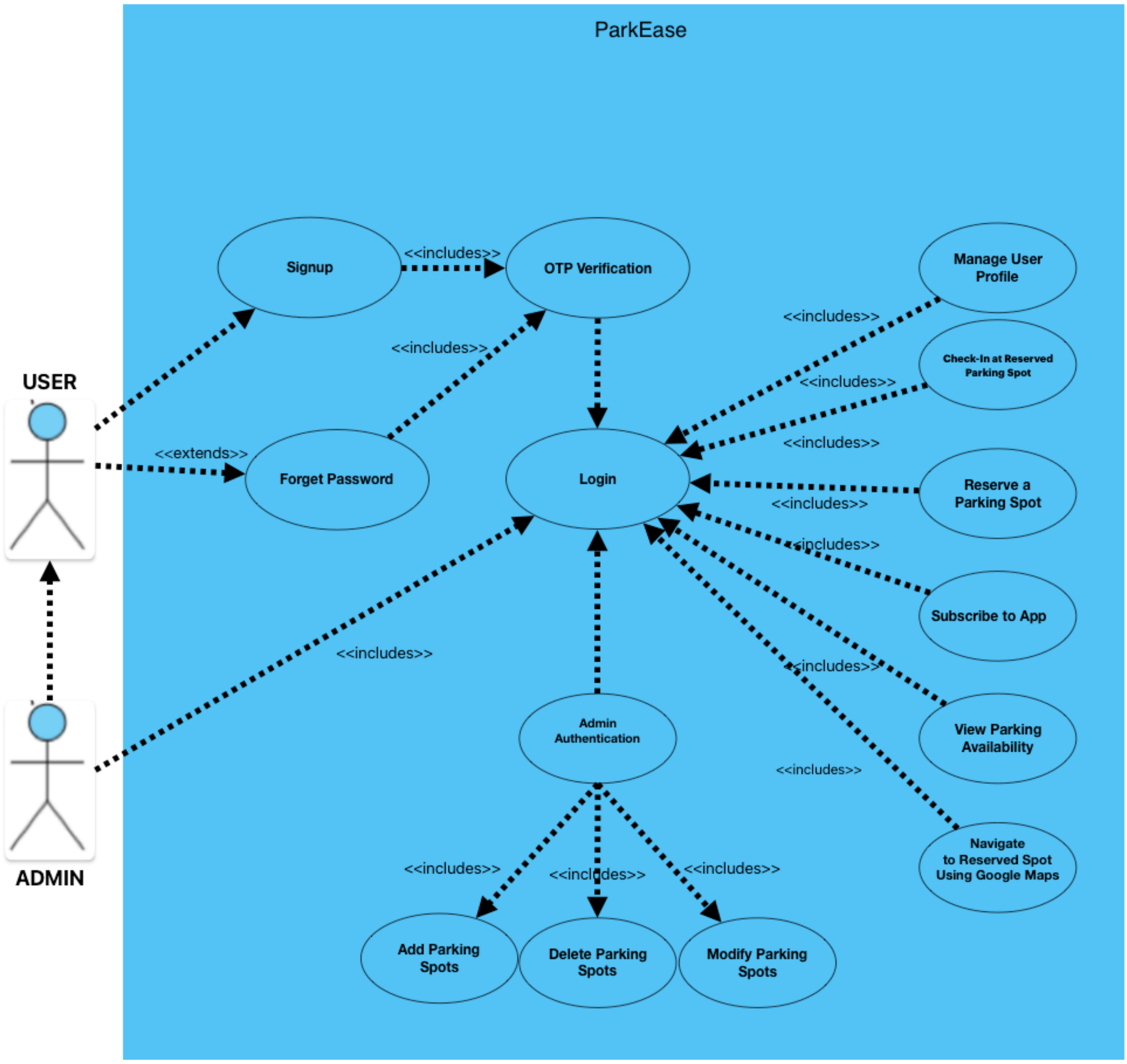


Figure 4.2.1 Use case diagram

Element	Details
Use Case Name	**Signup**
Goal	Register and create a new user account in the app
Preconditions	User has the app installed and does not have an account
Actors	End User
Main Success Scenario	1. User opens the app and selects "Signup". 2. User enters required information (e.g., email, phone number). 3. User sets a password. 4. User receives OTP via SMS (Rapid SMS API). 5. User enters the received OTP. 6. User's information is verified and account is created. 7. User is taken to the login screen or directly logged in.
Extensions	1a. User tries to register with an email that is already in use. 1b. User is informed and asked to try a different email or log in. 2a. User enters an invalid phone number. 2b. User is prompted to enter a valid phone number. 5a. User enters an incorrect OTP. 5b. User is allowed to try again or resend OTP.
Postconditions	User's account is created and user is logged in or ready to log in.
Quality Requirements	The signup process must be completed within 5 minutes to prevent OTP expiry.

Table 4.2.1 Signup Use Case

Element	Details
Use Case Name	**Login**
Goal	Authenticate and log into the app using an account
Preconditions	User has the app installed and has an existing account
Actors	End User
Main Success Scenario	1. User opens the app and selects "Login". 2. User enters their credentials (e.g., email and password). 3. User's credentials are authenticated. 4. User is logged into the app.
Extensions	2a. User enters incorrect credentials. 2b. User is informed of the error and can try to enter credentials again. 2c. User selects "Forgot Password" to initiate password recovery. 3a. Backend service is unavailable. 3b. User is informed and asked to try again later.
Postconditions	User is logged into their account and directed to the app's main interface.

Table 4.2.2 Login Use Case

Element	Details
Use Case Name	**Forget Password**
Goal	Reset the user's forgotten password through OTP verification
Actors	End User
Main Success Scenario	1. User selects "Forget Password" on the login screen. 2. User enters their registered phone number. 3. System validates the phone number and sends an OTP via SMS. 4. User enters the received OTP. 5. System verifies the OTP. 6. User is prompted to set a new password. 7. User sets a new password and is taken to the login screen or directly logged in.
Preconditions	User has an existing account with a verified phone number.
Postconditions	User's password is reset, and the user is logged in or ready to log in.

Table 4.2.3 Forget Password Use Case

Element	Details
Use Case Name	**Send OTP**
Goal	Send an OTP to verify the user's phone number
Actors	System
Main Success Scenario	1. System triggers the OTP process in response to a user action (signup or password reset). 2. System generates a unique OTP. 3. System sends the OTP to the user's provided phone number via SMS (SMS Gateway API). 4. User receives the OTP. 5. System waits for user to enter the OTP for verification.
Preconditions	User has initiated a signup or forget password request.
Postconditions	OTP is sent to the user's phone number, awaiting verification.

Table 4.2.4 OTP Use Case

Element	Details
Use Case Name	**Subscribe to App**
Goal	Subscribe to the app's premium services via online payment.
Preconditions	User is logged in and has valid payment information registered or entered during the process.
Actors	End User
Trigger	User selects the option to subscribe to premium services.
Main Success Scenario	1. User navigates to the subscription section in the app. 2. User reviews the subscription options and benefits. 3. User selects a subscription plan. 4. User is prompted to confirm payment method. 5. User confirms and authorizes payment. 6. Payment is processed securely via 2CheckOut. 7. User receives confirmation of successful subscription.
Extensions	4a. Payment method is invalid or transaction fails. 4b. User is notified and asked to provide a different payment method. 4c. User selects to add a new payment method and proceeds with subscription. 5a. User decides to cancel the process. 5b. User exits the subscription process and no changes are made.
Postconditions	User has access to premium features and services based on the chosen subscription plan.

Table 4.2.5 Subscribe Use Case

Element	Details
Use Case Name	**Manage User Profile**
Goal	To allow the user to update or modify their profile details.
Preconditions	User is logged into the app.
Actors	End User
Trigger	User selects the "Profile" or "Settings" option.
Main Success Scenario	1. User navigates to profile settings. 2. User updates desired profile details (e.g., name, contact info). 3. User submits the changes. 4. System validates and saves the new details. 5. User receives confirmation of update.
Extensions	3a. User enters invalid data. 3b. System displays an error message and requests valid information. 4a. System is unable to save changes (e.g., server error). 4b. User is informed and asked to try again later.
Postconditions	User's profile is updated with new details.

Table 4.2.6 Manage User Profile Use Case

Element	Details
Use Case Name	**Check-In at Reserved Parking Spot**
Goal	Confirm user's arrival at the reserved parking spot within the stipulated time.
Preconditions	User has made a parking reservation and is at the parking location.
Actors	End User (Driver)
Trigger	User arrives at the parking location and wants to check in.
Main Success Scenario	1. User navigates to the reservation in the app. 2. User selects the option to check in. 3. App verifies the location of the user. 4. App confirms the check-in. 5. Parking spot status updates to "occupied".
Extensions	3a. User attempts to check in from a different location. 3b. App denies check-in and informs user they need to be at the reserved location. 3c. User requests assistance or guidance to the correct parking spot.
Postconditions	The reservation is confirmed; the parking spot is occupied by the user.

Table 4.2.7 Check-In at Reserved Parking Spot Use Case

Element	Details
Use Case Name	**Navigate to Reserved Spot Using Google Maps**
Goal	To guide the user to their reserved parking spot using navigation.
Preconditions	User has an active parking spot reservation.
Actors	End User
Main Success Scenario	1. System retrieves the location of the reserved spot. 2. System launches Google Maps with the destination set. 3. Google Maps provides turn-by-turn navigation to the spot.
Extensions	2a. Google Maps is unable to provide navigation (e.g., lack of GPS signal). 2b. User is notified and given alternative directions if possible.
Postconditions	User arrives at the reserved parking location.

Table 4.2.8 Navigate to Reserved Spot Using Google Maps Use Case

Element	Details
Use Case Name	**Reserve a Parking Spot**
Goal	To allow the user to reserve an available parking spot.
Preconditions	User is logged in and has payment method on file.
Actors	End User
Main Success Scenario	1. User selects desired parking location. 2. User selects the time and duration for reservation. 3. System calculates the cost and requests confirmation. 4. User confirms and completes payment. 5. System confirms reservation and provides details.
Extensions	2a. Selected spot is no longer available. 2b. User is notified and asked to choose another spot. 3a. Payment method is declined. 3b. User is prompted to update payment information.
Postconditions	Parking spot is reserved for the user.

Table 4.2.9 Reserve Parking Spot Use Case

Element	Details
Use Case Name	**View Parking Availability**
Goal	To display real-time availability of parking spots.
Preconditions	User is logged into the app.
Actors	End User
Main Success Scenario	1. User selects location to view parking spots. 2. System displays available spots and relevant information (e.g., location, price).
Extensions	1a. There are no available spots. 1b. System informs the user and may offer to notify when spots become available.
Postconditions	User is informed of parking spot availability.

Table 4.2.10 View Parking Availability Use Case

Element	Details
Use Case Name	**Admin Authentication**
Use Case ID	AD001
Goal	Authenticate an admin and verify their role in the system.
Primary Actor	Admin
Preconditions	Admin has the app installed and has admin credentials.
Main Flow	1. Admin selects the option to log in. 2. Admin enters their credentials. 3. System verifies credentials and checks the database for admin role. 4. Admin is granted access to admin functionalities.
Postconditions	Admin is logged into the system with access to admin-specific features.
Extensions	1. Credentials are invalid; admin is prompted to retry. 2. Credentials do not grant admin access; user is informed they lack admin privileges.

Table 4.2.11 Admin Authentication Use Case

Element	Details
Use Case Name	**Add Parking Spots**
Use Case ID	AD002
Goal	Input new parking spots into the system
Primary Actor	Admin
Preconditions	Admin is authenticated and verified as an admin.
Main Flow	1. Admin inputs details of a new parking spot 2. Saves the new parking spot in the system
Postconditions	New parking spot is available for users
Extensions	Details are invalid; admin corrects and resaves

Table 4.2.12 Add Parking Spots Use Case

Element	Details
Use Case Name	**Modify Parking Spots**
Use Case ID	AD003
Goal	Update details of existing parking spots
Primary Actor	Admin
Preconditions	Admin is authenticated and verified as an admin.
Main Flow	1. Admin selects a parking spot to modify 2. Updates details and saves changes
Postconditions	Parking spot details are updated
Extensions	Update fails; admin retries

Table 4.2.13 Modify Parking Spot Use Case

Element	Details
Use Case Name	**Delete Parking Spots**
Use Case ID	AD004
Goal	Remove parking spots from the system
Primary Actor	Admin
Preconditions	Admin is authenticated and verified as an admin.
Main Flow	1. Admin selects a parking spot to delete 2. Confirms deletion
Postconditions	Parking spot is removed from availability
Extensions	Deletion fails; admin retries

Table 4.2.14 Delete Parking Spots Parking Spot Use Case

4.3 Activity Diagrams

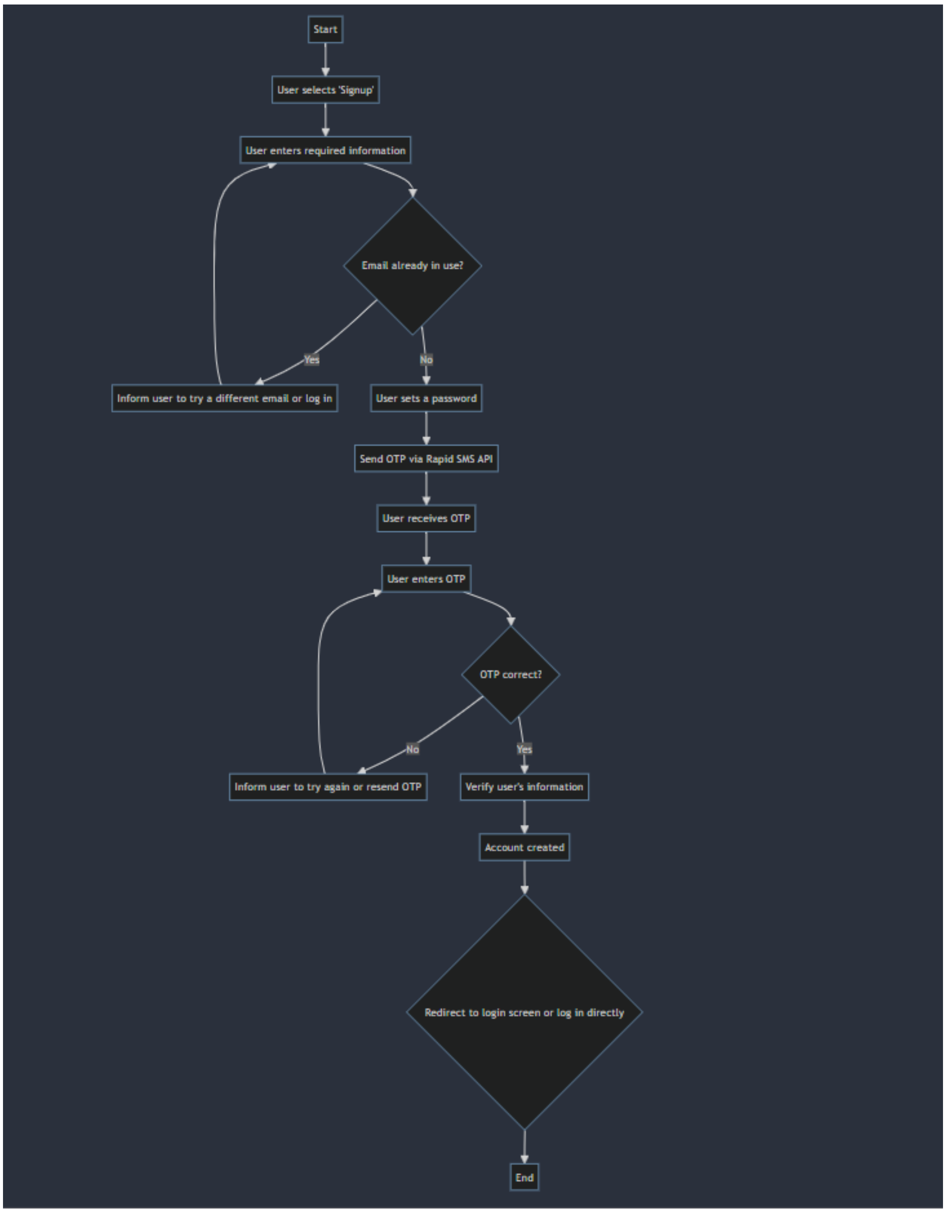

Start
User selects 'Signup'
User enters required information
Email already in use?
Yes
No
Inform user to try a different email or log in
User sets a password
Send OTP via Rapid SMS API
User receives OTP
User enters OTP
OTP correct?
No
Yes
Inform user to try again or resend OTP
Verify user's information
Account created
Redirect to login screen or log in directly
End

Figure 4.3.1 Register Activity Diagram

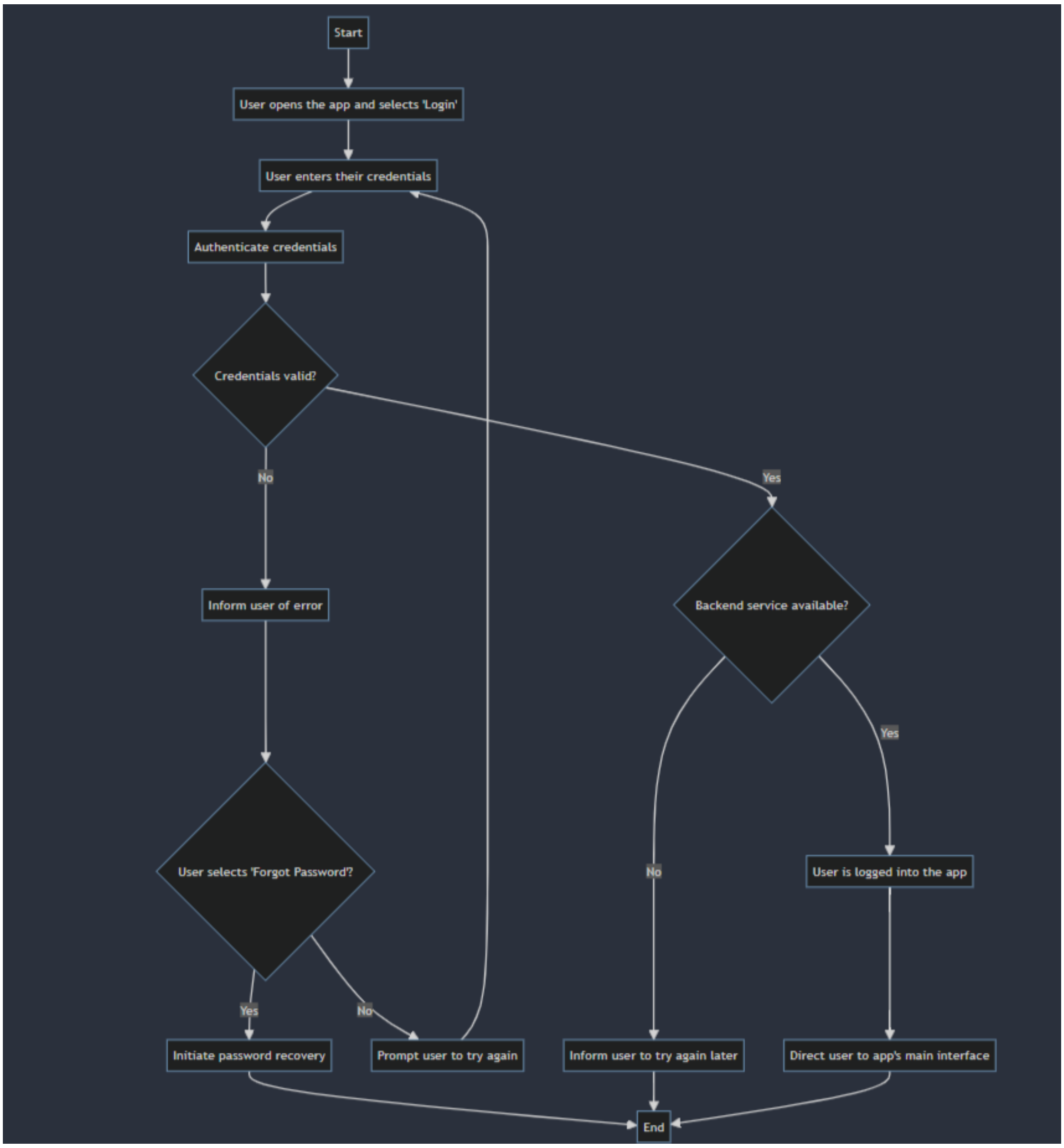

Start
User opens the app and selects 'Login'
User enters their credentials
Authenticate credentials
Credentials valid?
No
Yes
Inform user of error
Backend service available?
Yes
User selects 'Forgot Password'?
No
User is logged into the app
Yes
No
Initiate password recovery
Prompt user to try again
Inform user to try again later
Direct user to app's main interface
End

Figure 4.3.2 Login Activity Diagram

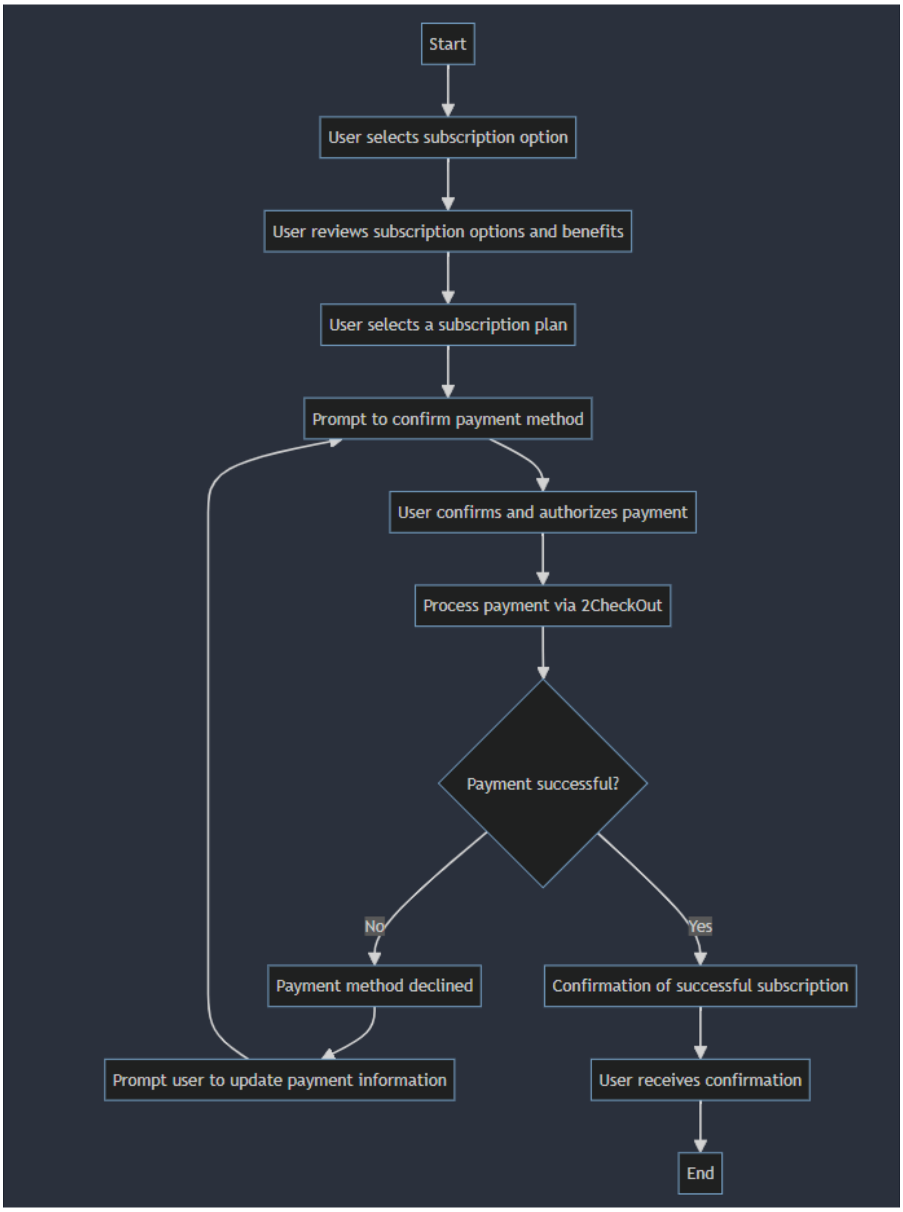

Start
User selects subscription option
User reviews subscription options and benefits
User selects a subscription plan
Prompt to confirm payment method
User confirms and authorizes payment
Process payment via 2CheckOut
Payment successful?
No
Yes
Payment method declined
Confirmation of successful subscription
Prompt user to update payment information
User receives confirmation
End

Figure 4.3.3 Subscribe Activity Diagram

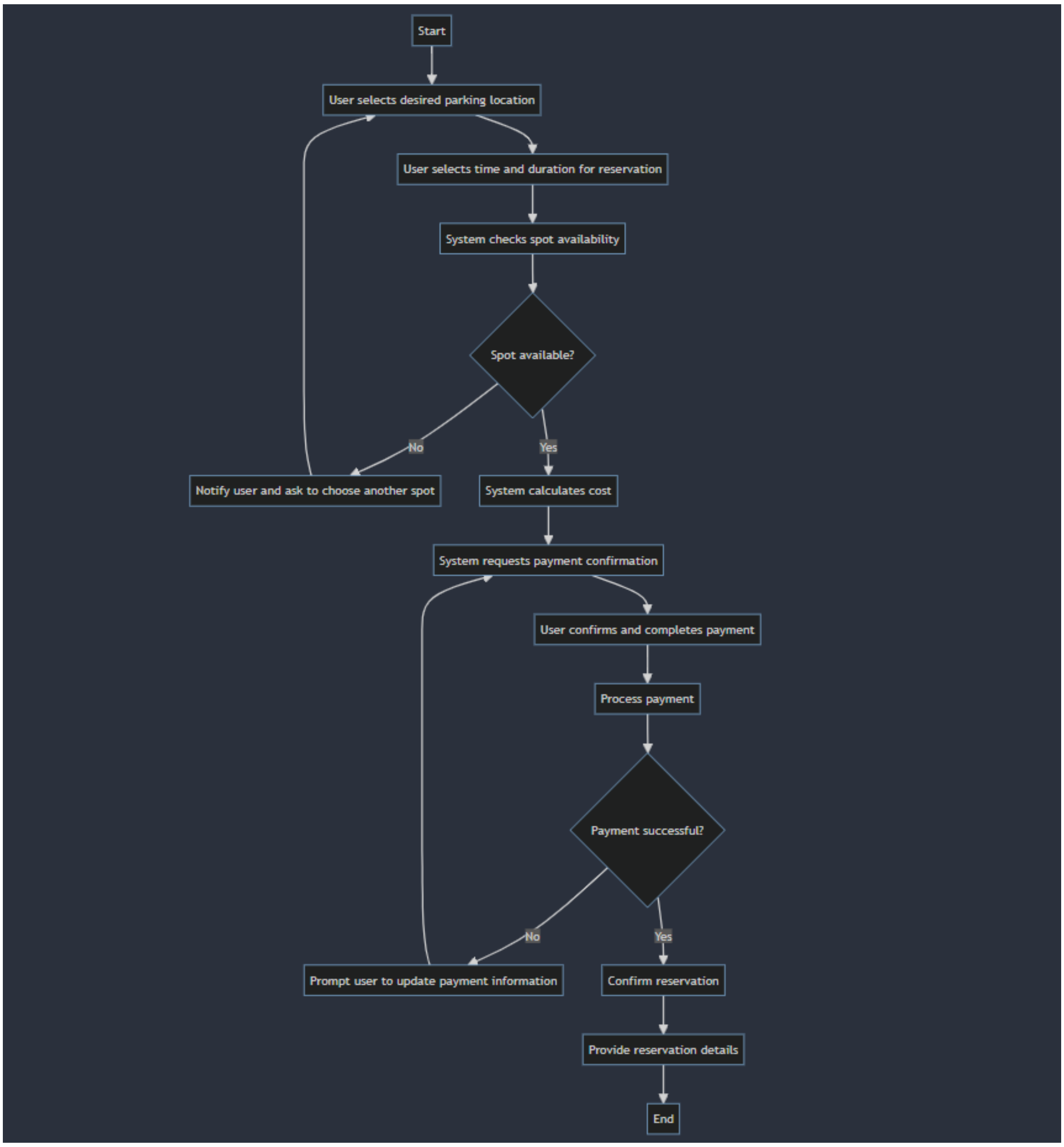

Start
User selects desired parking location
User selects time and duration for reservation
System checks spot availability
Spot available?
No
Yes
Notify user and ask to choose another spot
System calculates cost
System requests payment confirmation
User confirms and completes payment
Process payment
Payment successful?
No
Yes
Prompt user to update payment information
Confirm reservation
Provide reservation details
End

Figure 4.3.4 Reservation Activity Diagram

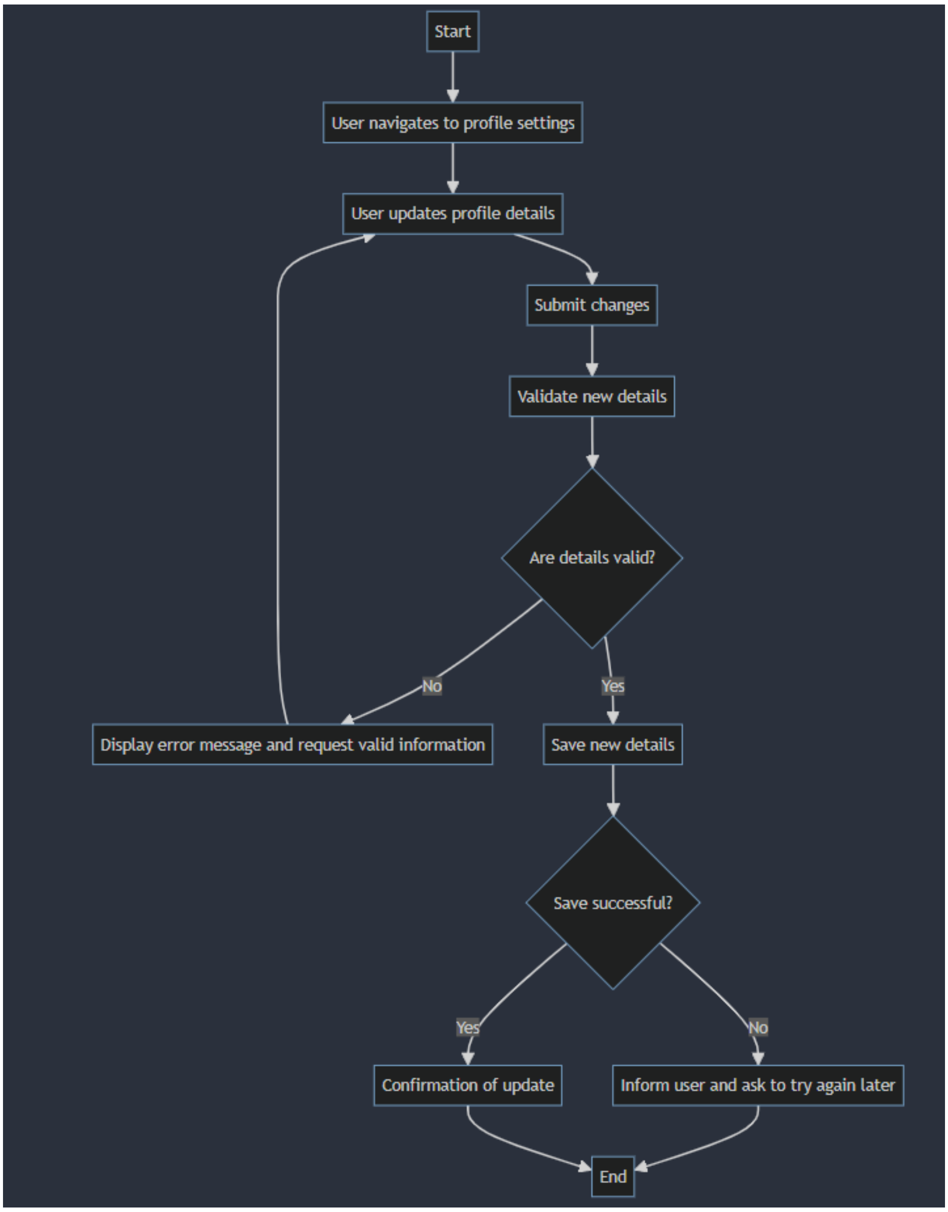

Start
User navigates to profile settings
User updates profile details
Submit changes
Validate new details
Are details valid?
No
Yes
Display error message and request valid information
Save new details
Save successful?
Yes
No
Confirmation of update
Inform user and ask to try again later
End

Figure 4.3.5 Manage User Profile Activity Diagram

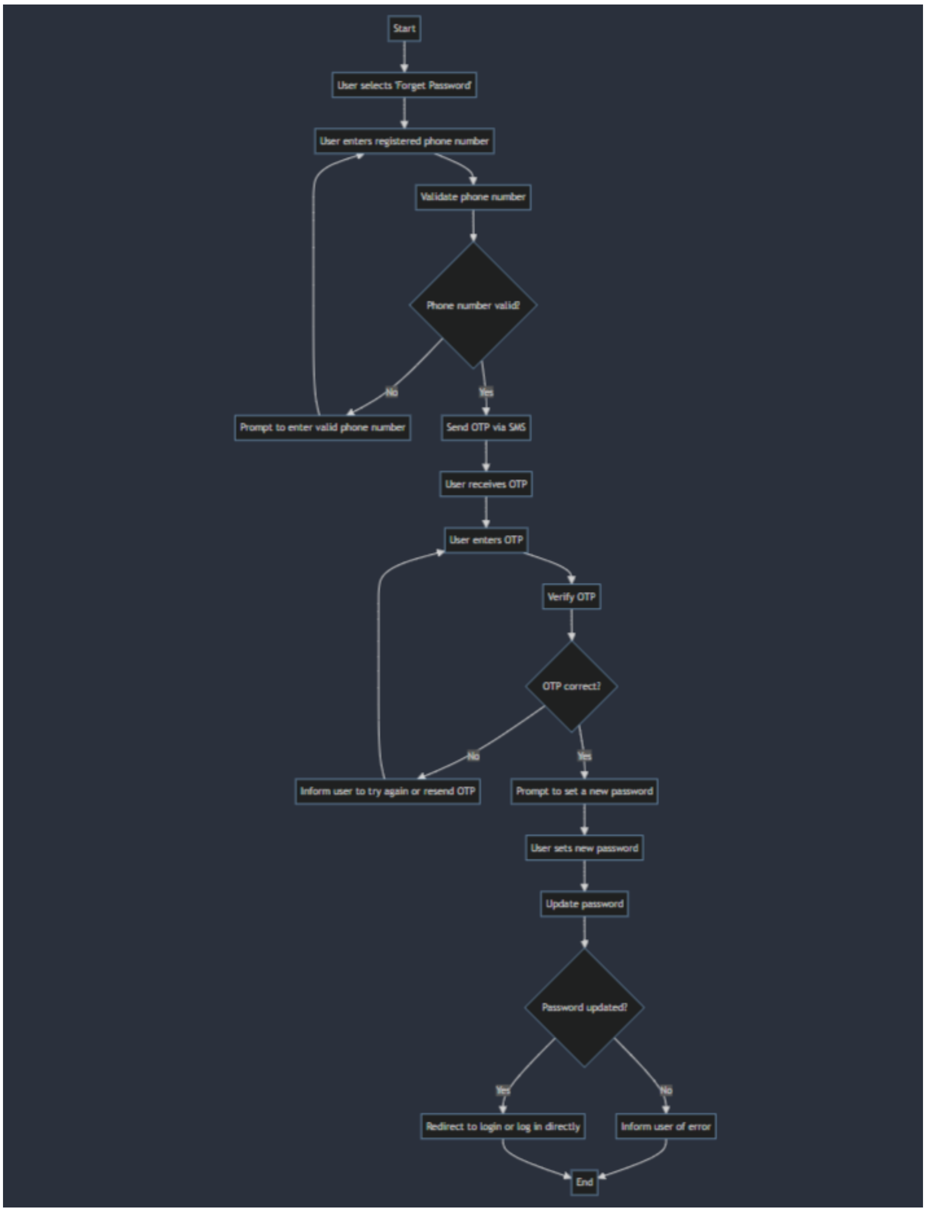


Figure 4.3.6 Forget Password Activity Diagram

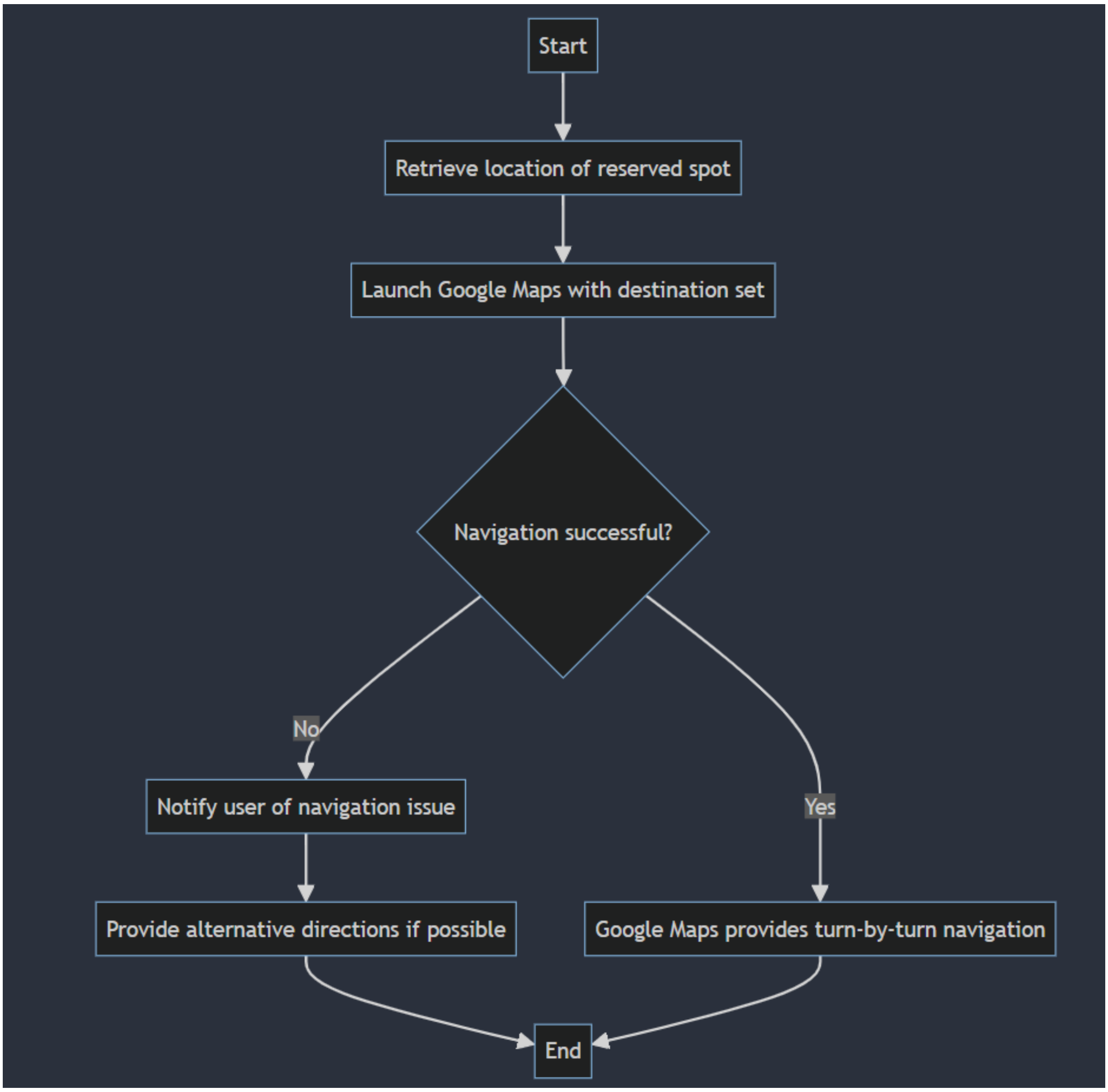

Start
Retrieve location of reserved spot
Launch Google Maps with destination set
Navigation successful?
No
Yes
Notify user of navigation issue
Provide alternative directions if possible
Google Maps provides turn-by-turn navigation
End

Figure 4.3.7 Navigate To Spot Activity Diagram

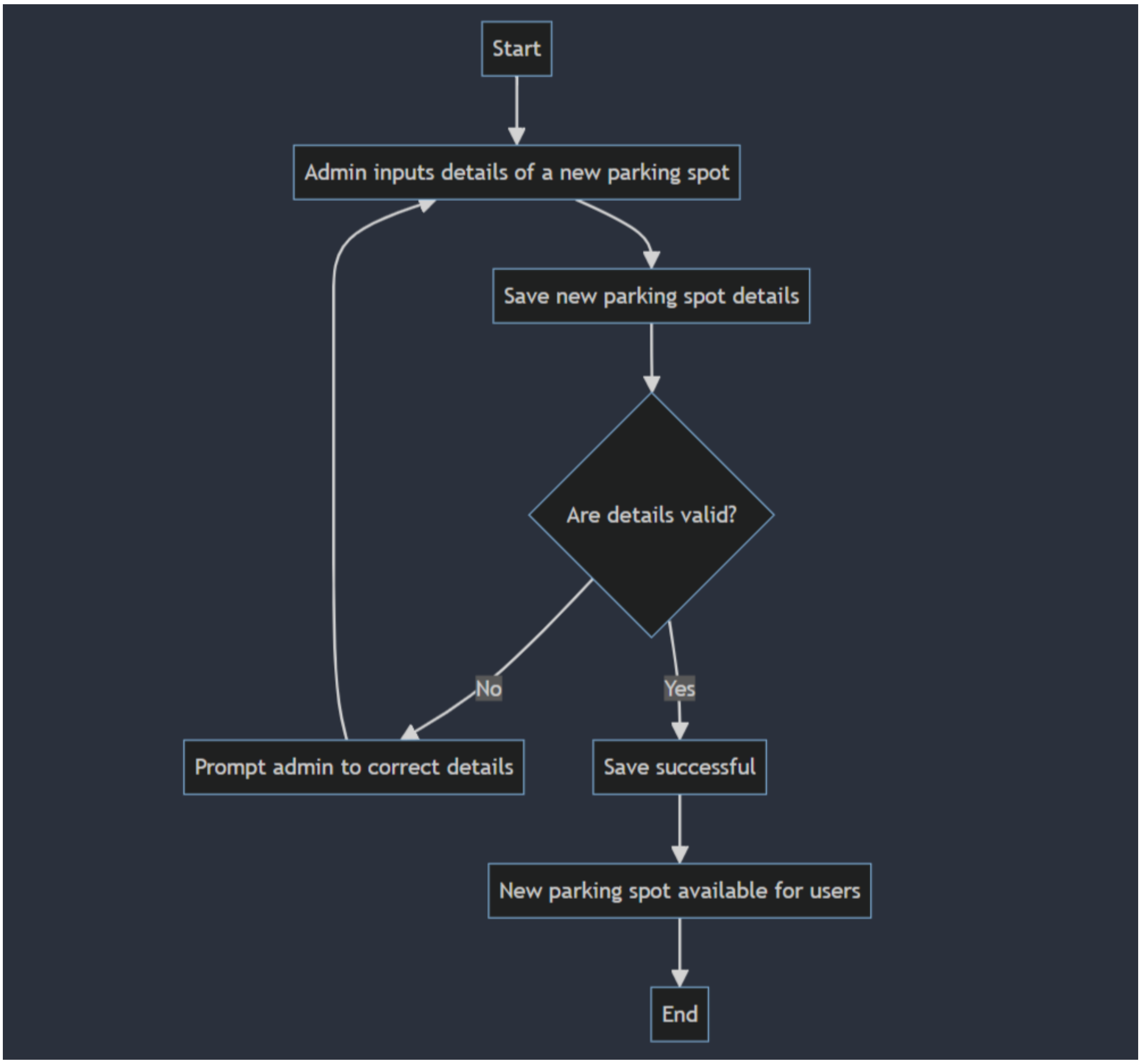

Start
Admin inputs details of a new parking spot
Save new parking spot details
Are details valid?
No
Yes
Prompt admin to correct details
Save successful
New parking spot available for users
End

Figure 4.3.8 Create Spot Activity Diagram

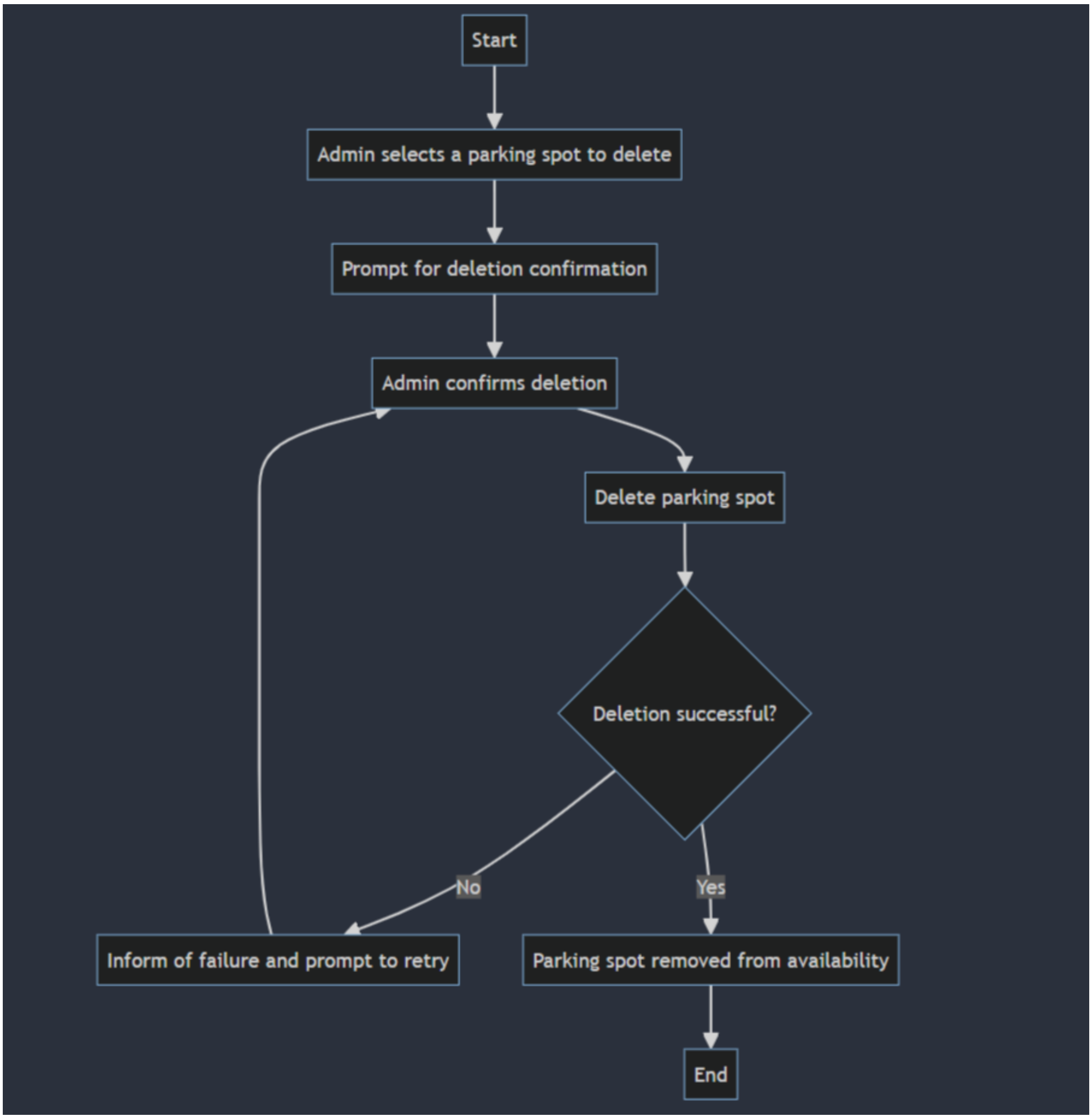

Start
Admin selects a parking spot to delete
Prompt for deletion confirmation
Admin confirms deletion
Delete parking spot
Deletion successful?
No
Yes
Inform of failure and prompt to retry
Parking spot removed from availability
End

Figure 4.3.9 Delete Spot Activity Diagram

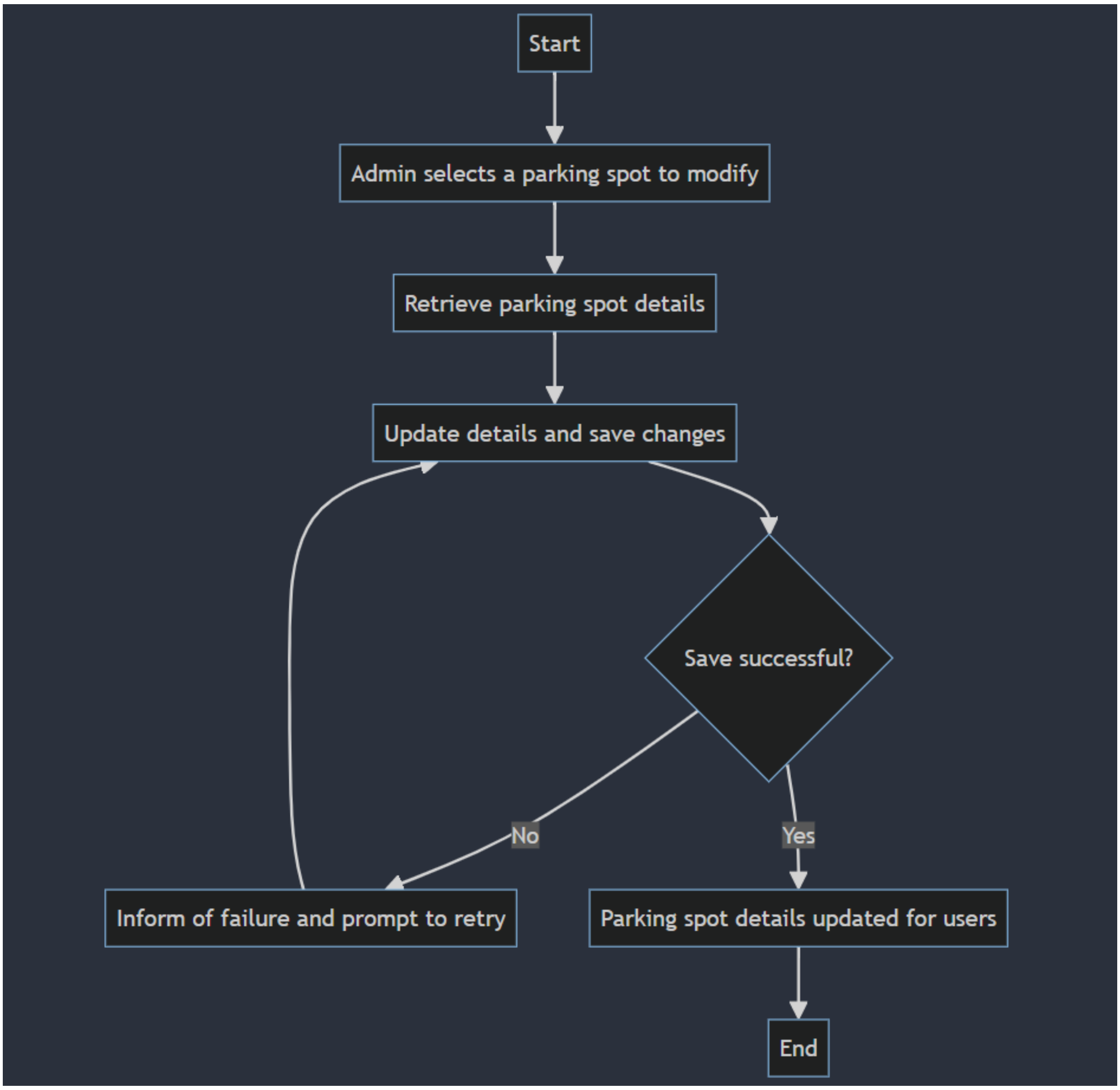

Start
Admin selects a parking spot to modify
Retrieve parking spot details
Update details and save changes
Save successful?
No
Yes
Inform of failure and prompt to retry
Parking spot details updated for users
End

Figure 4.3.10 Modify Spot Activity Diagram

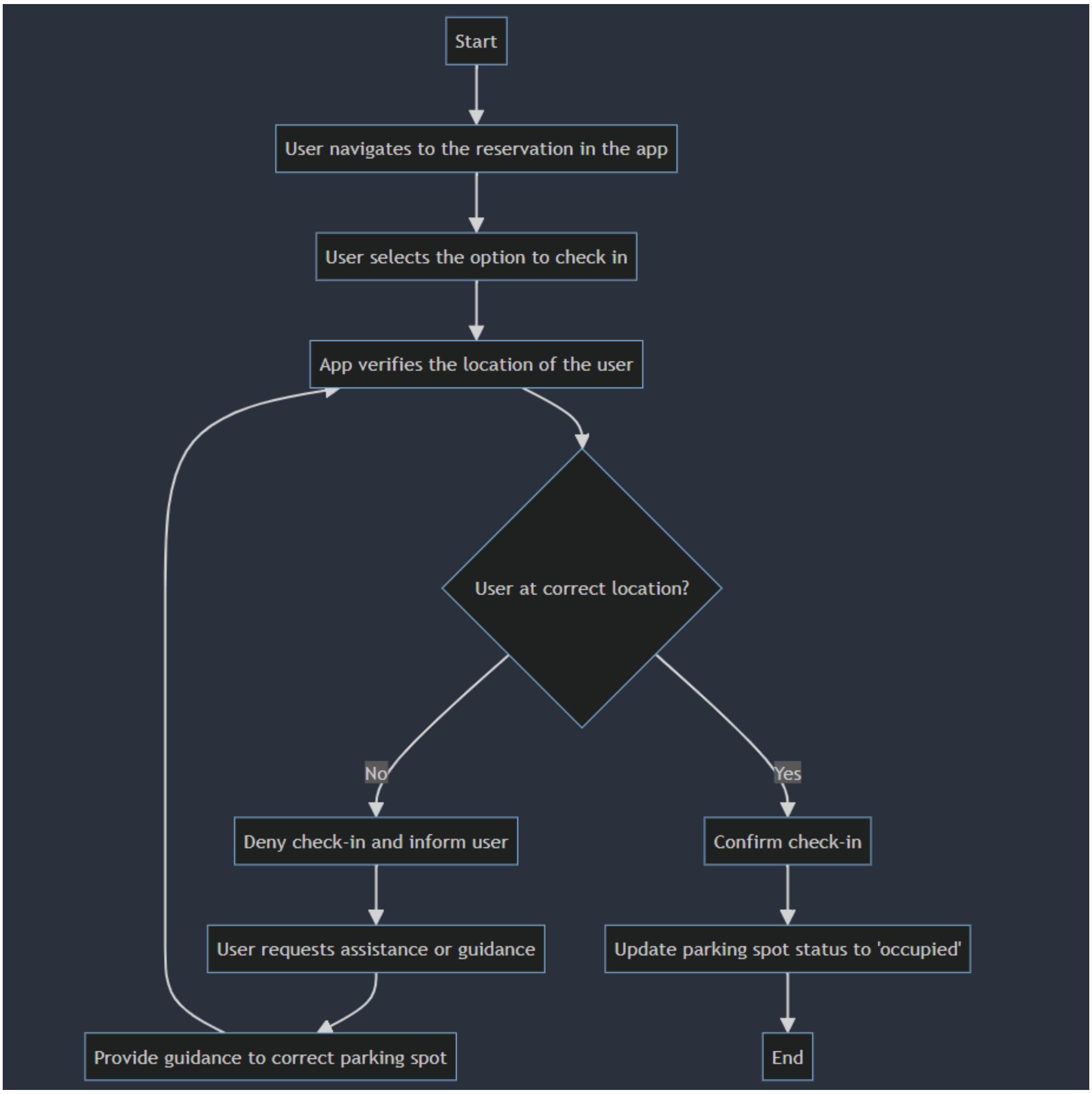

Start
User navigates to the reservation in the app
User selects the option to check in
App verifies the location of the user
User at correct location?
No
Yes
Deny check-in and inform user
Confirm check-in
User requests assistance or guidance
Update parking spot status to 'occupied'
Provide guidance to correct parking spot
End

Figure 4.3.11 Check-In Activity Diagram

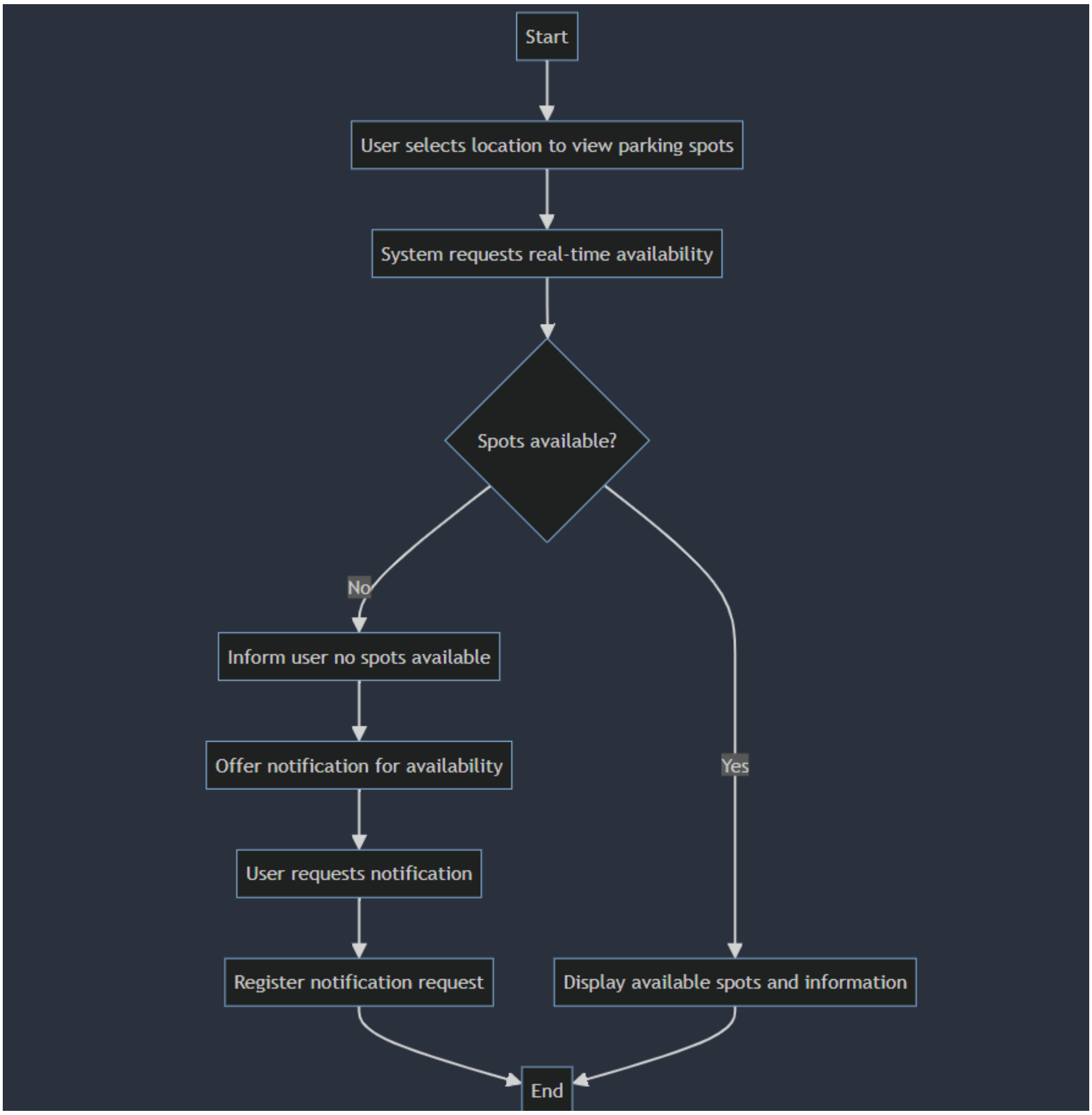

Start
User selects location to view parking spots
System requests real-time availability
Spots available?
No
Yes
Inform user no spots available
Offer notification for availability
User requests notification
Register notification request
Display available spots and information
End

Figure 4.3.12 View Parking Spots Activity Diagram

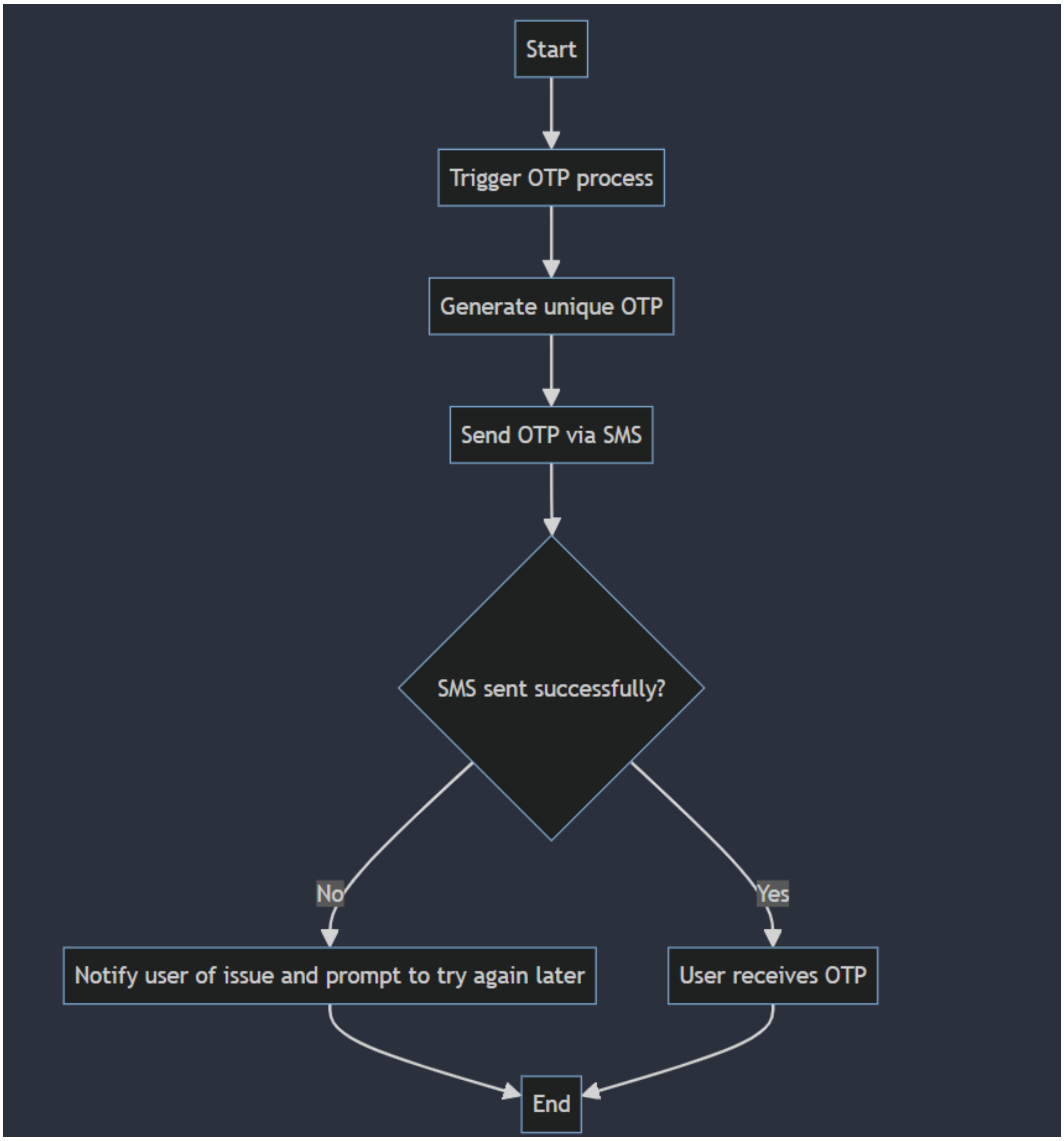


Figure 4.3.13 Send OTP Activity Diagram

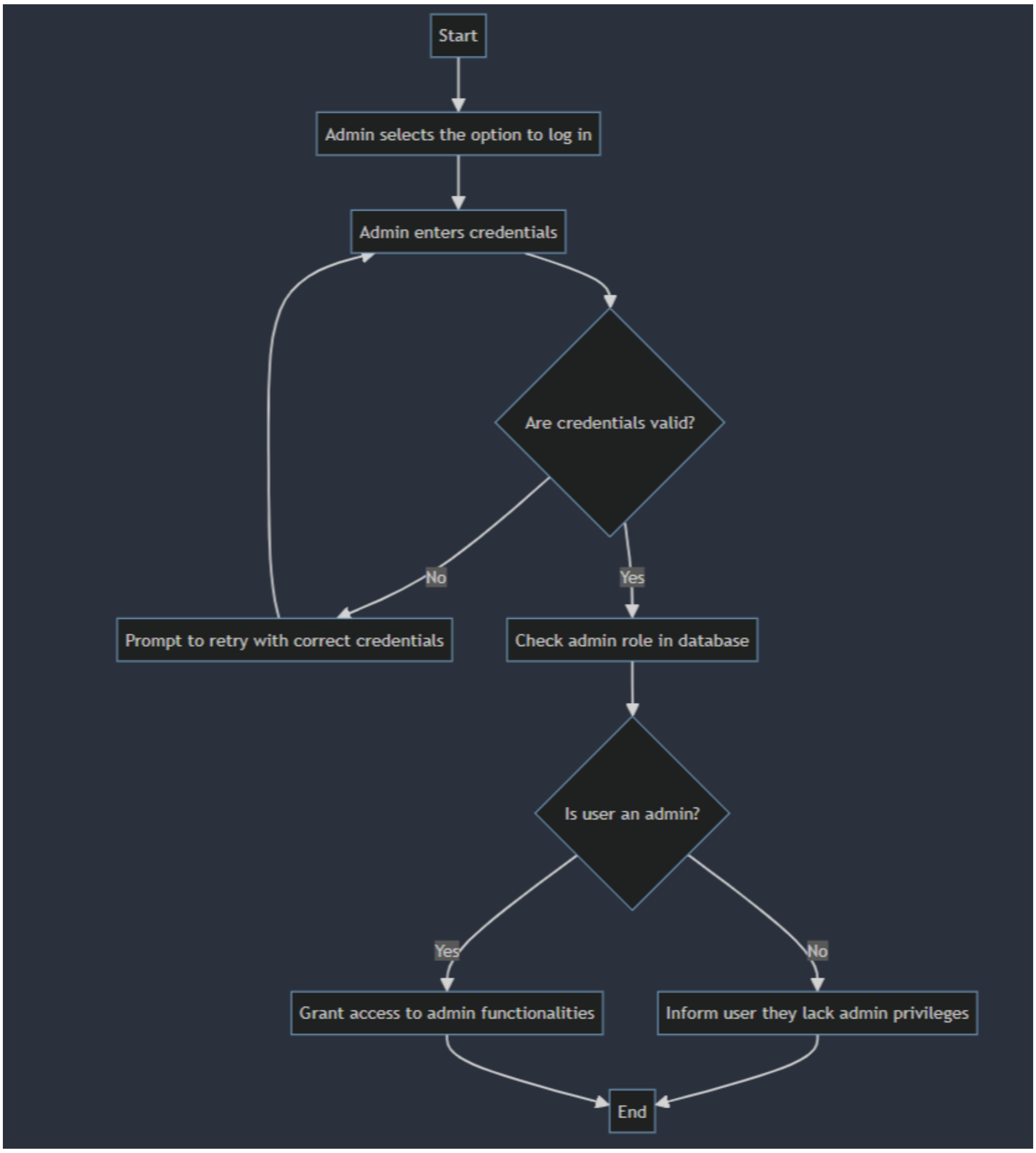

Start
Admin selects the option to log in
Admin enters credentials
Are credentials valid?
No
Yes
Prompt to retry with correct credentials
Check admin role in database
Is user an admin?
Yes
No
Grant access to admin functionalities
Inform user they lack admin privileges
End

Figure 4.3.14 Admin Authentication Activity Diagram

4.4 Sequence Diagrams

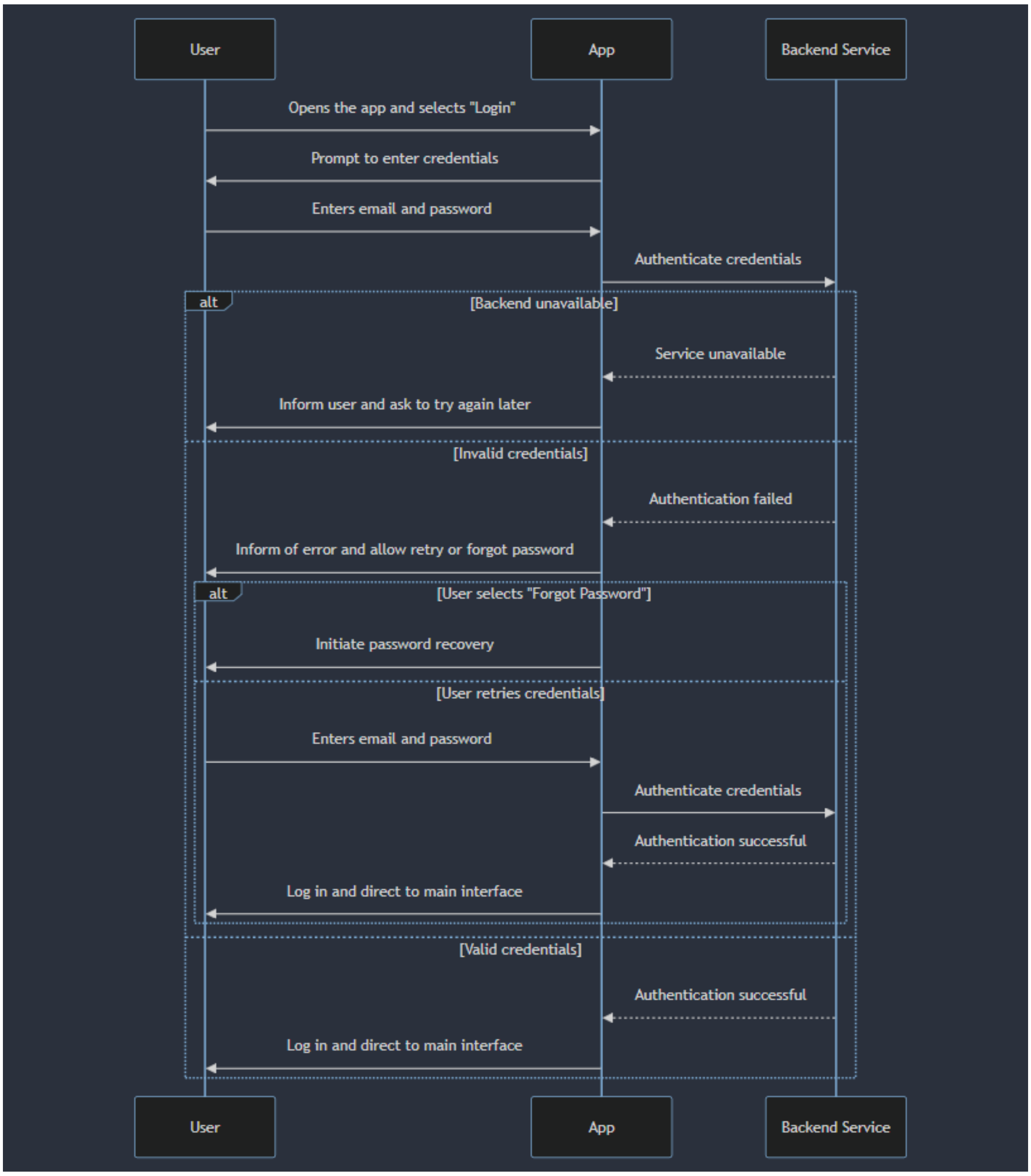

User
App
Backend Service
Opens the app and selects "Login"
Prompt to enter credentials
Enters email and password
Authenticate credentials
alt
[Backend unavailable]
Service unavailable
Inform user and ask to try again later
[Invalid credentials]
Authentication failed
Inform of error and allow retry or forgot password
alt
[User selects "Forgot Password"]
Initiate password recovery
[User retries credentials]
Enters email and password
Authenticate credentials
Authentication successful
Log in and direct to main interface
[Valid credentials]
Authentication successful
Log in and direct to main interface
User
App
Backend Service

Figure 4.4.1 Register Sequence Diagram

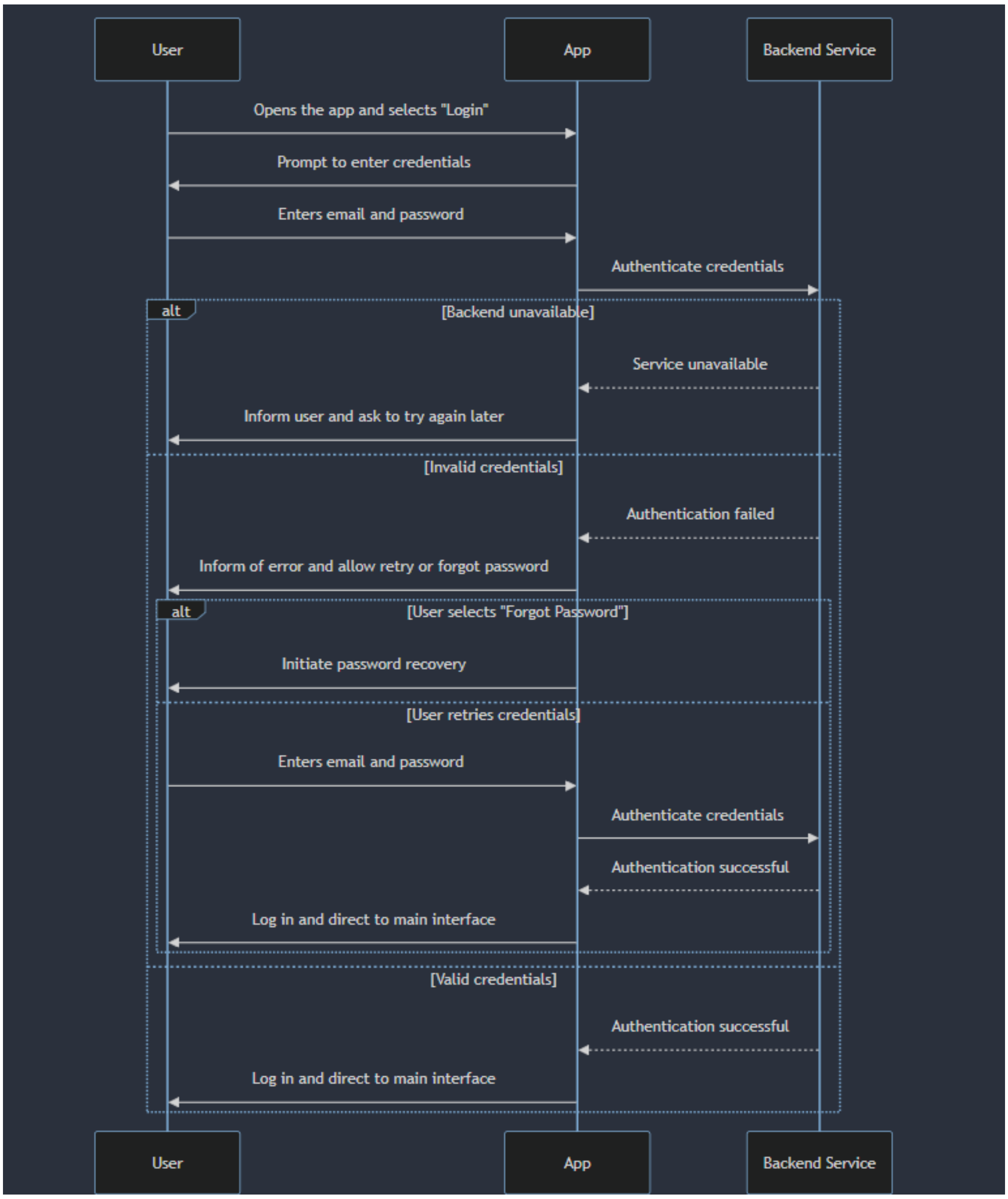

User
App
Backend Service
Opens the app and selects "Login"
Prompt to enter credentials
Enters email and password
Authenticate credentials
alt
[Backend unavailable]
Service unavailable
Inform user and ask to try again later
[Invalid credentials]
Authentication failed
Inform of error and allow retry or forgot password
alt
[User selects "Forgot Password"]
Initiate password recovery
[User retries credentials]
Enters email and password
Authenticate credentials
Authentication successful
Log in and direct to main interface
[Valid credentials]
Authentication successful
Log in and direct to main interface
User
App
Backend Service

Figure 4.4.2 Login Sequence Diagram

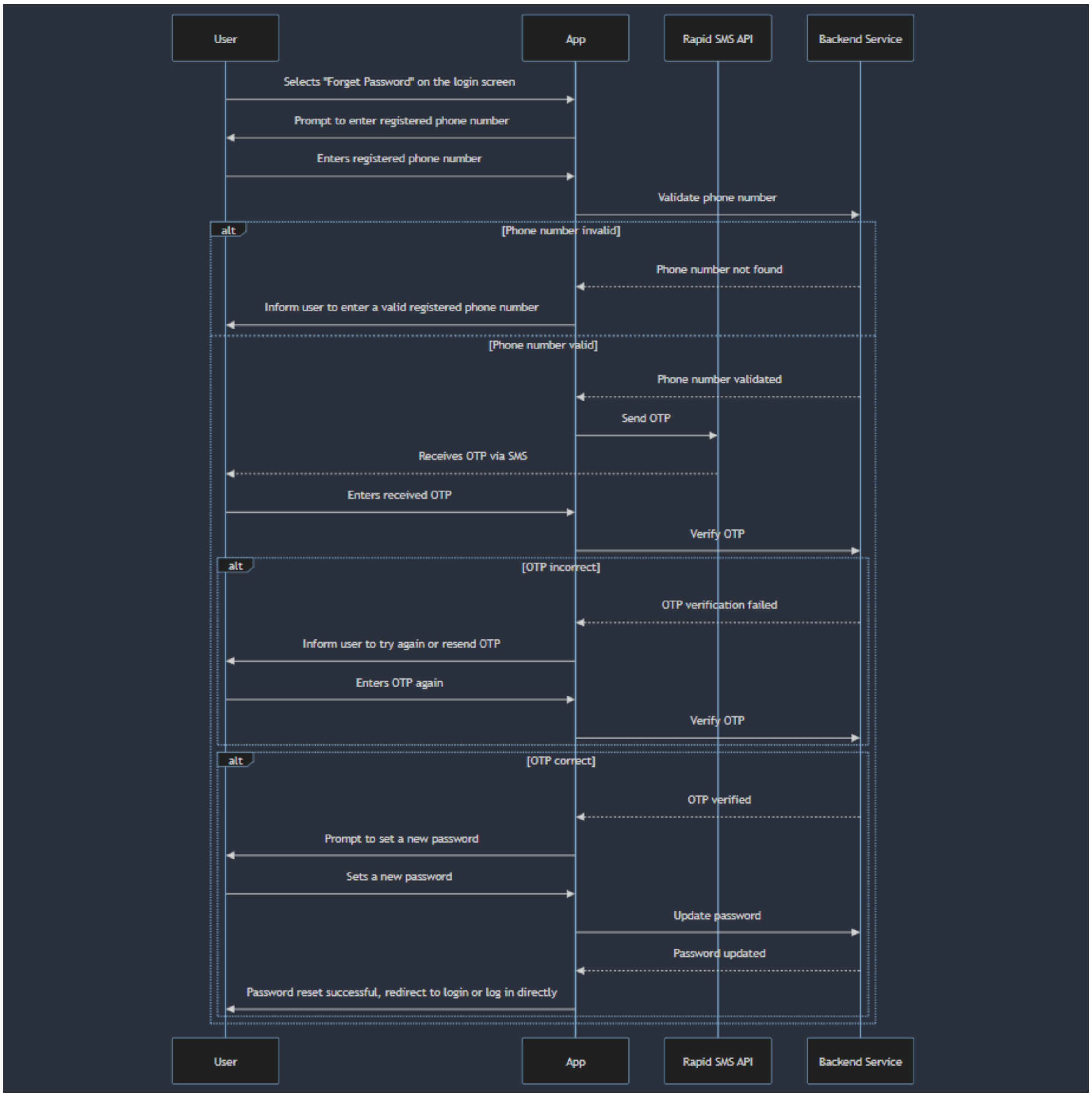


Figure 4.4.3 Reset Password Sequence Diagram

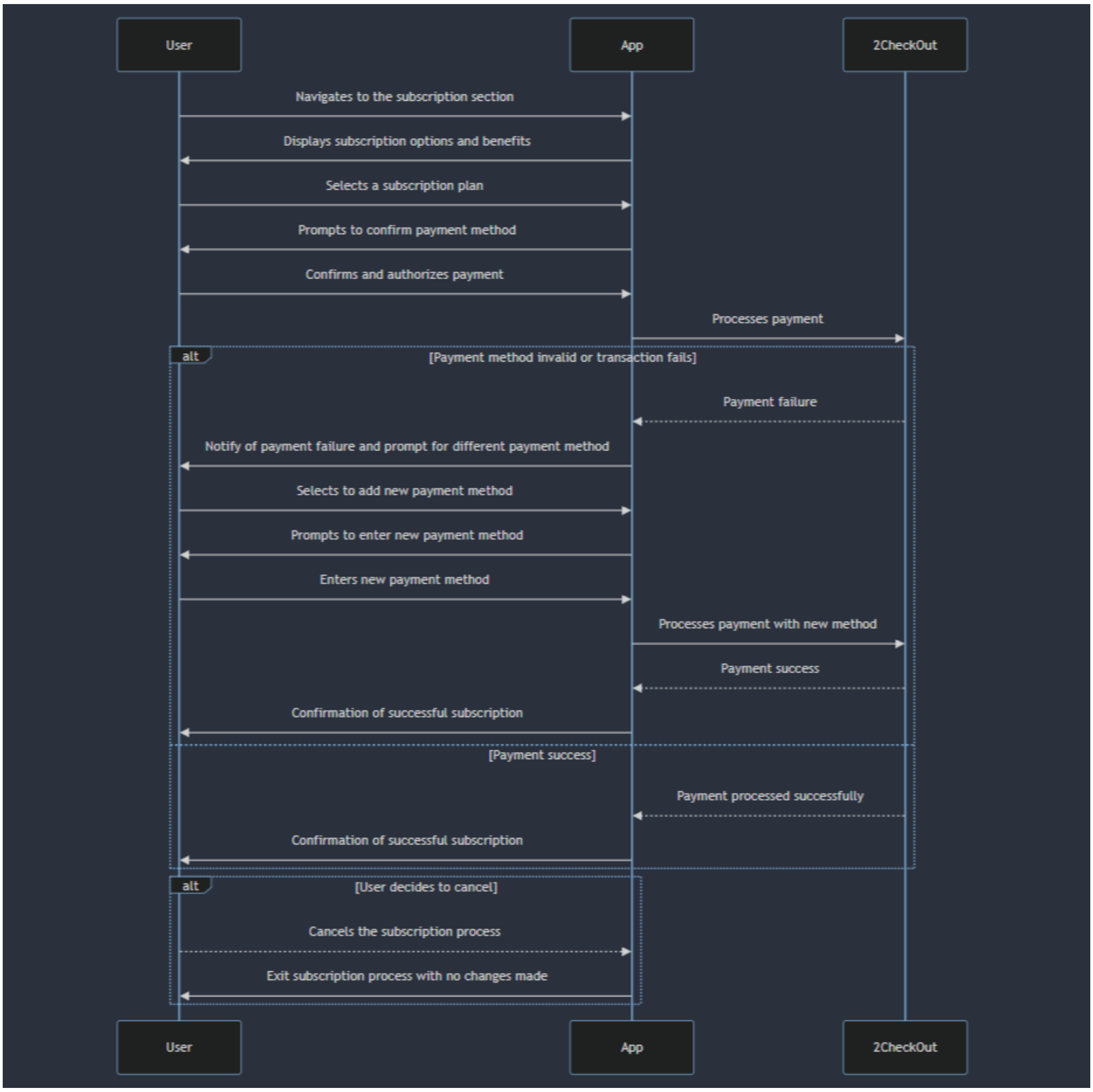

User
App
2CheckOut
Navigates to the subscription section
Displays subscription options and benefits
Selects a subscription plan
Prompts to confirm payment method
Confirms and authorizes payment
Processes payment
alt
[Payment method invalid or transaction fails]
Payment failure
Notify of payment failure and prompt for different payment method
Selects to add new payment method
Prompts to enter new payment method
Enters new payment method
Processes payment with new method
Payment success
Confirmation of successful subscription
[Payment success]
Payment processed successfully
Confirmation of successful subscription
alt
[User decides to cancel]
Cancels the subscription process
Exit subscription process with no changes made
User
App
2CheckOut

Figure 4.4.4 Subscribe Sequence Diagram

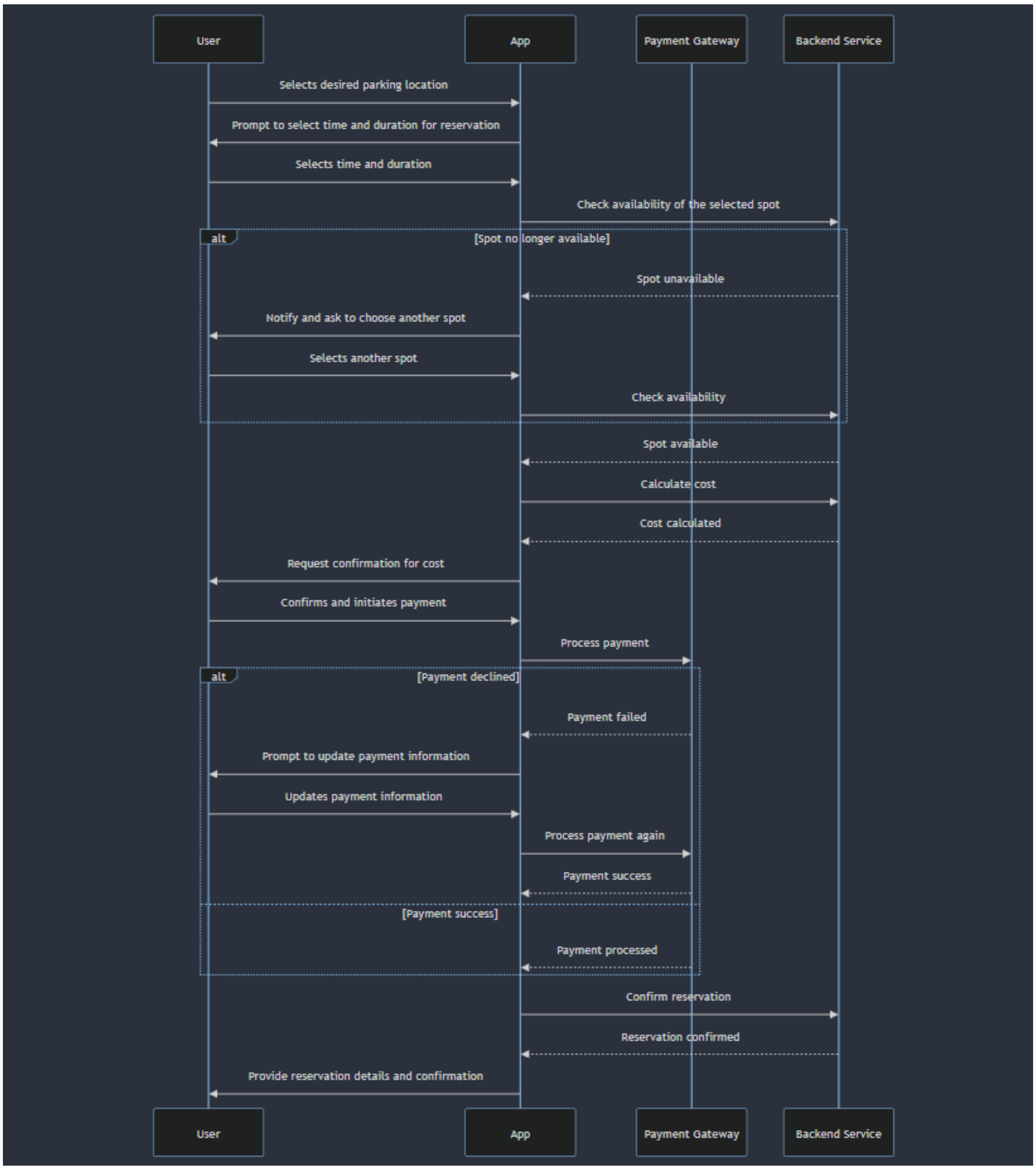

User
App
Payment Gateway
Backend Service
Selects desired parking location
Prompt to select time and duration for reservation
Selects time and duration
Check availability of the selected spot
alt
[Spot no longer available]
Spot unavailable
Notify and ask to choose another spot
Selects another spot
Check availability
Spot available
Calculate cost
Cost calculated
Request confirmation for cost
Confirms and initiates payment
Process payment
alt
[Payment declined]
Payment failed
Prompt to update payment information
Updates payment information
Process payment again
Payment success
[Payment success]
Payment processed
Confirm reservation
Reservation confirmed
Provide reservation details and confirmation
User
App
Payment Gateway
Backend Service

Figure 4.4.5 Reservation Sequence Diagram

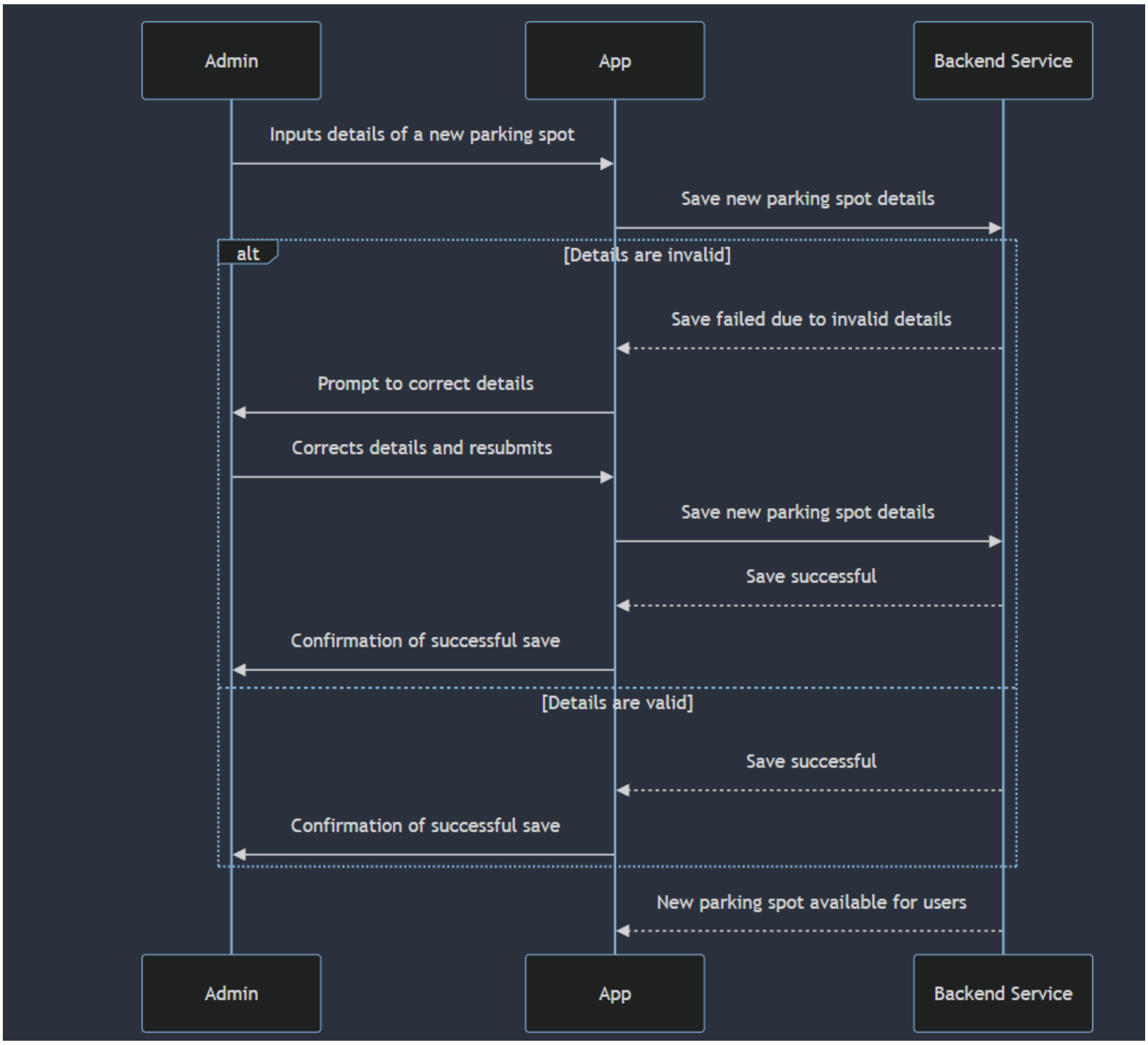

Admin
App
Backend Service
Inputs details of a new parking spot
Save new parking spot details
alt
[Details are invalid]
Save failed due to invalid details
Prompt to correct details
Corrects details and resubmits
Save new parking spot details
Save successful
Confirmation of successful save
[Details are valid]
Save successful
Confirmation of successful save
New parking spot available for users
Admin
App
Backend Service

Figure 4.4.6 Create Spot Sequence Diagram

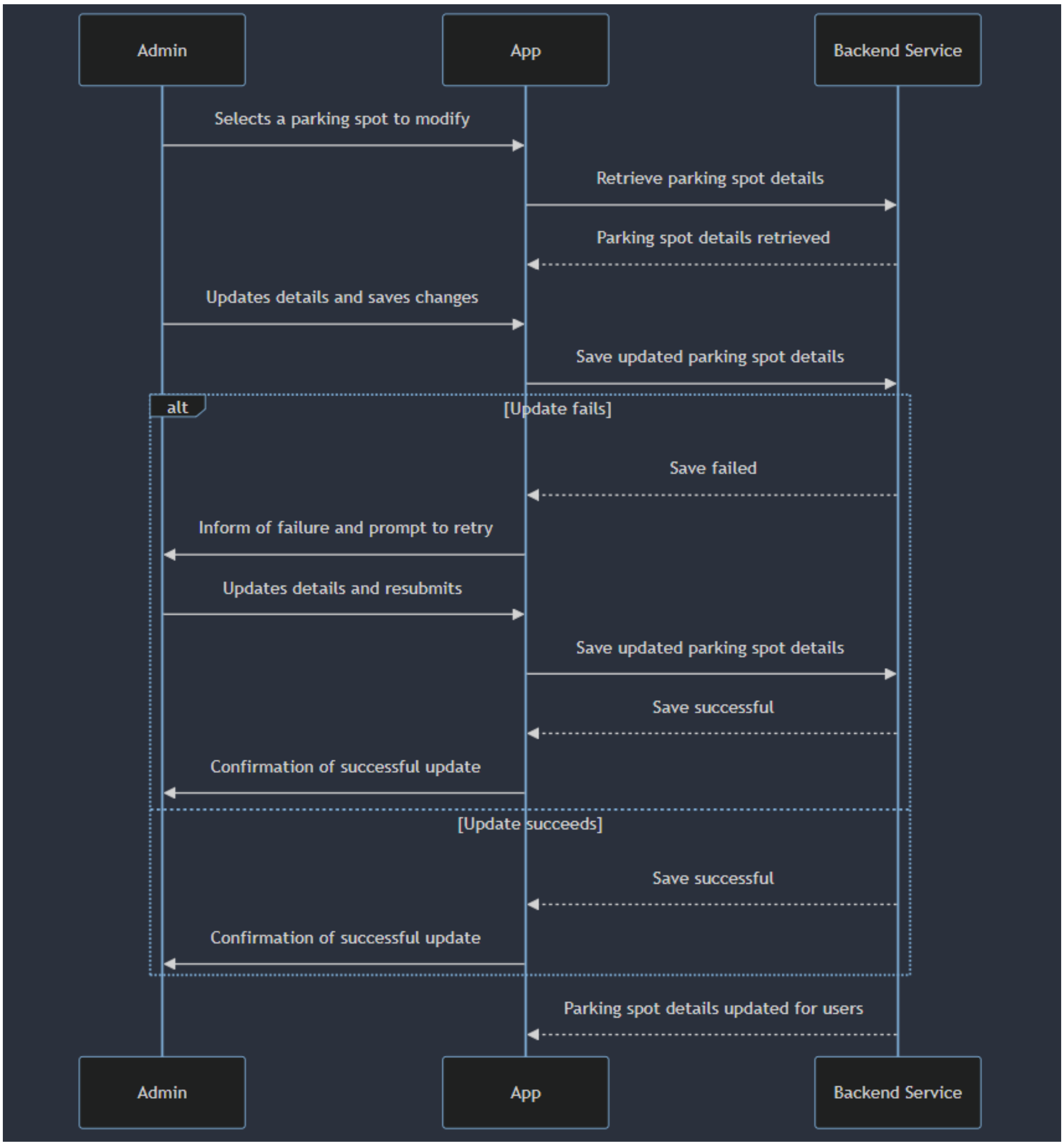

Admin
App
Backend Service
Selects a parking spot to modify
Retrieve parking spot details
Parking spot details retrieved
Updates details and saves changes
Save updated parking spot details
alt
[Update fails]
Save failed
Inform of failure and prompt to retry
Updates details and resubmits
Save updated parking spot details
Save successful
Confirmation of successful update
[Update succeeds]
Save successful
Confirmation of successful update
Parking spot details updated for users
Admin
App
Backend Service

Figure 4.4.7 Modify Spot Sequence Diagram

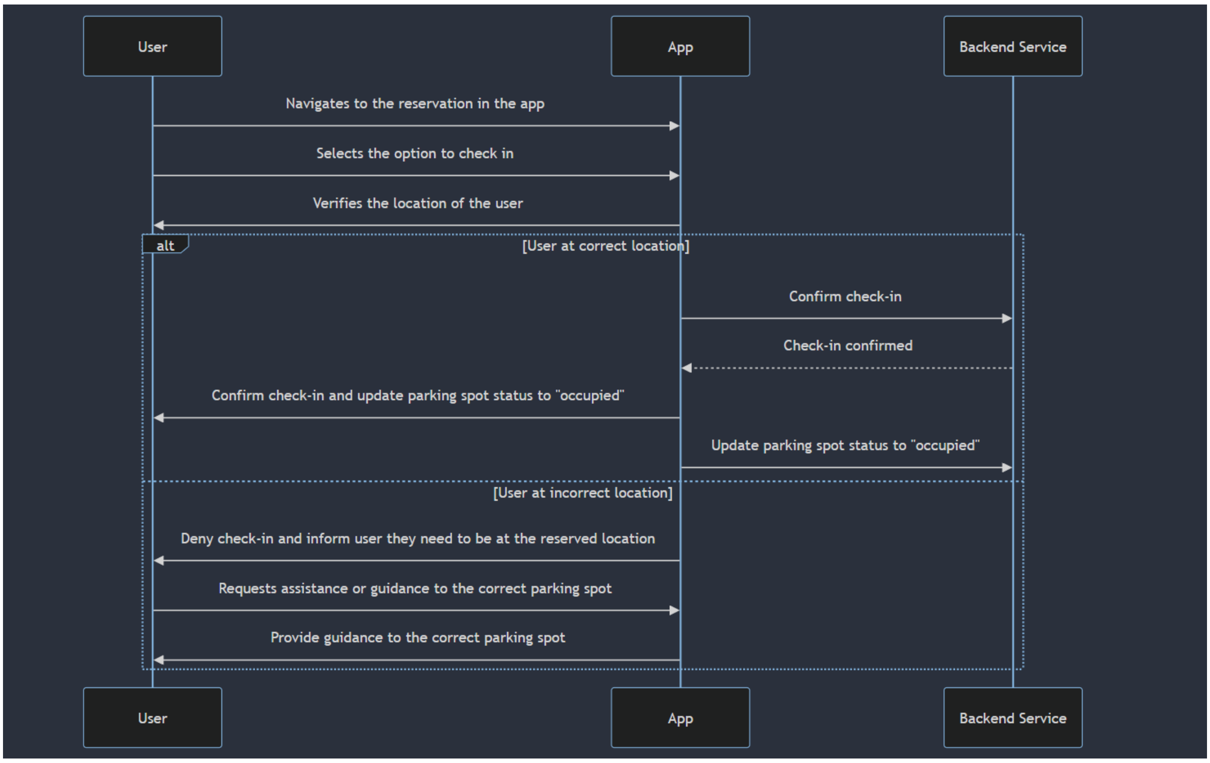

User
App
Backend Service
Navigates to the reservation in the app
Selects the option to check in
Verifies the location of the user
alt
[User at correct location]
Confirm check-in
Check-in confirmed
Confirm check-in and update parking spot status to "occupied"
Update parking spot status to "occupied"
[User at incorrect location]
Deny check-in and inform user they need to be at the reserved location
Requests assistance or guidance to the correct parking spot
Provide guidance to the correct parking spot
User
App
Backend Service

Figure 4.4.8 Check-In at Reserved Parking Spot Sequence Diagram

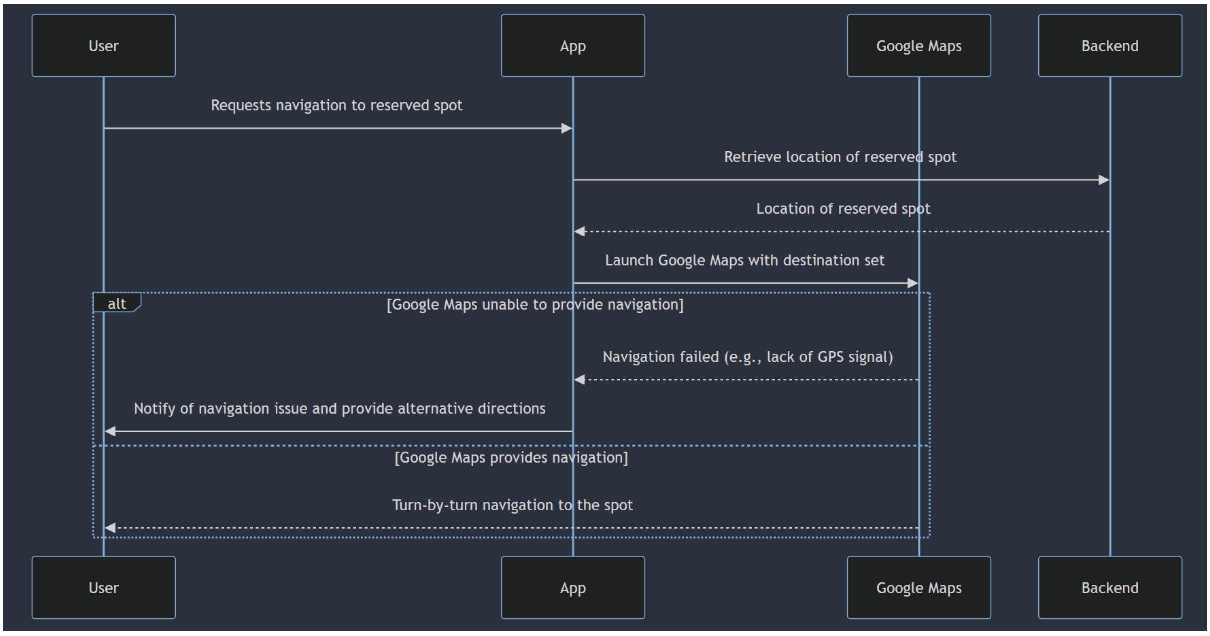

User
App
Google Maps
Backend
Requests navigation to reserved spot
Retrieve location of reserved spot
Location of reserved spot
Launch Google Maps with destination set
alt
[Google Maps unable to provide navigation]
Navigation failed (e.g., lack of GPS signal)
Notify of navigation issue and provide alternative directions
[Google Maps provides navigation]
Turn-by-turn navigation to the spot
User
App
Google Maps
Backend

Figure 4.4.9 Navigate to Reserved Spot Using Google Maps Sequence Diagram

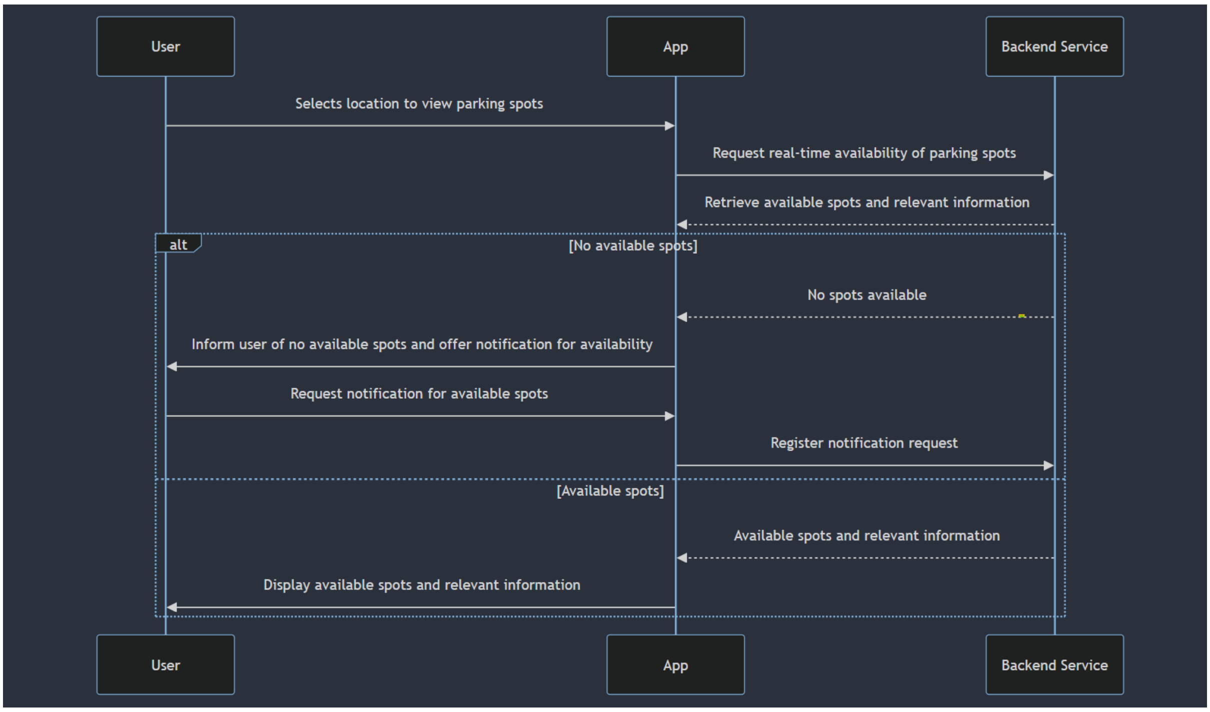

User
App
Backend Service
Selects location to view parking spots
Request real-time availability of parking spots
Retrieve available spots and relevant information
alt
[No available spots]
No spots available
Inform user of no available spots and offer notification for availability
Request notification for available spots
Register notification request
[Available spots]
Available spots and relevant information
Display available spots and relevant information
User
App
Backend Service

Figure 4.4.10 View Parking Availability Sequence Diagram

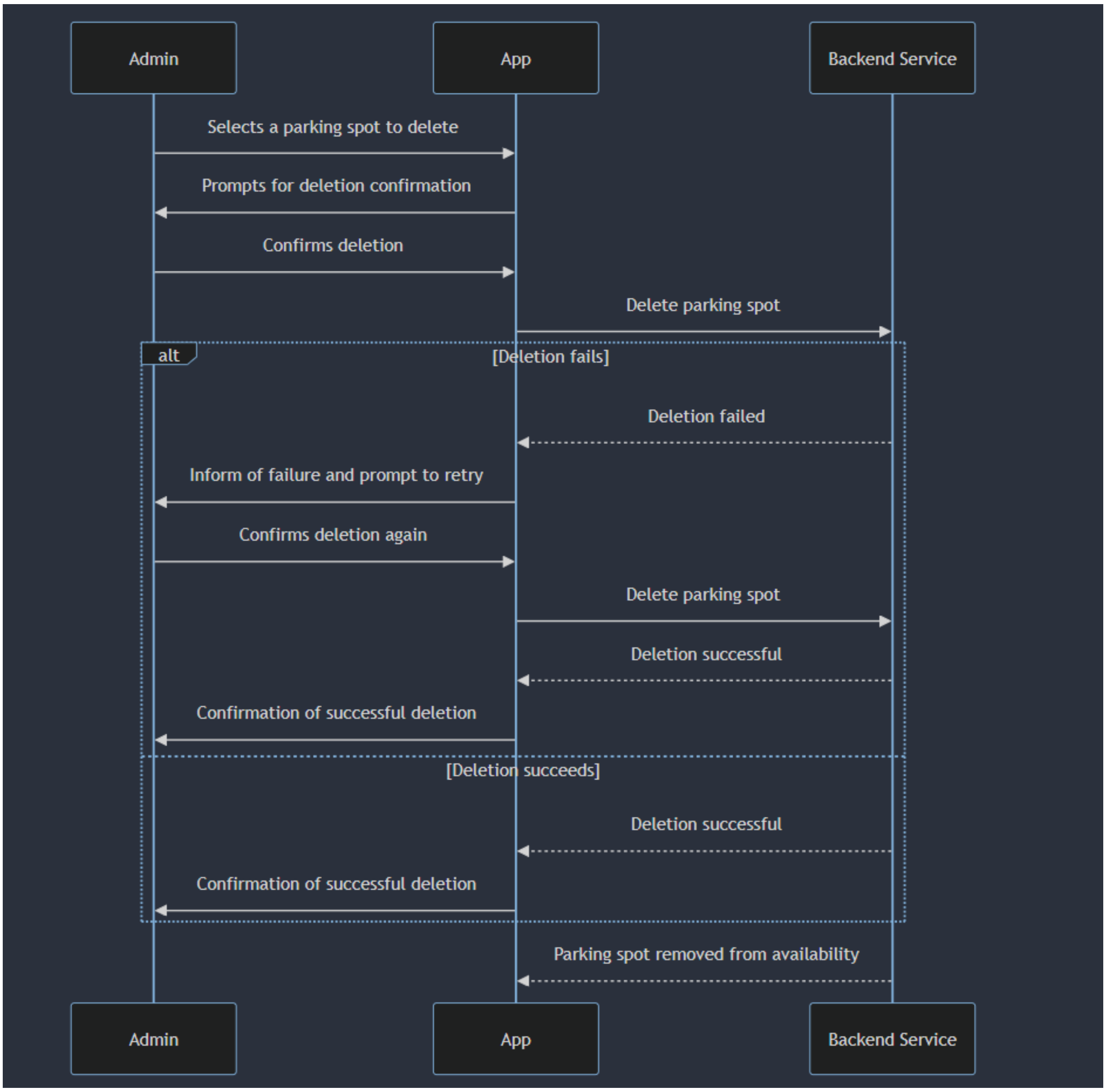


Figure 4.4.11 Delete Spot Sequence Diagram

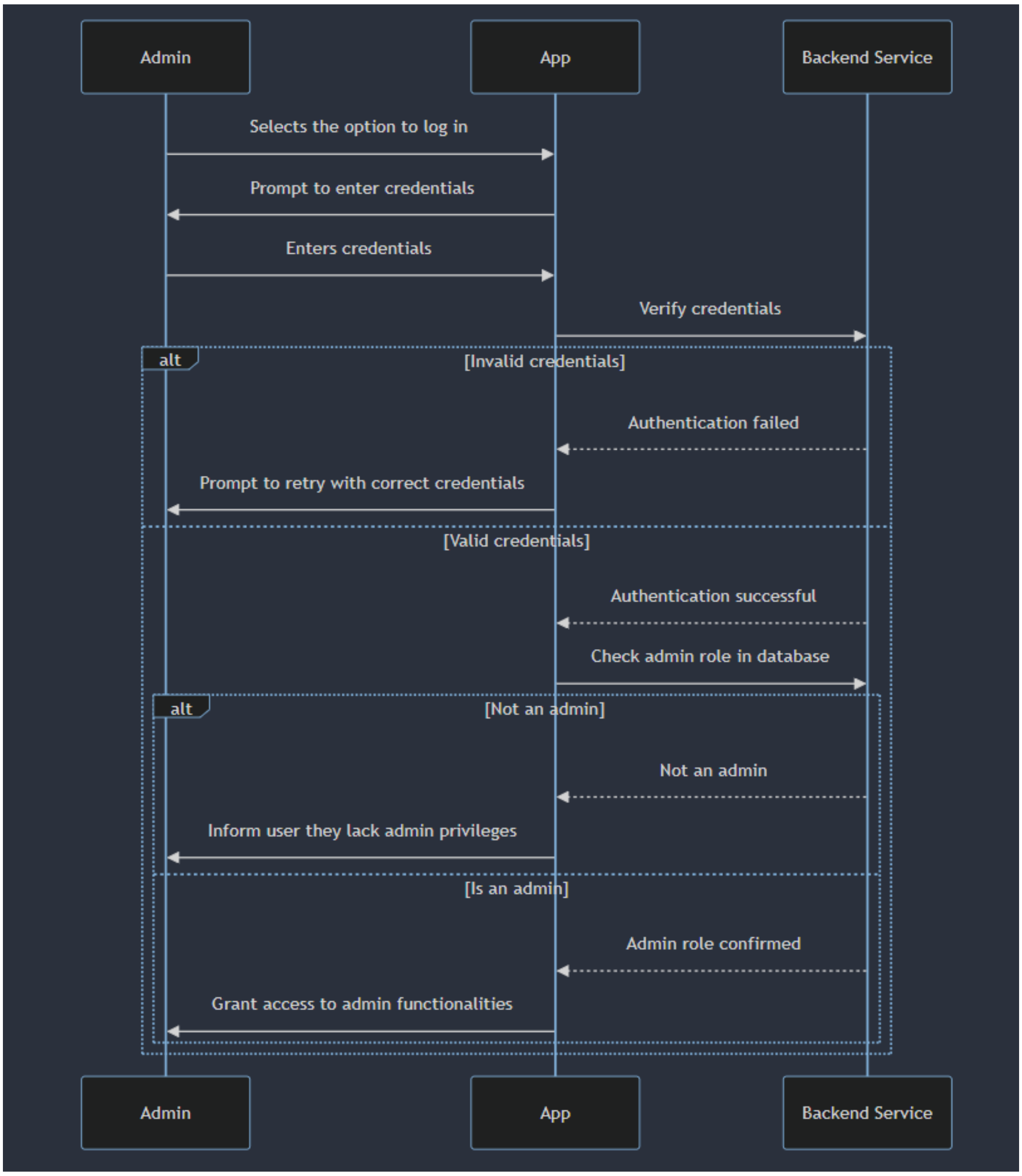

Admin
App
Backend Service
Selects the option to log in
Prompt to enter credentials
Enters credentials
Verify credentials
alt
[Invalid credentials]
Authentication failed
Prompt to retry with correct credentials
[Valid credentials]
Authentication successful
Check admin role in database
alt
[Not an admin]
Not an admin
Inform user they lack admin privileges
[Is an admin]
Admin role confirmed
Grant access to admin functionalities
Admin
App
Backend Service

Figure 4.4.12 Admin Authentication Sequence Diagram

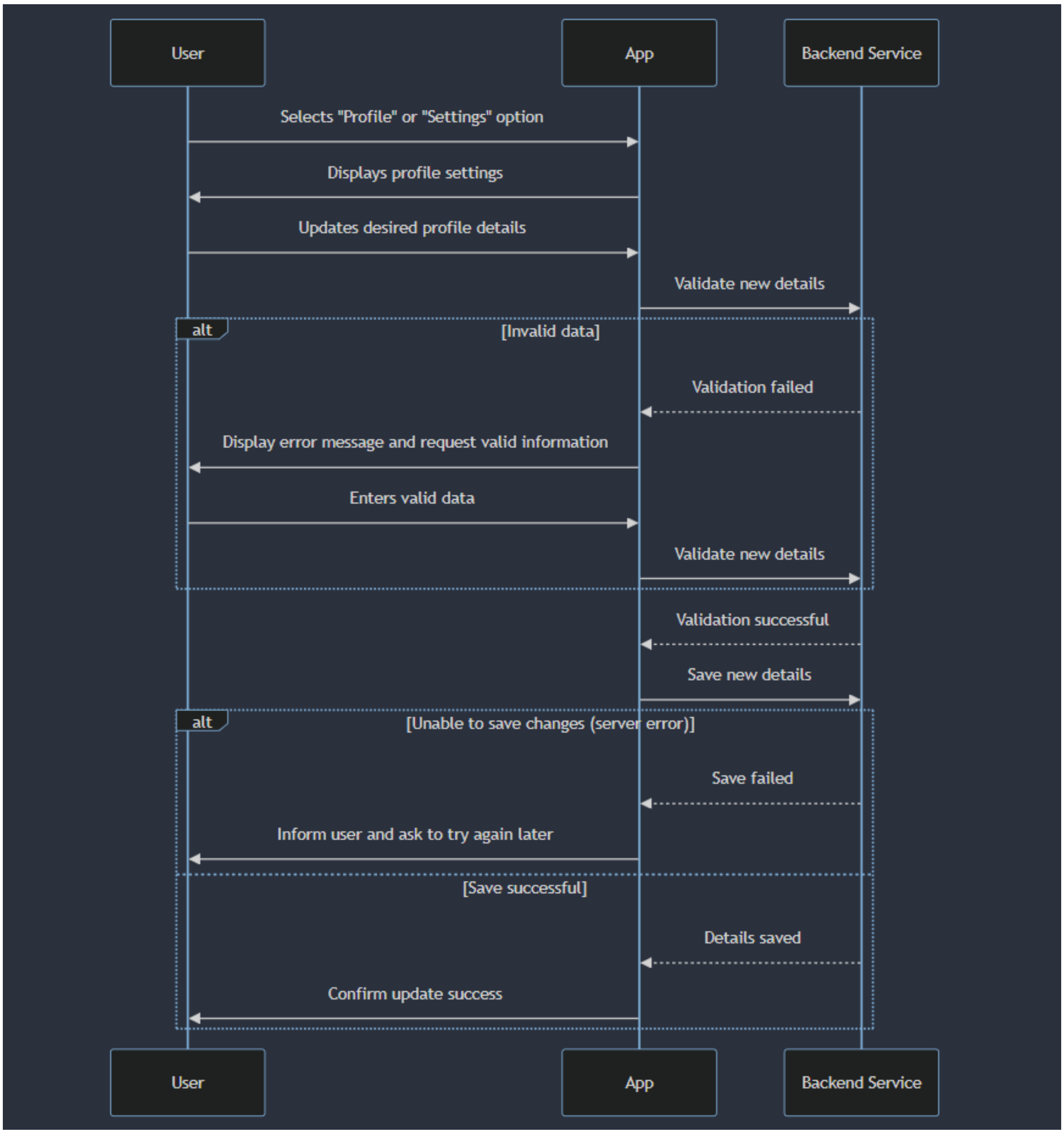


Figure 4.4.13 Manage Users Profile Sequence Diagram

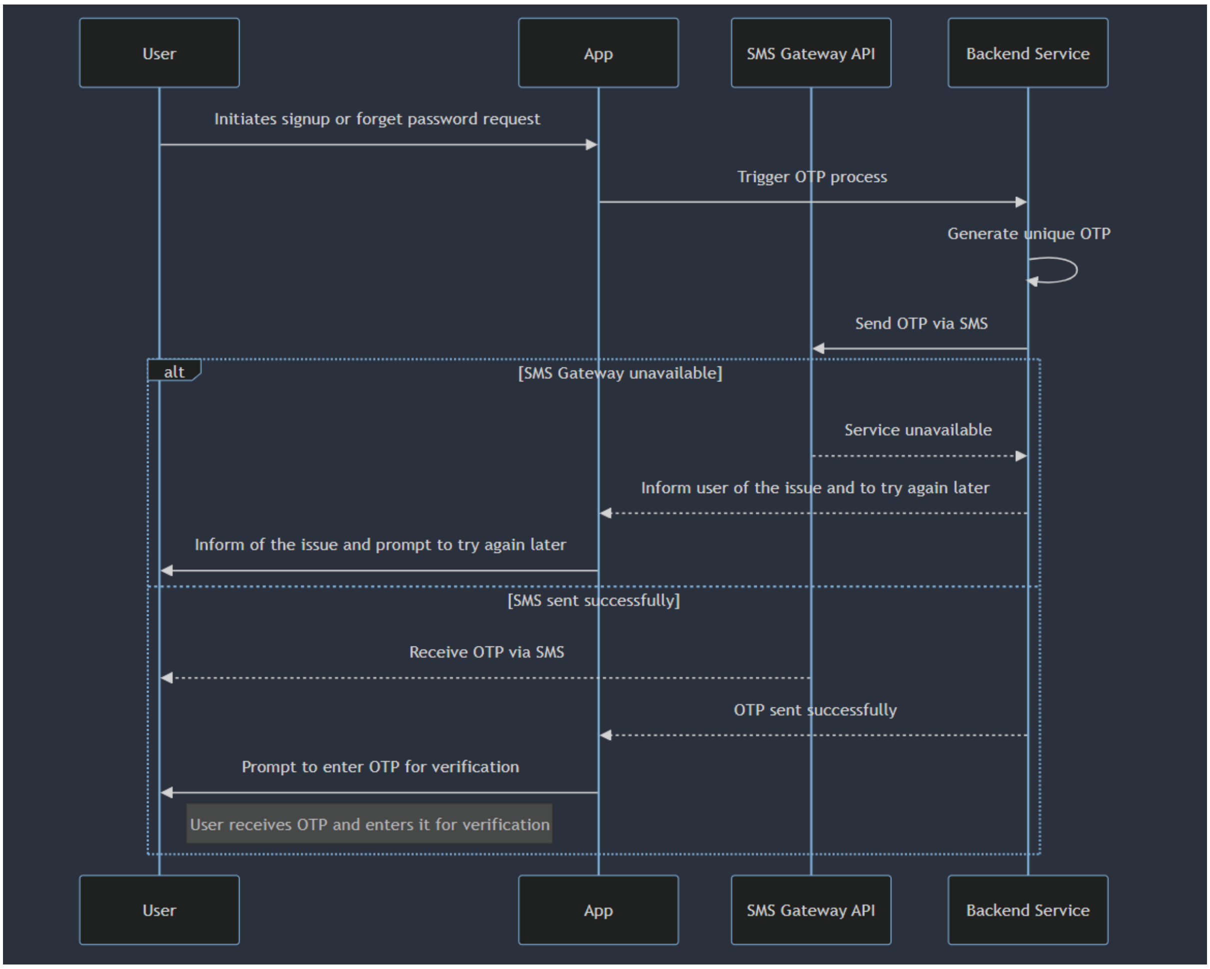

User
App
SMS Gateway API
Backend Service
Initiates signup or forget password request
Trigger OTP process
Generate unique OTP
Send OTP via SMS
alt
[SMS Gateway unavailable]
Service unavailable
Inform user of the issue and to try again later
Inform of the issue and prompt to try again later
[SMS sent successfully]
Receive OTP via SMS
OTP sent successfully
Prompt to enter OTP for verification
User receives OTP and enters it for verification
User
App
SMS Gateway API
Backend Service

Figure 4.4.14 Send OTP Sequence Diagram

5. Class Diagram

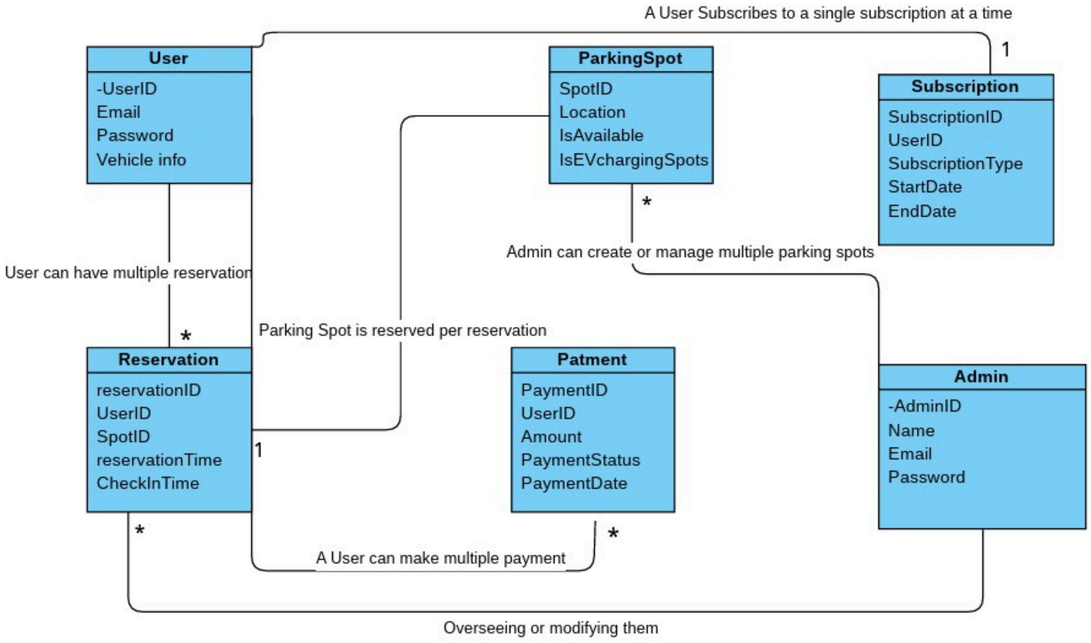


Figure 4.5.1 Class Diagram

6. Entity Relationship Diagram

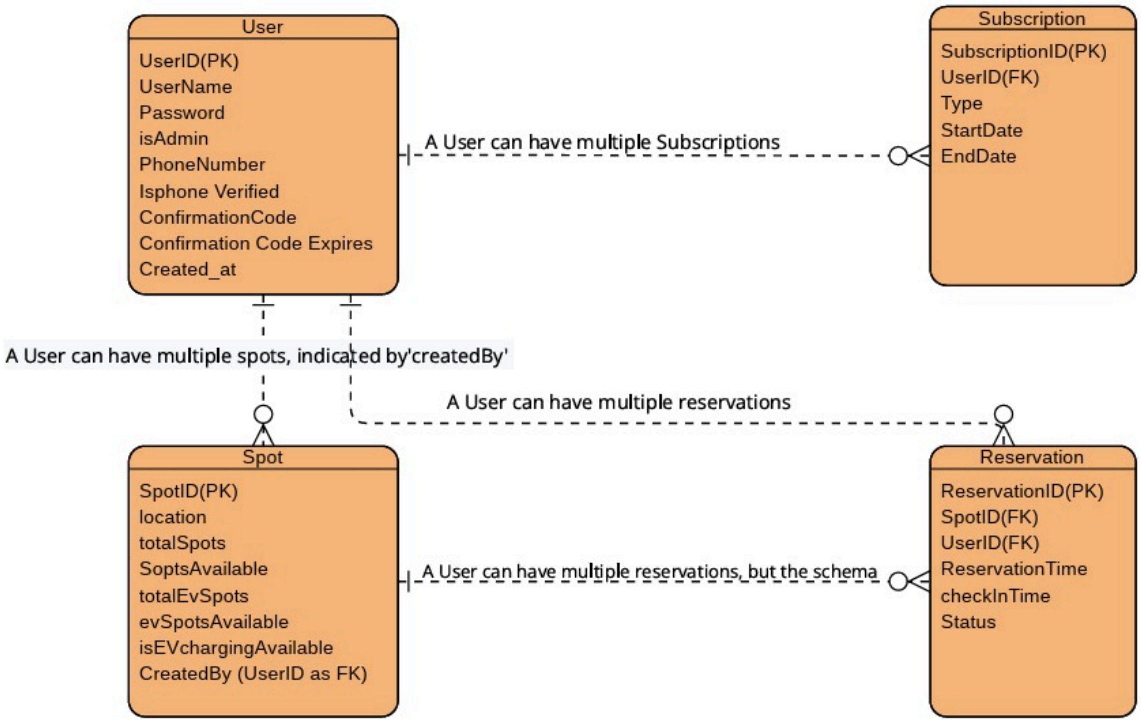


Figure 4.6.1 Entity Relationship Diagram

Chapter 5: System Implementation

This chapter discusses the implementation details of the "ParkEase" project, covering the development environment, database implementation, user interface construction, and functionality implementation. It also elaborates on the integration of external services/APIs, security measures, and performance optimization techniques, showcasing the practical application of the proposed design and architecture.

1. Development Environment

Tools Used:

1. **IDE**: Visual Studio Code (VSCode) for development.
2. **Version Control**: Integration of Git and GitHub for version control.
3. **Linters and Code Formatters**: ESLint for JavaScript, Prettier for code formatting.
4. **Debugging Tools**: Built-in VSCode debugger and Chrome DevTools.

Development Workflow:

1. Use of feature branches for isolated development.
2. Pull requests for code reviews and quality assurance.

2. User Interface Implementation

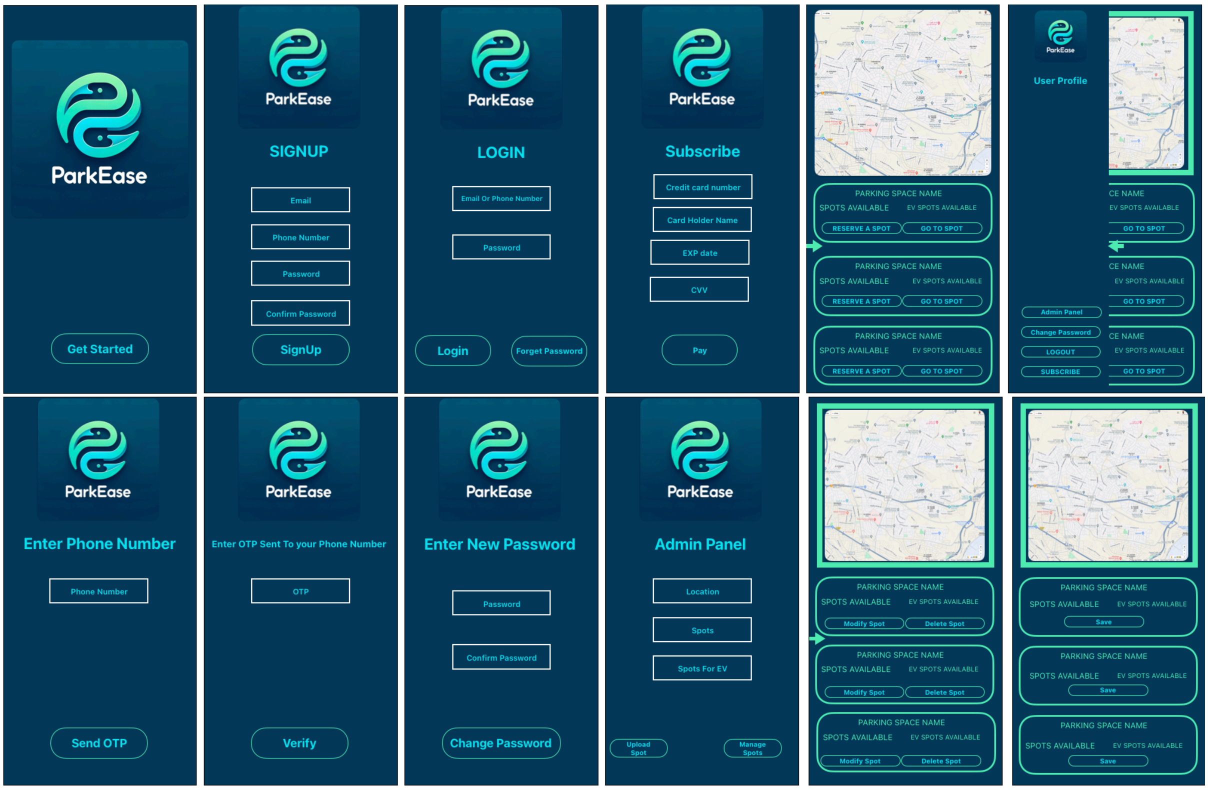


Figure 5.1.1 User Interface

- **Framework**: Developed using the Flutter framework for cross-platform compatibility.
- **Design**: User interfaces designed in Figma, focusing on ease of use, accessibility, and responsive design.
- Components:
    1. Navigation menus, forms for login and registration.
    2. Real-time parking availability display using list views and maps.

3. Database Implementation

A. **Database Used**: MongoDB Atlas for cloud-based database services.

B. Schema Design:

A. Users collection with fields for personal details, authentication tokens, and subscription status.
B. Parking spots collection with fields for location, availability, and reservation status.

C. **Indexes**: Implemented for efficient searching and querying.

4. Functionality Implementation

1. **Backend Services**: Developed using Node.js and Express.js for RESTful APIs.
2. **Authentication**: JWT (JSON Web Tokens) for secure authentication, bcrypt for password hashing.
3. **Payment Processing**: Integrated 2CheckOut for handling secure payments.
4. **Real-Time Data**: Utilized WebSockets for real-time updates on parking availability.

5. Performance Optimization

1. **Database Indexing**: Implemented to improve query performance.
2. **Code Optimization**: Minified JavaScript and CSS files, lazy loading of components.
3. **Caching**: Implemented server-side caching for frequently accessed data.

Chapter 6: System Testing and Installation

This chapter addresses the testing and installation processes of the "ParkEase" project. It describes various testing strategies, such as unit, integration, system, and user acceptance testing, as well as security and performance testing. The installation process is detailed to ensure the correct deployment of the system, and a thorough validation of requirements is conducted to confirm that the system fulfills the established criteria.

Introduction to Testing and Evaluation

Emphasizes the importance of testing in the software development lifecycle.

Ensures that all components of the system function correctly and efficiently.

Testing Strategy

Unit Testing:

Tools: Jest and Mocha for JavaScript unit testing.

Scope: Testing individual functions and components to ensure they work as intended.

Integration Testing:

Tools: Postman for API testing, ensuring different modules work together correctly.

Scope: Testing interactions between different parts of the system, such as user authentication and parking spot reservation.

System Testing:

Scope: End-to-end testing to validate the entire system's functionality.

Tools: Selenium for automated browser testing.

User Acceptance Testing (UAT):

Approach: Real-world scenarios and test cases to ensure the application meets user needs.

Participants: A group of end users who provide feedback on the system's usability and functionality.

Security Testing:

Tools: OWASP ZAP for vulnerability scanning.

Scope: Ensuring the application is secure from common threats such as SQL injection, XSS, and CSRF.

Performance Testing:

Tools: JMeter for load testing.

Scope: Evaluating the system's performance under various conditions, including peak usage times.

Installation Process

Preparation: Ensuring all prerequisites are met, such as setting up the necessary environment and dependencies.

Deployment:

Platform: Deployed using Railway for backend services.

Steps:

Setting up the server environment.

Deploying the application code.

Configuring the database and API integrations.

Running initial tests to verify installation.

Verification: Conducting tests post-deployment to ensure the system is functioning correctly.

Validation of Requirements

Ensuring the system meets the defined functional and non-functional requirements.

Conducting thorough testing to confirm that the system operates as intended and fulfills all project objectives.

Chapter 7: Conclusion & Future Work

5.1 Summary of Achievements

The "ParkEase" project has successfully completed the initial design and documentation phases. Key achievements include:

- Comprehensive Documentation: Developed a thorough set of documents outlining system requirements, architecture, and design.
- System Architecture and Design: Created detailed system architecture and design diagrams to guide future development.
- User Interface Prototypes: Completed preliminary designs and user interface prototypes using Figma, ensuring a user-friendly experience.

5.2 Evaluation of Project Goals

The project's documentation phase was aimed at laying a robust groundwork for the development phase:

- Clarity and Precision: The documentation provides clear and precise guidelines for developers, which will facilitate the efficient development of the app.
- Preparation for Implementation: The groundwork has been prepared with a detailed project plan and technological framework, setting the stage for successful implementation.

5.3 Limitations and Challenges

The project faced several challenges during the documentation phase:

- Scope Definition: Defining the exact scope of the application required extensive research and adjustment to align with realistic goals.
- Technical Planning: Deciding on the optimal technologies and tools involved extensive deliberations to balance functionality, cost, and future scalability.

5.4 Recommendations for Future Work

For the next phases of the "ParkEase" project, the following steps are recommended:

- Begin Development: Transition from planning to the development phase, implementing the designs and plans laid out in the documentation.
- User Testing and Feedback: Early and continuous user testing to iterate on the design based on real-world feedback.
- Marketing and User Education: Develop a marketing plan to increase user adoption and educate potential users about the benefits of the app.

5.5 Concluding Remarks

"ParkEase" is well-positioned for the next stages of development and eventual deployment. The documentation created provides a strong foundation for building a solution that not only addresses the challenges of urban parking but also enhances the experience of city driving. Future development will be crucial in bringing the documented ideas to fruition and achieving the intended impact on urban mobility.

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