NTU Ride Pilot

**24-FYP-204**



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**BACHELOR OF SCIENCE IN** **COMPUTER SCIENCE**

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# Certification

This is to certify that this project titled “**NTU Ride Pilot**” was found to satisfy the requirement for the award of a “**Bachelor of Sciences in Software Engineering**” degree by the Department of Computer Science, National Textile University.

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# Declaration

We hereby declared that this document is completely written by us, and it is totally our effort and none of anyone from outside of our group has copied it. This Report is purely written technically in accordance with our project.

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**Abstract**

Efficient and secure transportation is vital for educational institutions, where thousands of students rely on daily commutes. However, current systems face significant challenges, including inefficiencies, security vulnerabilities, and a lack of real-time tracking and communication. Issues such as overcrowding, unauthorized access, and poor resource utilization arise when students board buses without proper verification. Additionally, the absence of real-time bus monitoring and effective communication channels leads to confusion, delays, and suboptimal transport management. The NTU Ride Pilot addresses these challenges by integrating advanced technologies like RFID-based ID verification, live GPS tracking, and automated communication tools. The system ensures only authorized students access transport services, provides real-time visibility of bus locations for students, parents, and administrators, and enables timely updates regarding delays, route changes, or emergencies. It also tracks driver performance, monitors bus occupancy, and generates insights for optimizing route planning and capacity utilization. By modernizing transport operations, the NTU Ride Pilot enhances safety, boosts operational efficiency, and delivers a reliable and user-friendly commuting experience. This solution is an ideal choice for educational institutions aiming to transform their transportation infrastructure with secure and efficient technology.

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# List of Abbreviations

Table 1 List of Abbreviations

|  |  |
| --- | --- |
| NTURP | NTU Ride Pilot |
| RFID | Radio Frequency Identification |
| NTURP system | Admin Panel, Driver/Student App |
| GPS | Global Positioning System |

# CHAPTER 1

# Introduction

Proper transportation is a requirement in school systems of all types, where many thousands of students face daily transportation needs. But many institutions have problems such as ineffective workflow, potential and noted security threats, no real-time control and messaging systems. Children board buses without identification hence self-aggregation, trespass and misuse of transport means are common as are overcrowding. Further, there is the lack of real time tracking in buses as well as the performance of the drivers, and poor communication channels leads to confusion and poor control and co-ordination of transport operations.

To counter these challenges, we are optimistic about the implementation of the proposed NTURP system in an educational setting. This system incorporates high technologies such as RFID used for the identification process, real-time tracking using GPS, and technology-reliant alerting mechanisms for better transport logistics management. How it helps: It ensures that only approved students gain access to students’ transportation services, gives real-time mapping of the bus locations to students, parents, and administrative staff and assists in timely notification on any … delays, route alterations, or emergent situations. Further, it measures driving behaviour, controls the passenger load factor, and provides notifications for route efficiency and capacity management.

This solution does not address objectives present in the current status quo; it revolutionizes transport management turning it into a safe, optimised, and friendly environment for users. With the help of new technologies, the NTURP system increases security, optimizes the work of transport and ensures its safe functioning, which makes it a perfect choice for any school with the desire to create modern transport infrastructure.

## NTU Ride Pilot

NTURP is new approach for improving transportation services and gradually making transport secure and safe for education institutions. It encompasses up-to-date solutions such as RFID for persons’ identification, real-time GPS navigation, and an enhanced communication system to build an easy-to-navigate transportation environment. This system enables authorised institutions to finally determine the best routes for bus transport, the best capacity to be provided for each transport at a given period as well as the performance of the transporters in ensuring that students, parents and other members of the institution get secure and efficient means of transport.

## Reason to Develop

The development of the NTURP system is driven by several compelling factors, despite the existence of other transportation solutions:

### Addressing Unique Institutional Needs

Schools are bound to face certain problems such as intrusion, traffic congestion and improper signalling. These specific requirements cannot be served efficiently by generic transport management systems, and thus the need to develop a transport management solution for this environment specifically.

### Enhancing Safety and Security

This is important to avoid insecurity or that some students who are not using transport facilities benefit as others who deserve it are locked out. RFID approach encompasses accurate and almost instantaneous means of reducing misuse and increasing security for both students and drivers.

### Bridging Communication Gaps

Failure to share information with other transport departments, with parents and students results to disorganization. This presented system entails use of instantaneous notification for news such as delay, change of route and often emergencies to promote timely and precise communication.

### Optimizing Resource Management

Overcrowding or the underutilization of buses is a common issue. By integrating occupancy monitoring and route optimization, this system helps administrators allocate resources more efficiently, reducing costs and enhancing comfort.

### Scalability and Adaptability

The system can suit the requirements necessary to smoothly operate with fleet in any type of educational institution regardless of the scale of transportation system present there. It is also scalable where the institutions will be able to increase their profit as it responds to the changing transport needs.

This is much more than a technology enhancement project; it is a transformational project across the transport system that takes the future of transport safety and efficiency into consideration in an educational environment.

### Sharing Live Location

Through real-time tracking parents as well as students and school administrators can verify transportation location information. The tracking functionality cuts uncertainty while optimizing scheduling and provides boosted security thanks to real-time bus position monitoring. This initiative surpasses technology adoption to become an educational transformation that advances safety measures and managerial efficiency and operational effectiveness in the student transport system.

## Problem Statement

Public and private learning institutions are among the organizations that experience high levels of challenges when it comes to transportation management. Some of the widespread problems are overcrowded or, in contrast, underfilled buses, theft, poor communication with the bus drivers, and absence of the possibility of tracking a bus’s location. Such issues thus complicate movement, organization, and functioning, and pose risk to the learners, their parents, and school management. Currently available solutions do not always have the architecture and flexibility to meet these specific institutional requirements.

## Purpose

The primary objective of the developed NTURP system is to become a one-stop for all the transport management needs of educational establishments. Through secure access verification, GPS tracking while the bus is in operation, and other communication features, the developers of the system intend to enhance the performance, safety, and overall communication into the student, parents, school, and bus company.

## Project Goals

* Implement secure ID verification to prevent unauthorized access.
* Provide live bus location tracking for real-time visibility and improved coordination.
* Enable real-time notifications for updates such as delays, route changes, or emergencies.
* Track key metrics like speed, stop intervals, and adherence to schedules.
* Streamline bus scheduling, capacity management, and route planning.
* Ensure an intuitive interface for administrators, parents, and students.

## Objectives

* Objectives of the project are as follows:
* Integrate RFID-based ID verification to ensure only authorized users board the buses.
* Provide GPS-enabled tracking for buses accessible to students, parents, and administrators.
* Enable alerts for overcrowding or underutilization to optimize bus capacity.
* Monitor driver behaviour to ensure adherence to safety and efficiency standards.
* Develop a mobile app for notifications and updates to keep all stakeholders informed.

## Project Scope

Even though this system is created for educational institution it can be expanded at other domains including corporate transport, public streamlined or private bus lines. The architecture of FMGO enables flexibility and expansion depending on the transportation needs and its functionality and organization.

## Proposed Solution

The system provides efficient and well-structured functional solutions for transportation management. The solution offers RFID for ID check during entry, GPS tracking for buses in real time, alert on occupancy, checking of driver performance, and mobile applications. Through this system, there will be highly improved efficiency in the running of institutions, minimized wastage of resources, and improved safety and reliability of transport for all users

## Cost Benefit Analysis

As the NTU Ride Pilot functions to enhance NTU University’s transportation system effectiveness combined with improved security protocols and user accessibility. This Cost-Benefit Analysis (CBA) conducts financial evaluation by aligning development expenses with operational costs against future benefits.

### Cost Analysis

#### Hardware Costs (One-Time Costs for One Bus)

Table 2 Cost Analysis

|  |  |  |  |
| --- | --- | --- | --- |
| **Item** | **Cost (RS)** | **Quantity** | **Total Cost (RS)** |
| RFID Device | 1200 | 1 | 1200 |
| Student Cards | 40 | 50 | 2000 |
| Connector | 150 | 1 | 150 |
| **Total Hardware Cost** | 3350 | 1 | 3350 |

#### Software Costs

* Map box (Live Tracking) serves the company with free assistance under its Free Tier program.
* The free plan of Firebase Database Management operates currently at no expense.
* The added number of buses at NTU could require purchasing paid plans from Map box and Firebase.

### Operational & Maintenance Costs

The project currently uses a free-tier structure but operational expenses alongside maintenance costs constitute the recurring expenses for the future. There are no ongoing expenses since the project development occurs under free-tier conditions. However, potential future costs include:

* The project may require costs for Firebase Paid Plan data storage and database services.
* Future web-based expansion of the system by NTU will incur both domain and hosting fees.
* The project will require expenses for both system upgrades and security patches together with future enhancement and support costs.

### Benefit Analysis

#### Tangible Benefits

* RFID technology removes the possibility of unauthorized bus access.
* The current tracking system blocks unauthorized route changes and unauthorized stopovers.
* Automated card checker technology reduces the time needed for students to join the system.
* Customers together with administrative staff can monitor buses online and minimize waiting at bus stops.
* The digital complaint platform diminishes the time needed for resolution while guaranteeing better customer service.
* Through live monitoring admins gain better control over their bus routes which allows them to improve route scheduling according to current use levels.
* The method extends to multiple buses through basic software upgrades.

#### Intangible Benefits

* Real-time tracking combined with efficient student on boarding systems produce superior user satisfaction.
* Students along with parents achieve better peace of mind when they have verified access to the bus system.
* The implementation of digital systems provides two main benefits: it decreases physical documentation while ensuring precise information recording.
* Efficient route management through the system helps reduce emissions and fuel consumption.
* The institution stands ahead as a pioneer through its adoption of modern transportation systems.

### Future Recommendations for Cost Optimization

* If NTU expands, evaluate paid plans for Firebase and Map box only when necessary.
* If a web-based system is implemented, consider cost-effective hosting providers.
* Reduce RFID costs by purchasing student cards in bulk.
* Use tracking data to optimize bus schedules, reducing fuel costs.

## Project Scheduling

Below is the Gantt chart that has been developed for the NTURP project. This chart is intended to illustrate the project’s schedule: the time when each activity was planned/started and the time when it was planned/ended. They give a broad plan of how the various tasks in the project are expected to be done, and when thus help in keeping track of the project. The time plan of the project is illustrated in the Gantt chart in Figure 1.1 below.

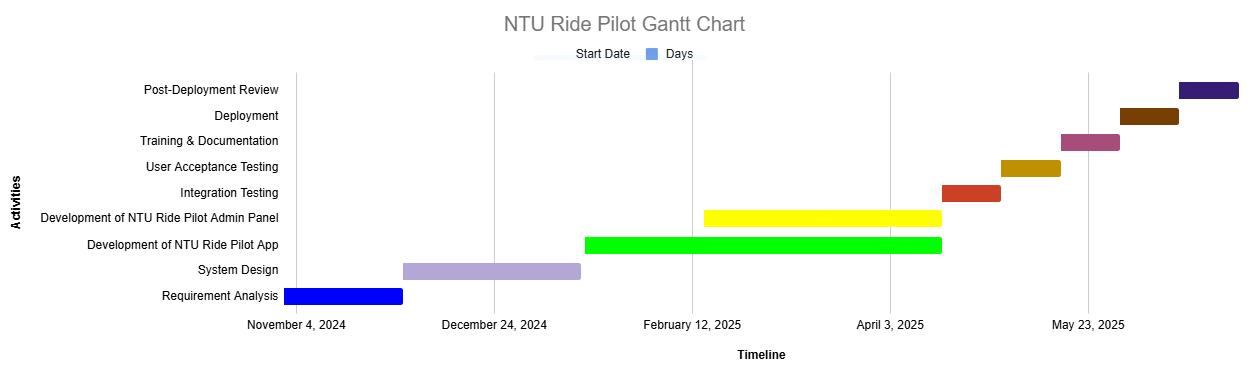


Figure 1 Gantt Chart

**CHAPTER 2**

1. **Literature Review**

The NTURP aims to enhance transportation services for students and parents by integrating technologies such as RFID scanning, GPS tracking, real-time data analytics, and mapping services. This chapter reviews existing literature and technologies pertinent to the project, including RFID technology in transportation systems, GPS-based bus tracking, load management in public transportation, predictive arrival systems, and the utilization of mapping APIs like Google Maps and Map box. Additionally, it examines existing student transportation management systems to identify current solutions and gaps.

* 1. **Related Work**

Several transportation management systems cater to student transit needs, offering features like GPS tracking, route optimization, and parent communication. Notable examples include:

### Tyler Technologies’ Student Transportation Software

Provides integrated solutions for bus routing, fleet maintenance, and parent communication, connecting various aspects of transportation management. (TylerTechnologies)

Cons:

* High implementation and licensing costs for smaller institutions.
* Steep learning curve for administrators unfamiliar with the software.
* Limited customization options for unique institutional requirements.

### Edulog

Combines school bus routing, GPS fleet tracking, student journeyship management, and parent communication apps into a single platform, aiming to streamline transportation operations. (Edulog)

Cons:

* Complex setup and configuration for multi-campus institutions.
* Frequent updates are causing temporary compatibility issues.
* Limited integration with non-standard hardware or legacy systems.

### Loqqat

Provides a smart real-time school bus tracker and management software, enabling route scheduling and live tracking to ensure student safety. (Loqqat)

Cons:

* Narrow focus on live tracking, lacking advanced features like fleet maintenance.
* Limited scalability for large institutions with extensive fleets.
* Higher costs for adding additional features beyond basic tracking.

## RFID Technology in Transportation Systems

RFID is widely used in transportation for access control and validation of the user. The usage of an RFID tag within student cards enables easy barcode scanning and validation strengthening the parameter of user credibility. The literature review also focuses on RFID advantages concerning reliability, fast processing, and accuracy in real situations for passenger identification, which would help in determining eligibility of passenger in bus systems.

RFID technology is also used in NTURP to authenticate fee payment and obtain time-based scanning to reduce misapplication of the system. The integration of RFID with time constraints means that the delivery will be partial and will ensure compliance and consequently trust among the stakeholders.

## GPS-Based Bus Tracking

With GPS, social transport has been revolutionized through tracking vehicles in the road networks. In doing so, passengers and bus administrators can track bus positions thus increasing the buses’ operational visibility and service delivery. GPS tracking and the provision of estimated arrival time are found to increase the user satisfaction since the device continually and accurately indicates the location.

In NTURP, GPS tracking helps parents and students in planning their travel effectively. When partnered with predictive algorithms, GPS data eliminates the prospects of early or late estimates and keeps drivers on their toes. The same also contains important information about the best route choice and the most suitable time in the context of transportation by bus.

## Load Management in Public Transportation

It is very important to strike a balance between the number of passengers and the carriage capacity in a public transport system because an excess or a shortage of passengers causes problems. Methods like weight sensors and real-time passenger count are found efficient for measuring the bus holding capacity.

In addition to real time load analysis for safety of passengers and bus fleet, NTURP also includes efficient bus operation. Prepare for the load according to the existing pattern and data and use the pattern to estimate the demand for various products or services.

## Predictive Arrival Systems

The estimates of arrival are derived from the GPS, traffic and past records making them reliable for PSA. Research shows that such systems improve user trust and satisfaction. Use of enhanced features and the integration of more advanced machine learning algorithms can of course enhance the accuracy of the predictions.

In NTURP, arrival features that predict help to cut down waiting time and thus the result is convenient to both students and parents. These features, implemented in simple presentations with user-friendly interfaces, are helpful for a user.

## Google Maps and Map box

Mapping services are integral to transportation management systems, providing visualization and geolocation functionalities.

### Google Maps API

Google Maps API is a full service solution for map integration which allows for real time traffic data, route and time estimations. The versatile Log parser and its reliability is a clear reason why developers choose to work with the company. To work in NTURP, Google Maps API is quite helpful in providing real time location of buses and their estimated time of arrival, thus making the general user interface more effective.

### Map box

Map box is an interactive map tool which operating system can be adapted according to the preferences of the developers. It provides dynamic app theme support, working offline maps, and improved integration options. In certain niches of mapping specifically designed solutions, Map box is flexible and fast. For NTURP, Map box gives an opportunity to design compelling, user-friendly front ends for users.

It means that the decision to choose, for example, Google Maps API instead of Map box, will be based on the specifications, the cost, and the expectations from users. Both solutions are fundamental in the establishment of safe transport networks.

**CHAPTER 3**

1. **System Requirements**

In this bankruptcy, all of the useful requirements of the NTURP and the overall requirement of the stockholders are documented as it’s an important a part of a mission or product that allows to satisfy stakeholder’s necessities. Now, we can speak system necessities, practical necessities, software program development, and present and selected methodology with the purpose of technique. These sections describe software program methodologies which are present and decided on for this assignment with the glide of machine and alertness detail depicted.

## Functional Requirements

### User Authentication and Authorization:

There should be user roles supported in the system (Admin, Driver, Conductor, Student) and only allow access after a proper authentication. It must have a module for creating the user base, the role they should have, and the permission of the role to open some of the modules that a user should open.

### Bus and Route Management

The Admin should also be able to handle bus detail and want to set territories or routes for buses. The Driver should have the facility to record/update the driving routes for individual buses. Also there exists the scenario where the Admin needs to view a list of available buses and their corresponding routes.

### Ride Management

The Driver must be able to initiate or end a ride, with the system tracking the live location of buses during active rides. The Driver is responsible for authenticating student cards when they board the bus, and the system must record ride data, including the bus number, route, boarded students, and the driver. Both Admin and Students must have access to the bus’s live location, while Admin also be able to view the complete ride history for all buses.

### Bus Card Management

The admin must be able to assign bus cards to students, as well as revoke or enable student bus cards as needed. The system must also verify student bus cards during boarding to ensure proper access.

### Session and Student Management

The system must allow the Admin to create and end user sessions, as well as set their expiry dates. It should automatically disable student cards when a session expires or is deleted. Additionally, the system must generate app credentials for students upon their addition to the system.

### Driver Management

Admin must be able to add and manage Drivers and Conductors within the system. Upon registration, the system must generate app credentials for these staff members to enable secure access and management of their duties.

### Complaint Management

Students and Drivers must have the ability to submit complaints through their apps. Admin should have a module to view, address, and resolve these complaints, and the system must maintain a record of all complaints along with their current statuses.

### Announcement Management

Admin must be able to create and manage announcements within the system. Announcements must be delivered as notifications to Drivers and Students through their apps to ensure timely updates.

### Notification and Alerts

The system must send notifications to Students and Drivers regarding announcements, route updates, and other relevant information. Additionally, the system must alert Admin if a bus deviates from its assigned route or leaves its designated area.

### Live Location Tracking

The system must track and display the real-time location of buses during active rides. Both Admin and Students should be able to access this live location data via their apps, and the system must store location data for ride history and analysis purposes.

## Non-Functional Requirements

### Security

Apply strict checks for the users’ authorization and authenticity.

### Performance

The system should be able to answer user actions on the application quickly.

### Availability

The system should be online all the time.

### Scalability

Also, the system must be capable providing its services to a rising number of users and data.

### Usability

Web based system should be easy to use and navigable with an aim of reaching the users of the product.

### Maintainability

It should be easy for the system to be maintained and upgraded from time without lots of time being consumed.

### Efficiency

While functioning, the system should effectively manage the amount and kinds of resources used and reduce response time.

## Use Case Diagram

In respect to showing graphic representations of actor communication with the components of the systems the best method therefore is to identify and draw Use Case diagrams that illustrate which actor can perform or accessing what function or component of the systems under consideration.

### Use Case of Sign In

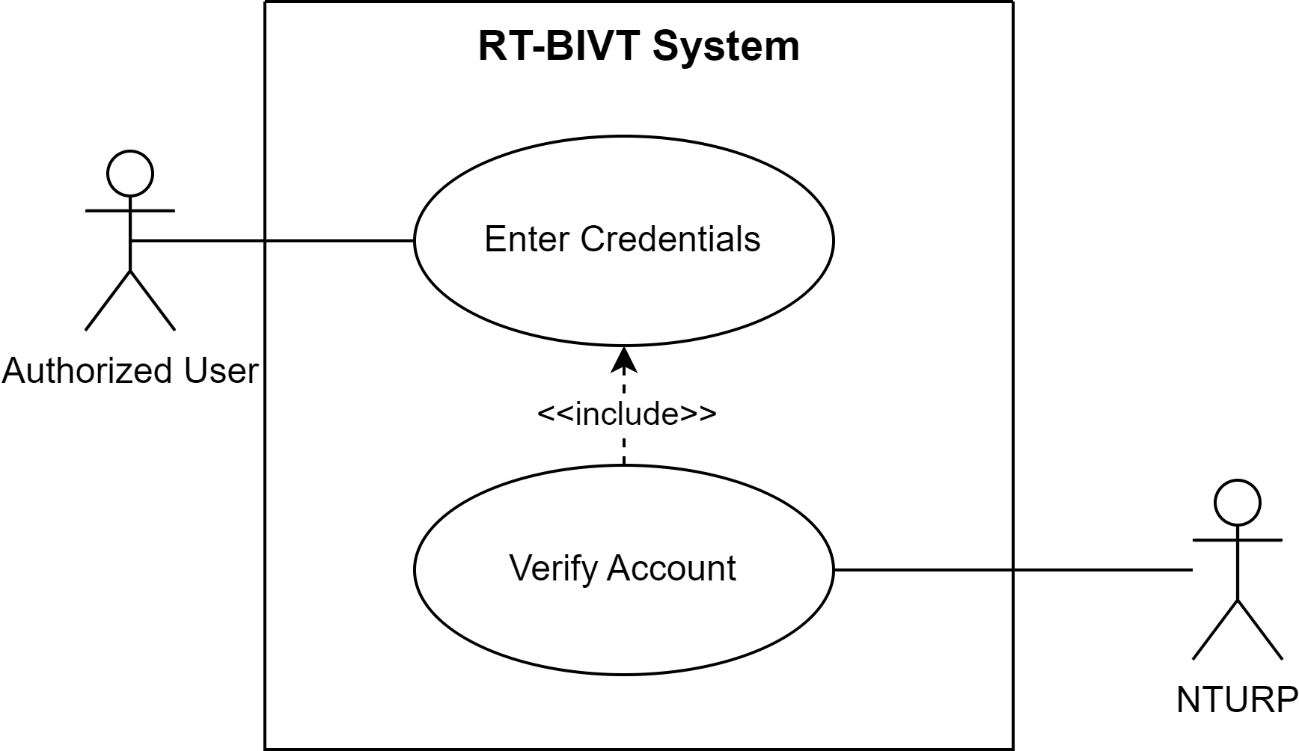


Figure 2 Use Case of Sign In

### Use Case of Sign Up



Figure 3 Use Case of Sign Up

### Use Case of Bus and Route Management

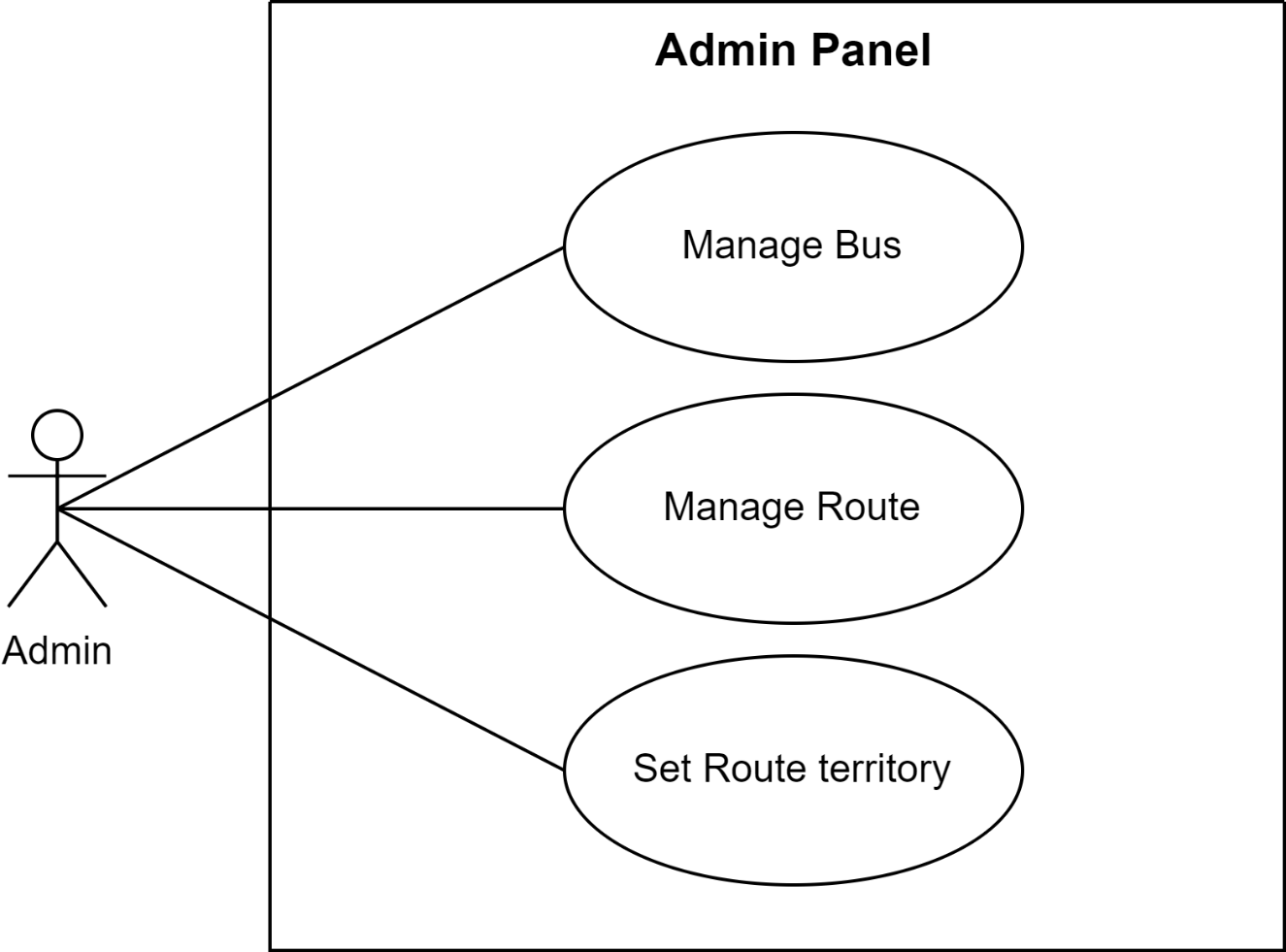


Figure 4 Use Case of Bus and Route Management

### Use Case of Ride Management

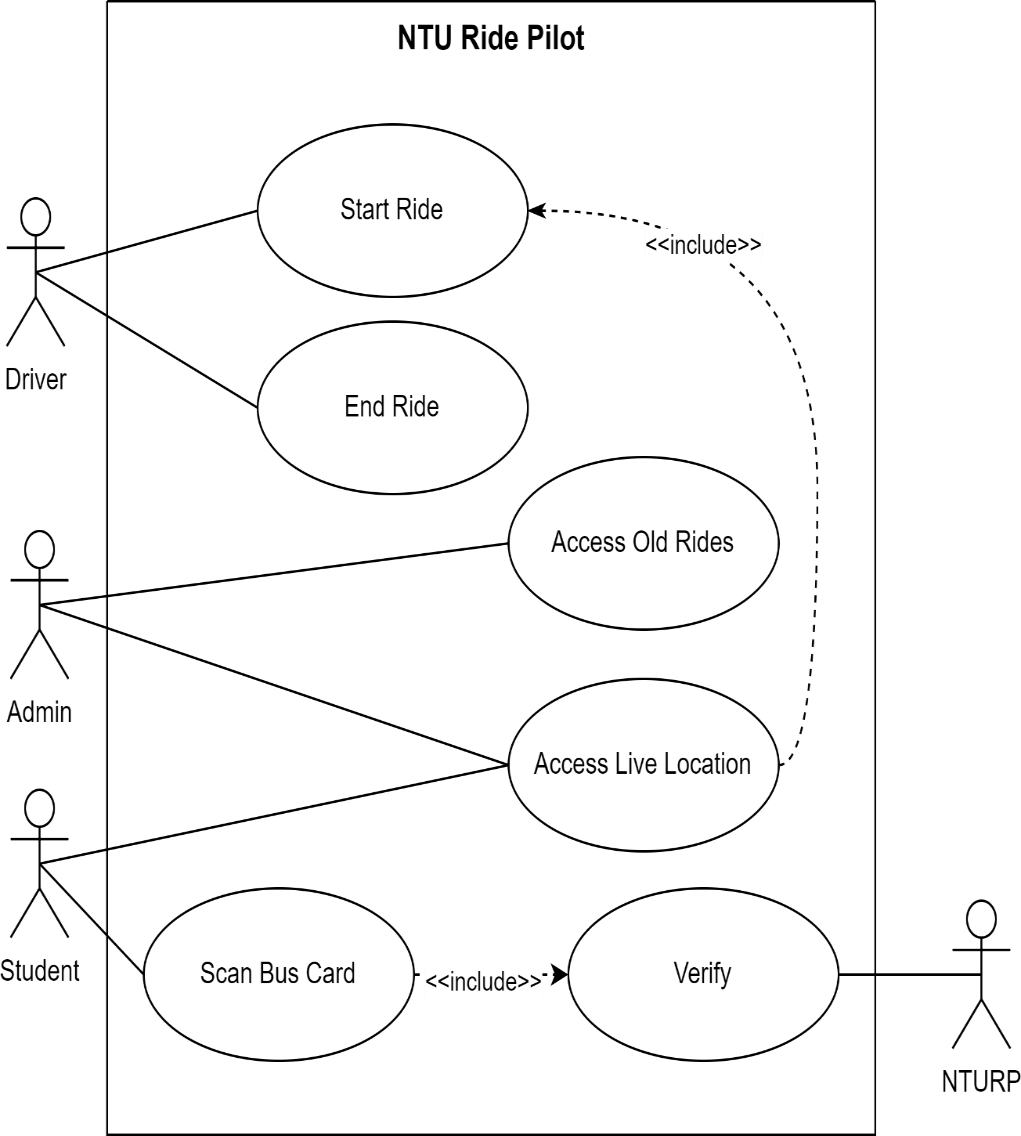


Figure 5 Use Case of Ride Management

### Use Case of Bus Card Management

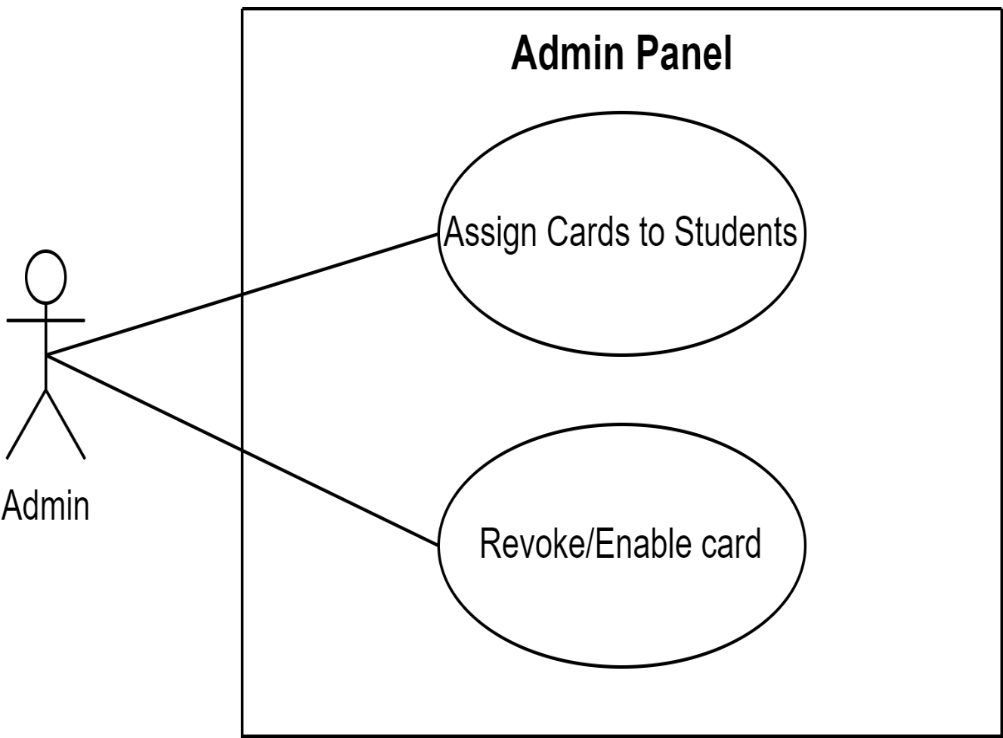


Figure 6 Use Case of Bus Card Management

### Use Case of Student & Session Management

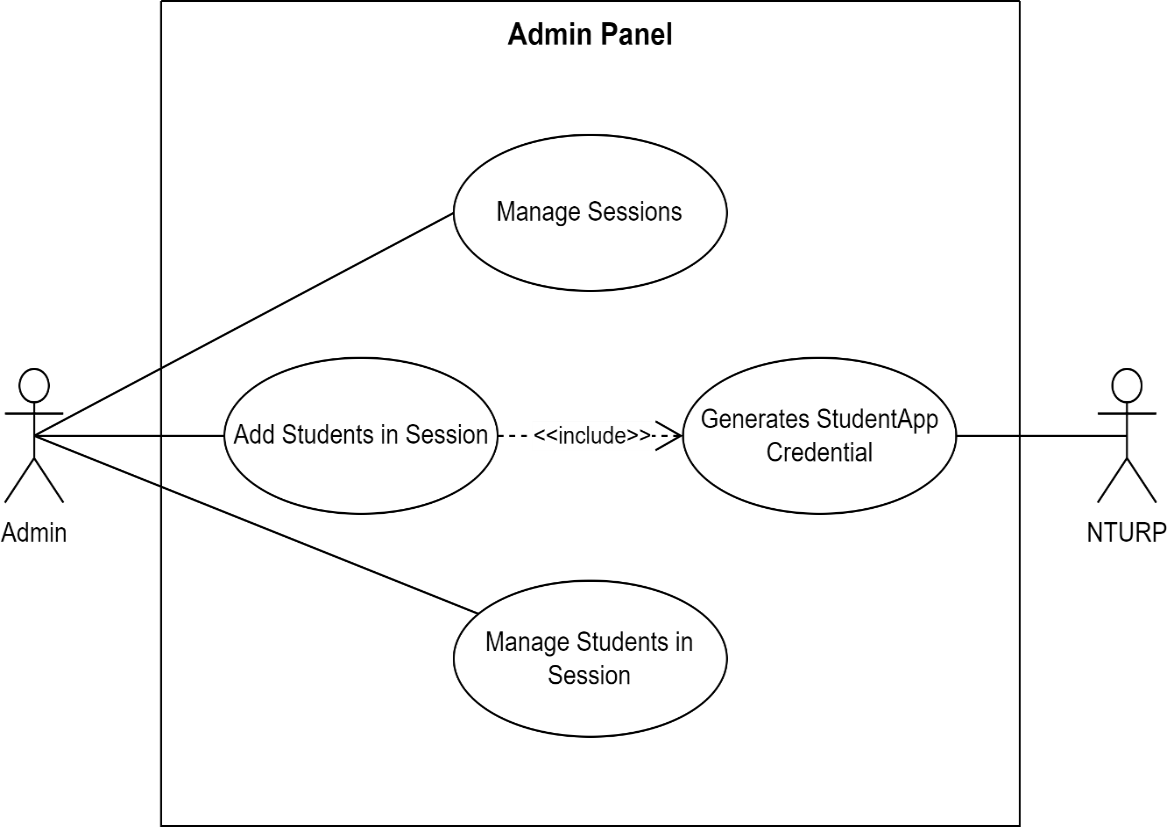


Figure 7 Use Case of Student & Session Management

### Use Case of Driver Management

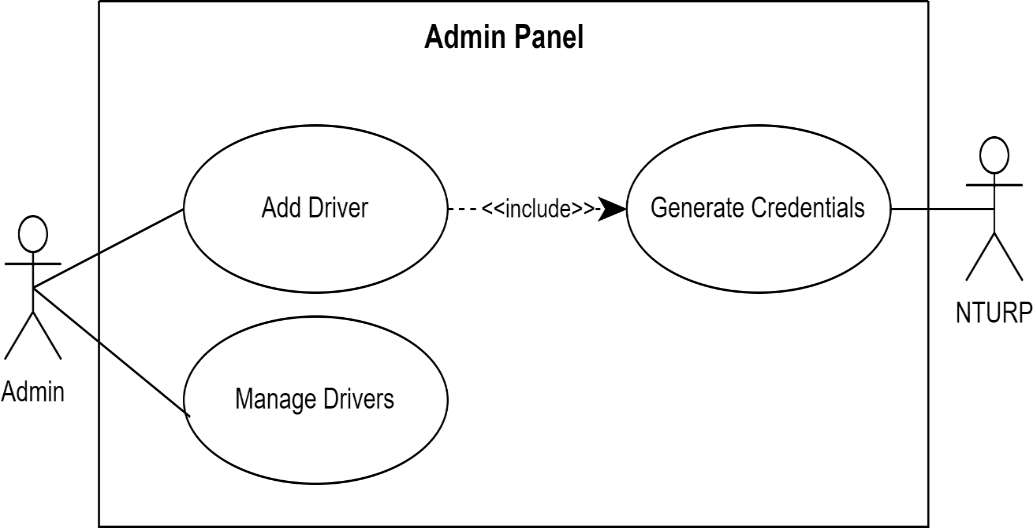


Figure 8 Use Case of Bus Staff Management

### Use Case of Complaint Management

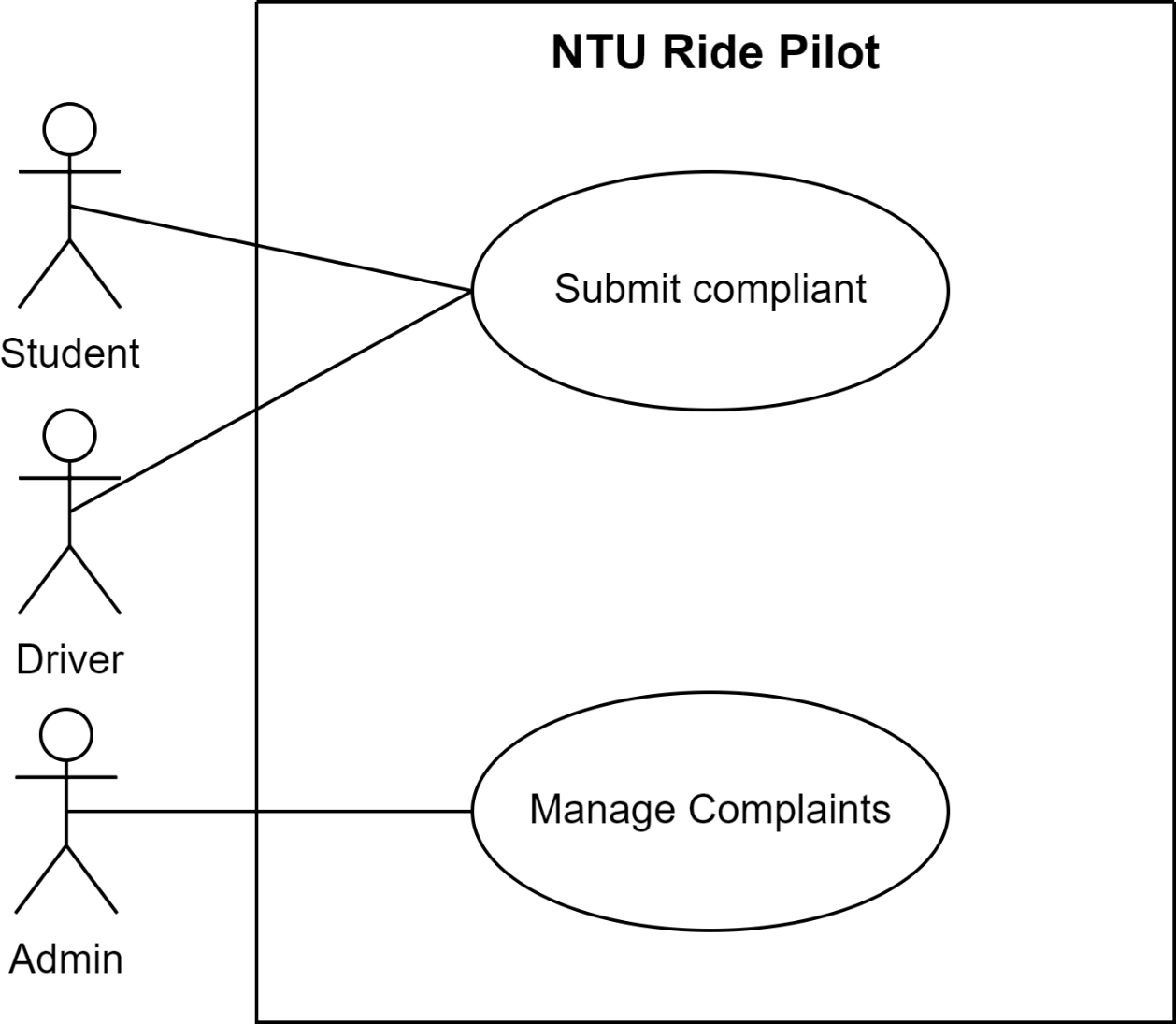
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Figure 9 Use Case of Complaint Management

### Use Case of Announcement Management

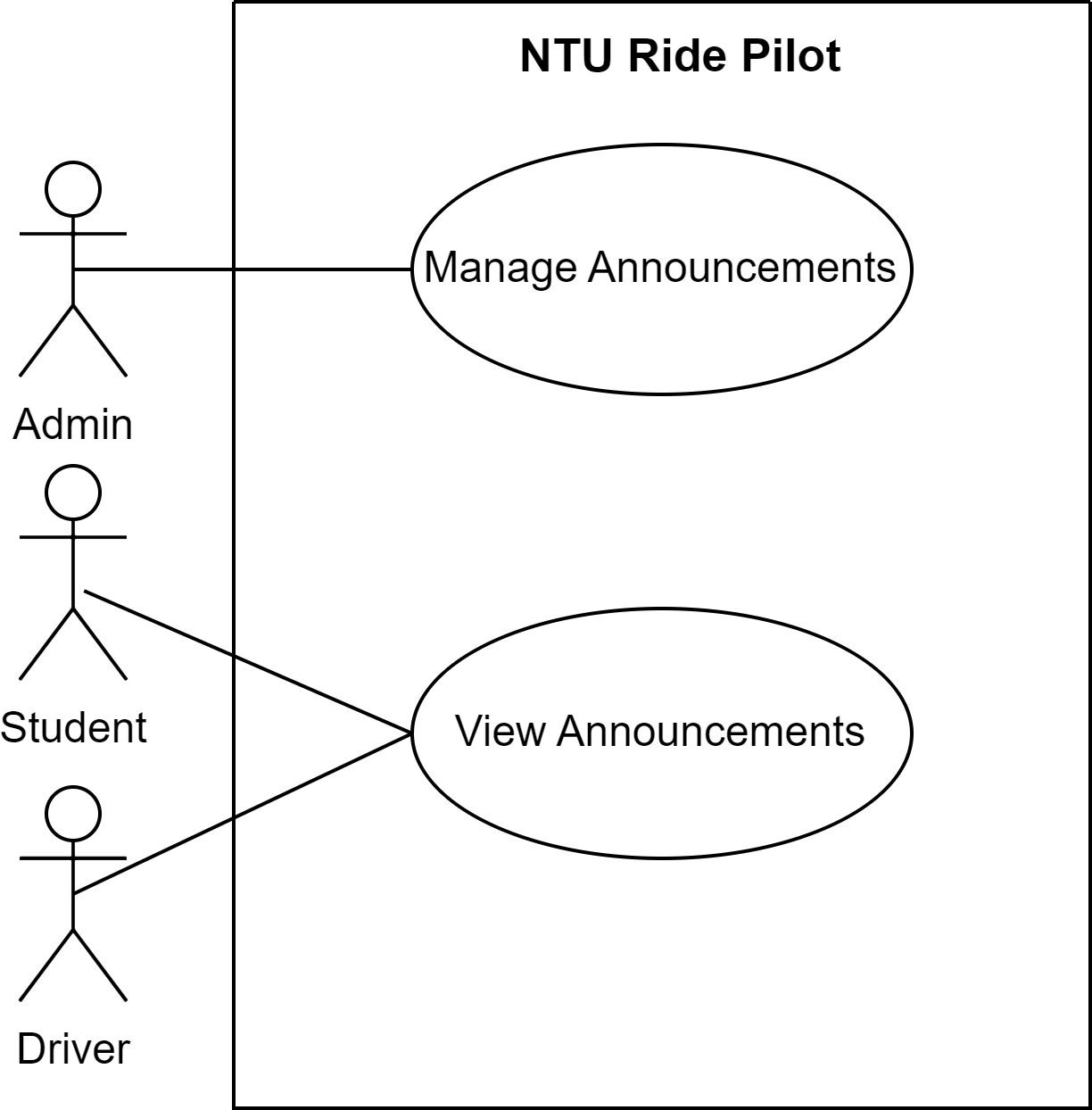


Figure 10 Use Case of Announcement Management

### Use Case of General Functionalities

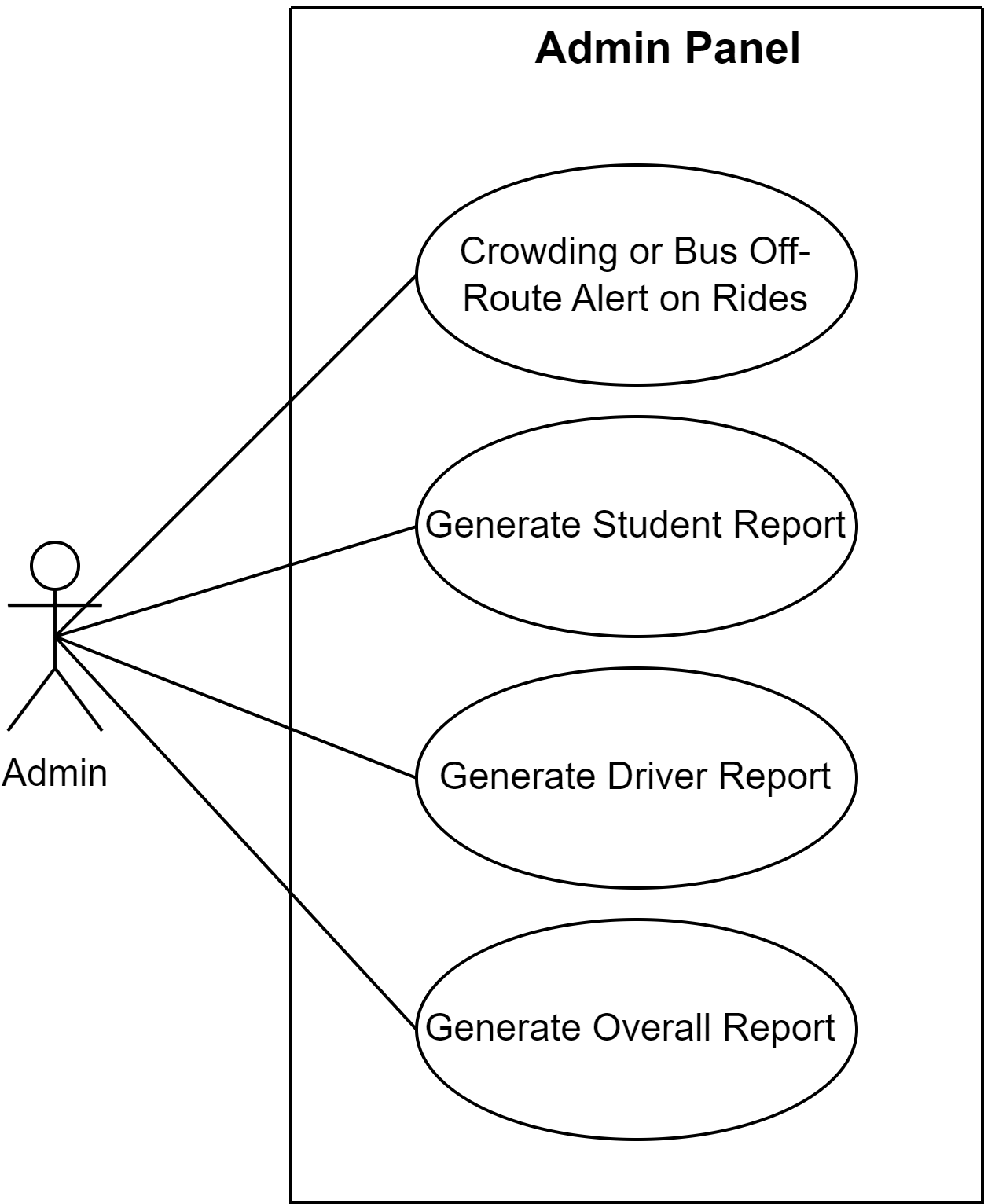


Figure 11 Use Case of General Functionalities

### Use Case of Admin Panel

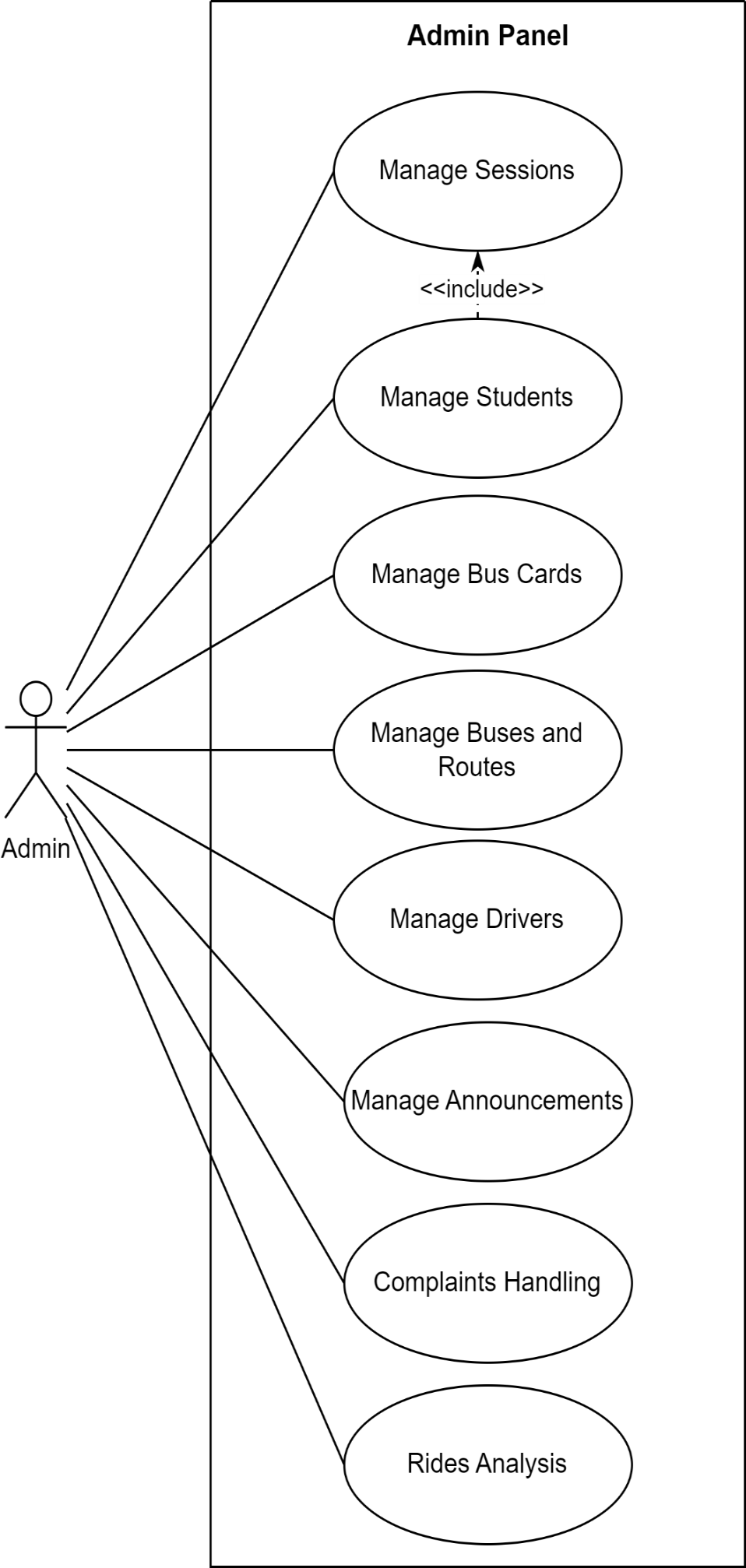
**

Figure 12 Use Case of Admin Panel

### Use Case of Mobile App

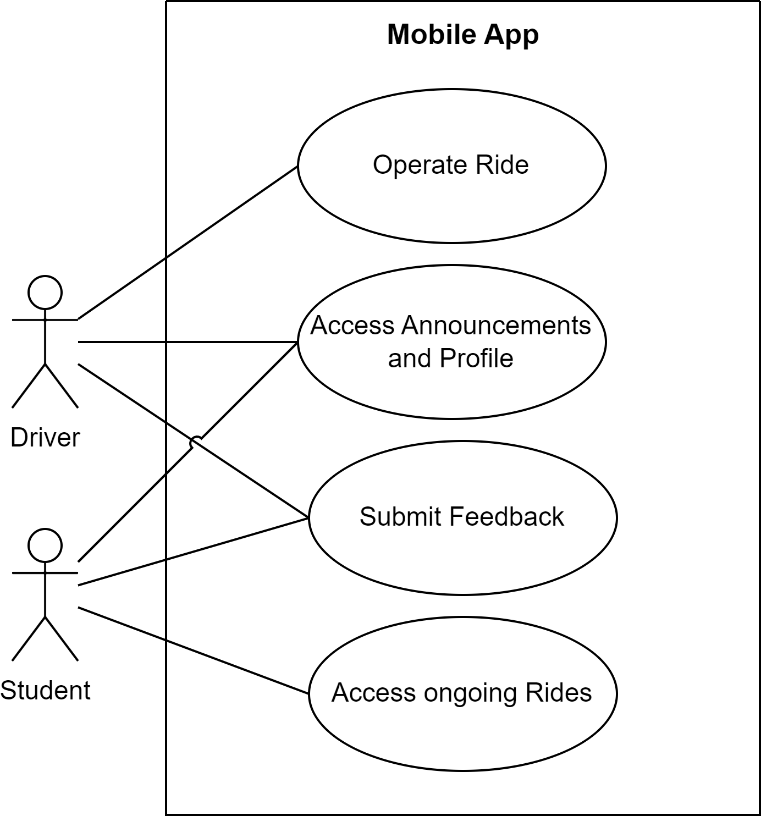


Figure 13 Use Case of Mobile App

## Use Case Description

Each use case involved in NTURP contains all necessary information including its use case id and name alongside description and pre- and post-conditions. A structured format within this description ensures both clarity and completeness during the definition of system interactions. The detailed documentation helps users understand both system behaviour and requirements from end-users.

### Description of Sign In:

Table 3 Description of Sign In

|  |  |
| --- | --- |
| Field | Details |
| Use Case Id | 01 |
| Use Case Name | Sign In |
| Actors | Authorized User |
| Description | Authorized users log in to the NTURP via provided applications. Access is denied if the user does not have an account or proper credentials. |
| Pre-condition | User must have an account and credentials. |
| Post-condition | User logs into the NTURP system or is denied access. |

### Description of Sign Up:

Table 4 Description of Sign Up

|  |  |
| --- | --- |
| Field | Details |
| Use Case Id | 02 |
| Use Case Name | Sign Up |
| Actors | Admin, Authorized User |
| Description | An Admin can assign specific roles and permissions to students and drivers. The admin is responsible for managing the creation of user accounts, including those for drivers and students. |
| Pre-condition | User must have an account, enough permissions and credentials to access system. |
| Post-condition | A new user is created with specific roles and permissions to operate with in NTURP. |

### Description of Bus and Route Management:

Table 5 Description of Bus and Route Management

|  |  |
| --- | --- |
| Field | Details |
| Use Case Id | 03 |
| Use Case Name | Bus and Route Management |
| Actors | Admin |
| Description | The admin is responsible for adding buses, defining routes, and assigning territories. |
| Pre-condition | Admin must be authenticated and have enough permissions to manage buses and routes. |
| Post-condition | The admin effectively oversees the management of buses, routes, and territories. |

### Description of Ride Management:

Table 6 Description of Ride Management

|  |  |
| --- | --- |
| Field | Details |
| Use Case Id | 04 |
| Use Case Name | Ride Management |
| Actors | Admin, Driver, Student |
| Description | The driver starts and ends rides while verifying student bus cards during the trip. The system logs ride-related data and tracks the bus's live location, enabling administration, students, and parents to access ride details and monitor the bus's real-time location. |
| Pre-condition | The driver must be authenticated and have specified the route and the bus they are assigned to. The student must possess a valid and active bus card. |
| Post-condition | The driver successfully operates the Rides, while the system tracks and updates the ride details and live bus location. This allows both administrators and students/parents to access the ride information and the live location of the bus. |

### Description of Bus Card Management:

Table 7 Description of Bus Card Management

|  |  |
| --- | --- |
| Field | Details |
| Use Case Id | 05 |
| Use Case Name | Bus Card Management |
| Actors | Admin |
| Description | The admin is responsible for assigning and managing student bus cards. |
| Pre-condition | The admin must be authenticated and have necessary permissions to manage bus cards. Students are required to be registered in the system. |
| Post-condition | The admin can successfully assign bus cards to students, revoke the cards to prevent further use, and re-enable them when needed. |

### Description of Session and Student Management:

Table 8 Description of Session and Student Management

|  |  |
| --- | --- |
| Field | Details |
| Use Case Id | 06 |
| Use Case Name | Session and Student Management |
| Actors | Admin, System |
| Description | The admin can create and terminate sessions, set session expiry, and manage students within the system. When a student is added, the system automatically generates app credentials for them. Expiring or deleting a session will deactivate all bus cards associated with that session. |
| Pre-condition | The admin must be authenticated and have necessary permissions to manage bus cards. Student data must be accurate and complete for the generation of credentials. |
| Post-condition | The admin effectively oversees both sessions and student management. |

### Description of Bus Staff Management:

Table 9 Description of Bus Staff Management

|  |  |
| --- | --- |
| Field | Details |
| Use Case Id | 07 |
| Use Case Name | Bus Staff Management |
| Actors | Admin, System |
| Description | The admin oversees drivers and conductors. When a new staff member is added, the system automatically generates app credentials for them. |
| Pre-condition | The admin must be authenticated and have necessary permissions to manage bus staff. |
| Post-condition | The admin effectively manages bus staff. |

### Description of Complaint Management:

Table 10 Description of Complaint Management

|  |  |
| --- | --- |
| Field | Details |
| Use Case Id | 08 |
| Use Case Name | Complaint Management |
| Actors | Student, Driver, Admin |
| Description | Students and drivers are allowed to submit complaints about transportation services and related concerns. |
| Pre-condition | All users are required to be authenticated. Administrators must also be authenticated and possess the necessary permissions to manage complaints. |
| Post-condition | Complaints submitted by students and drivers get reviewed and resolved by the authorities. |

### Description of Announcement Management:

Table 11 Description of Announcement Management

|  |  |
| --- | --- |
| Field | Details |
| Use Case Id | 09 |
| Use Case Name | Announcement Management |
| Actors | Admin, Driver, Student |
| Description | The admin shares announcements related to transportation. |
| Pre-condition | All users are required to be authenticated. |
| Post-condition | The administrator successfully posts announcements. |

### Description of General Functionalities:

Table 12 Description of General Functionalities

|  |  |
| --- | --- |
| Field | Details |
| Use Case Id | 10 |
| Use Case Name | General Functionalities |
| Actors | Users |
| Description | The admin can generate reports and analyse valuable information extracted from the data currently stored. |
| Pre-condition | The admin must be authenticated and have necessary permissions. |
| Post-condition | Administration makes better decisions and enhances services through the analysis of current transportation data. |

# Chapter 4

# Methodology

## 4.1 Agile Software Development Methodology

Agile methodology is an iterative and incremental approach to software development that emphasizes flexibility, collaboration, and customer feedback. Unlike traditional methodologies like the Waterfall model, Agile allows for adaptive planning, evolutionary development, and continual improvement, enabling rapid and flexible responses to change. It is particularly effective in managing the complexity and unpredictability of software projects.

## 4.2 Selected Methodology: Agile

A software development methodology is a way to improve development work with the help of dividing the development process into distinct phases to make a system with better productivity. It also helps to structure and control the whole system. It involves different methodologies, also called the Software Development Life Cycle, that are stages for software development with a certain set of rules. Generically, we categorized the methodologies into Rapid application development and planned-driven. Waterfall, spiral is planned driven while agile is Rad based.

## 4.3 Reasons for Selecting Agile Methodology

* Agile allows the project to adapt to changes in requirements and technology swiftly.
* Regular feedback from users ensures that the development aligns with the user's needs and expectations.
* Agile facilitates the delivery of small, workable segments of the project, ensuring a faster time-to-market and continuous improvement.
* Regular reviews and iterations help in early identification and resolution of issues, reducing the overall risk.

## 4.4 Agile Project Planning and Execution for NTURP

Agile project planning and execution involve the division of the project into sprints, with each sprint aimed at delivering a potentially shippable product increment. The key phases include:

* Gather and prioritize necessities for the NTURP undertaking, growing a product backlog.
* At the start of every dash, pick a hard and fast of capabilities from the product backlog and plan their delivery.
* Conduct day by day meetings to speak about development, demanding situations, and plan the day's paintings.
* Develop, take a look at, and combine features inside the dash.
* At the quilt of every sprint, reveal the finished paintings to stakeholders and collect comments.
* Reflect at the sprint to identify successes and regions for development.
* Plan releases based totally at the undertaking progress, stakeholder comments, and marketplace situations.



Figure 14 Agile Model

# Chapter 5

# 5 Architecture Design

## 5.1 Activity Diagram

### 5.1.1 Mobile Application

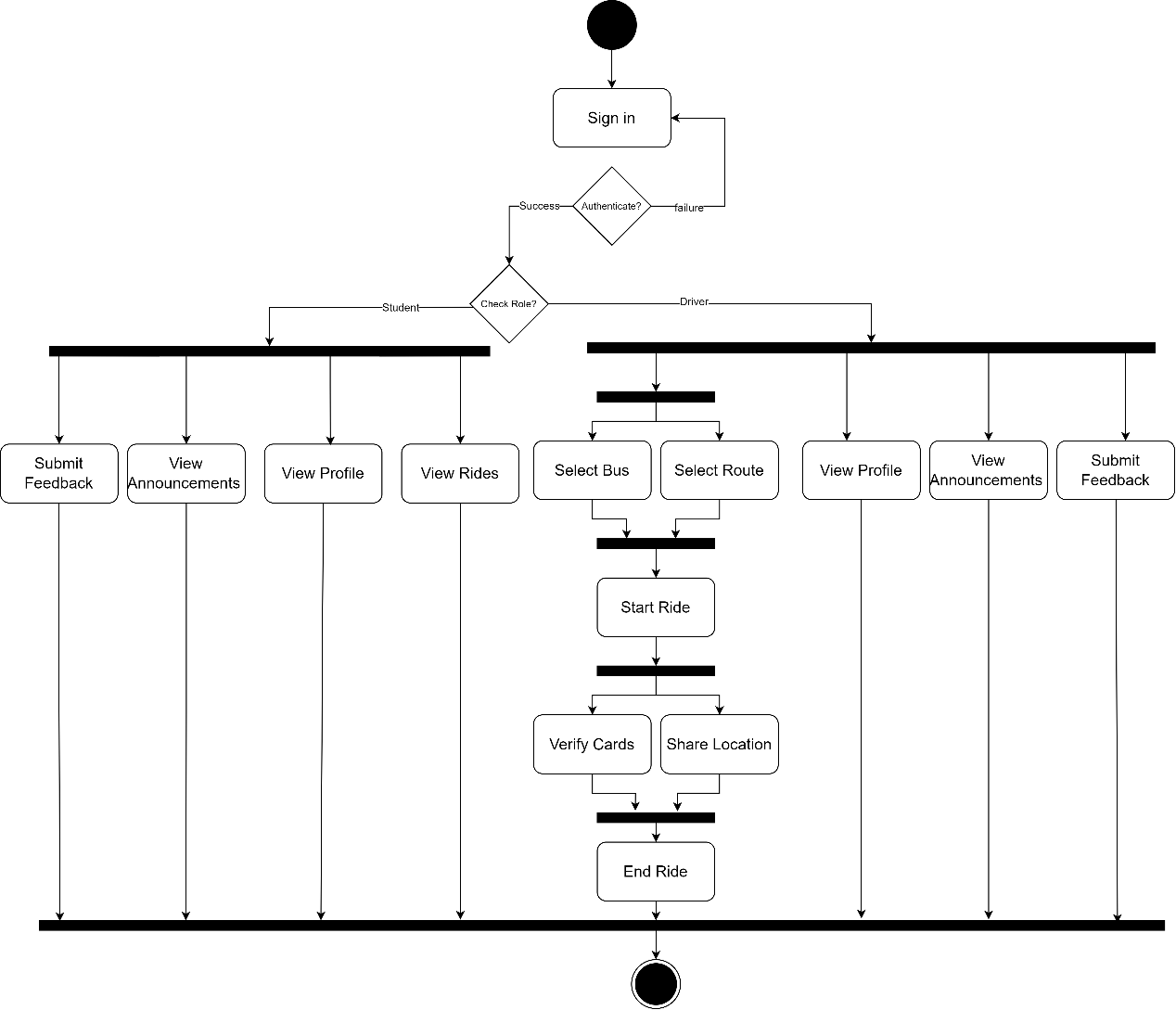


Figure 15 Activity diagram of mobile app

### 5.1.2 Admin Panel

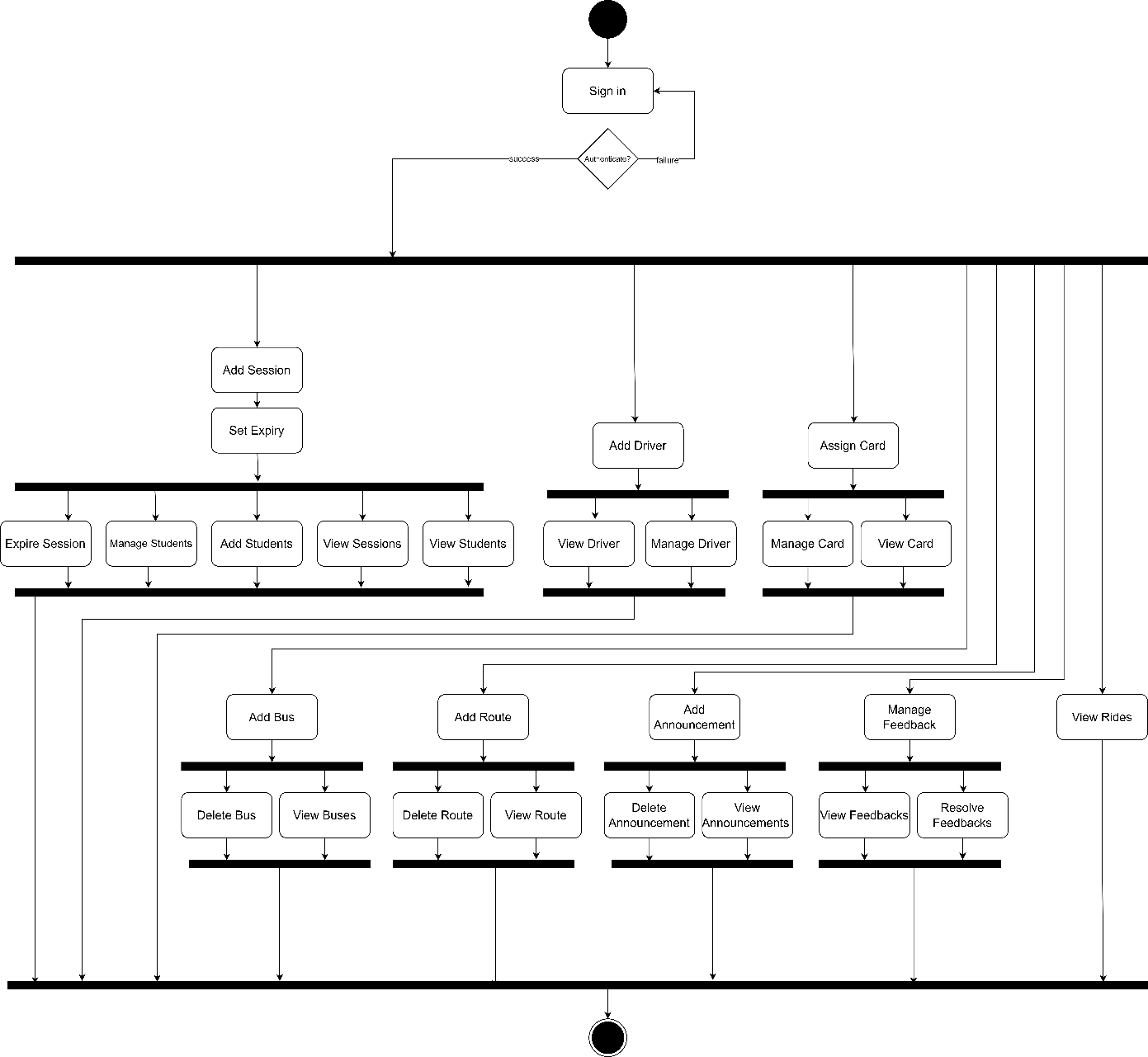


Figure 16 Activity diagram of Admin panel

## 5.2 Database Design

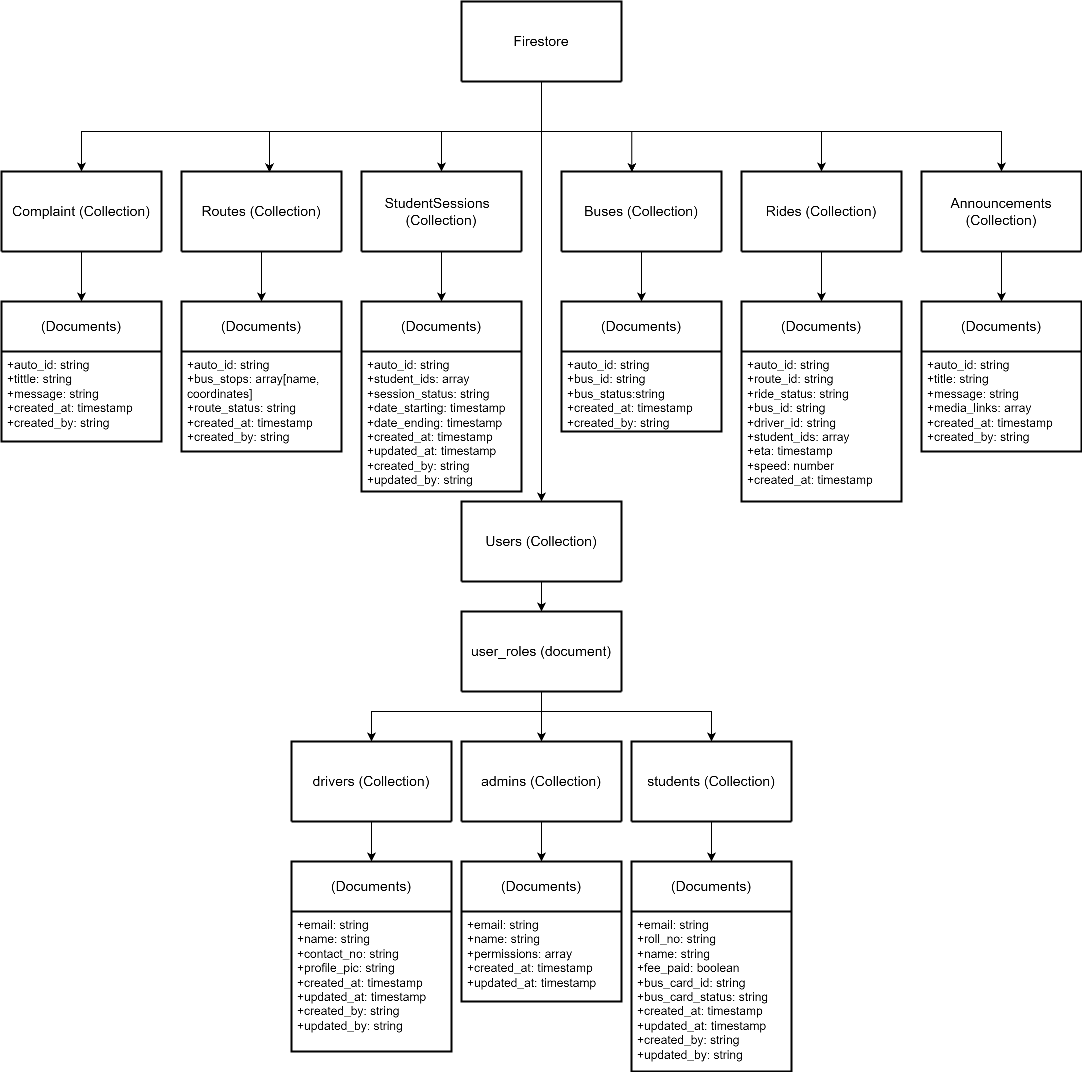


Figure 17 Database Design

## 5.3 Sequence Diagram

### 5.3.1 Admin Panel

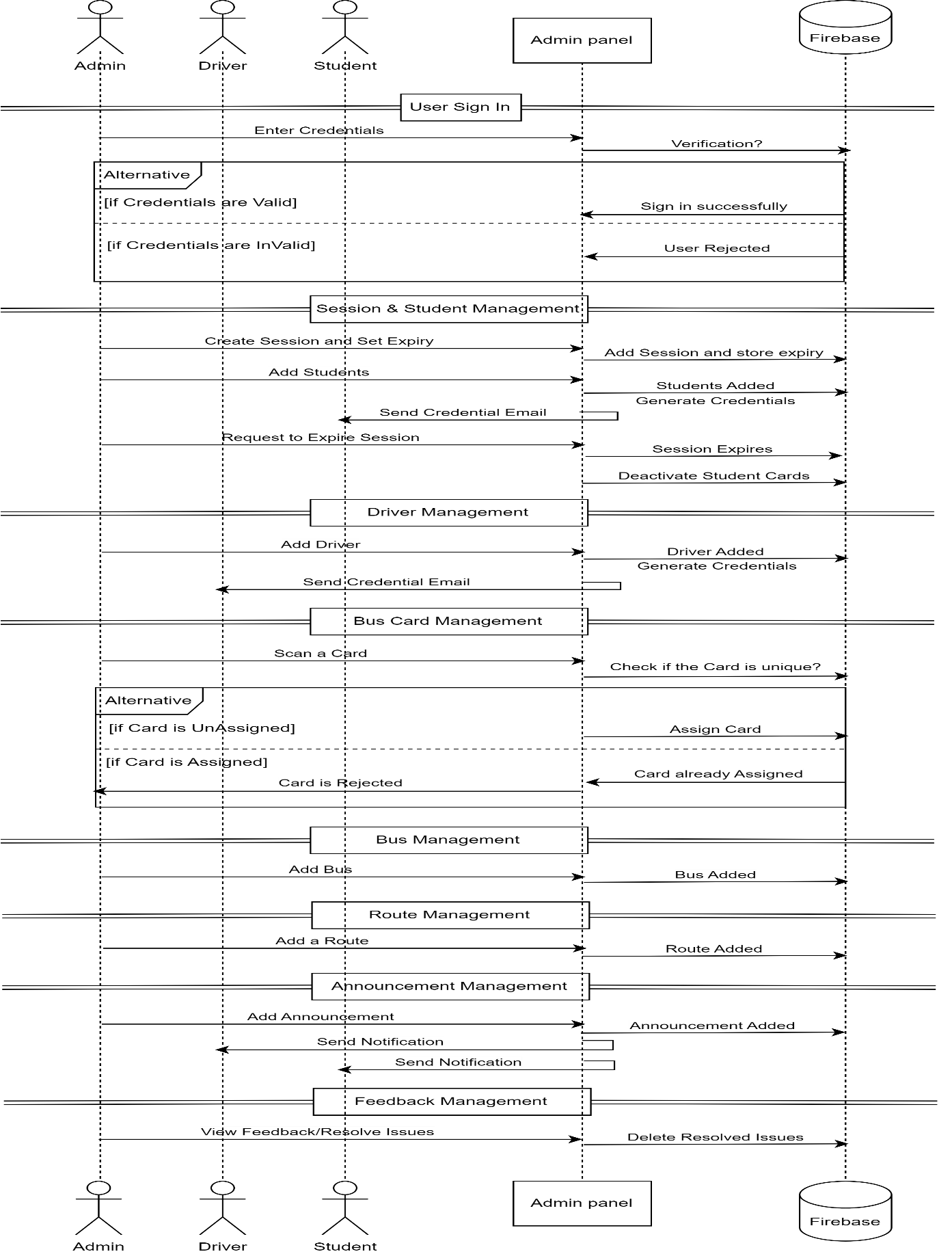
**

Figure 18 Sequence diagram of Admin Panel

### 5.3.2 Mobile App

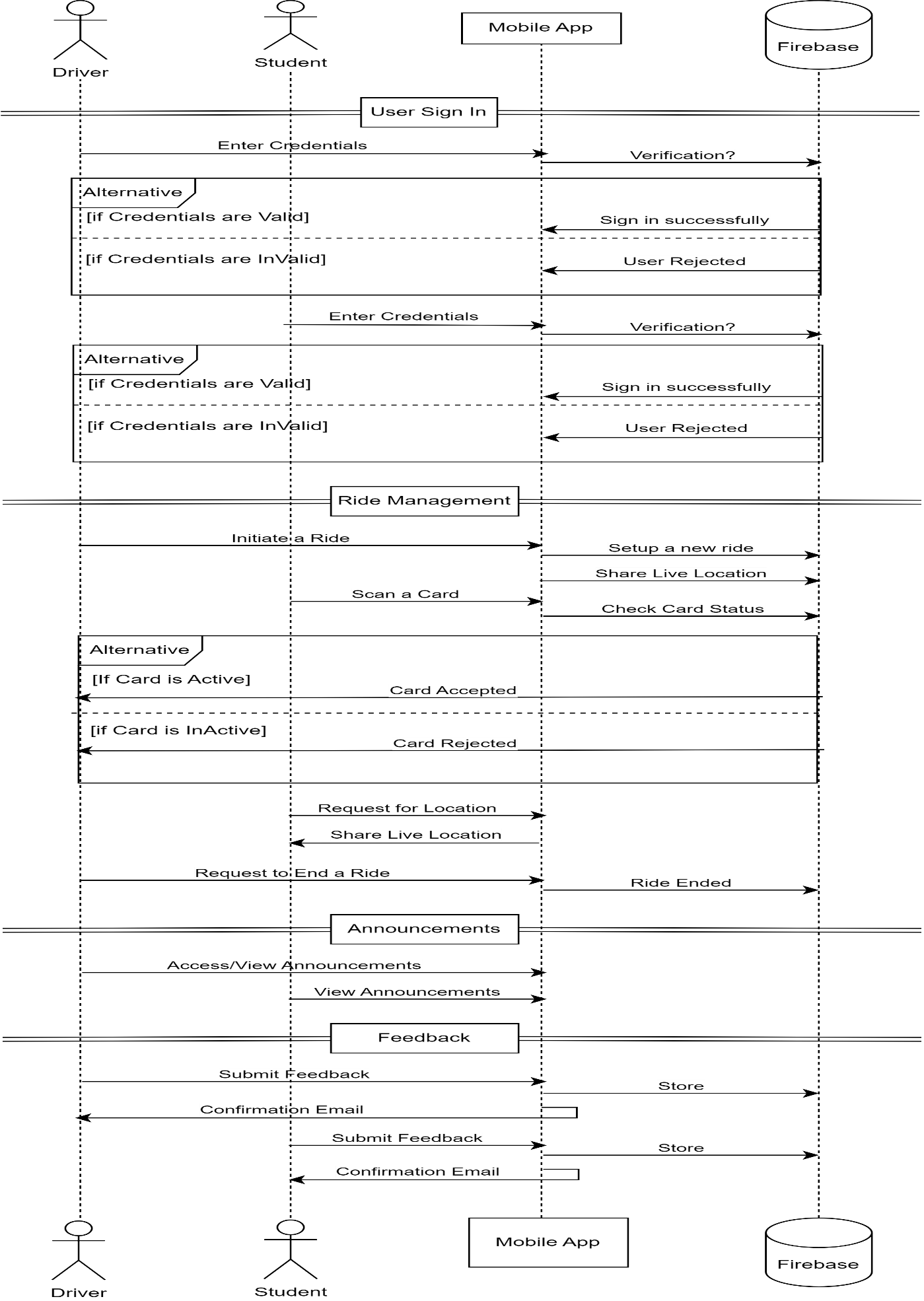


Figure 19 Sequence diagram of Mobile App

## 5.4 Class Diagram

### 5.4.1 Mobile Application

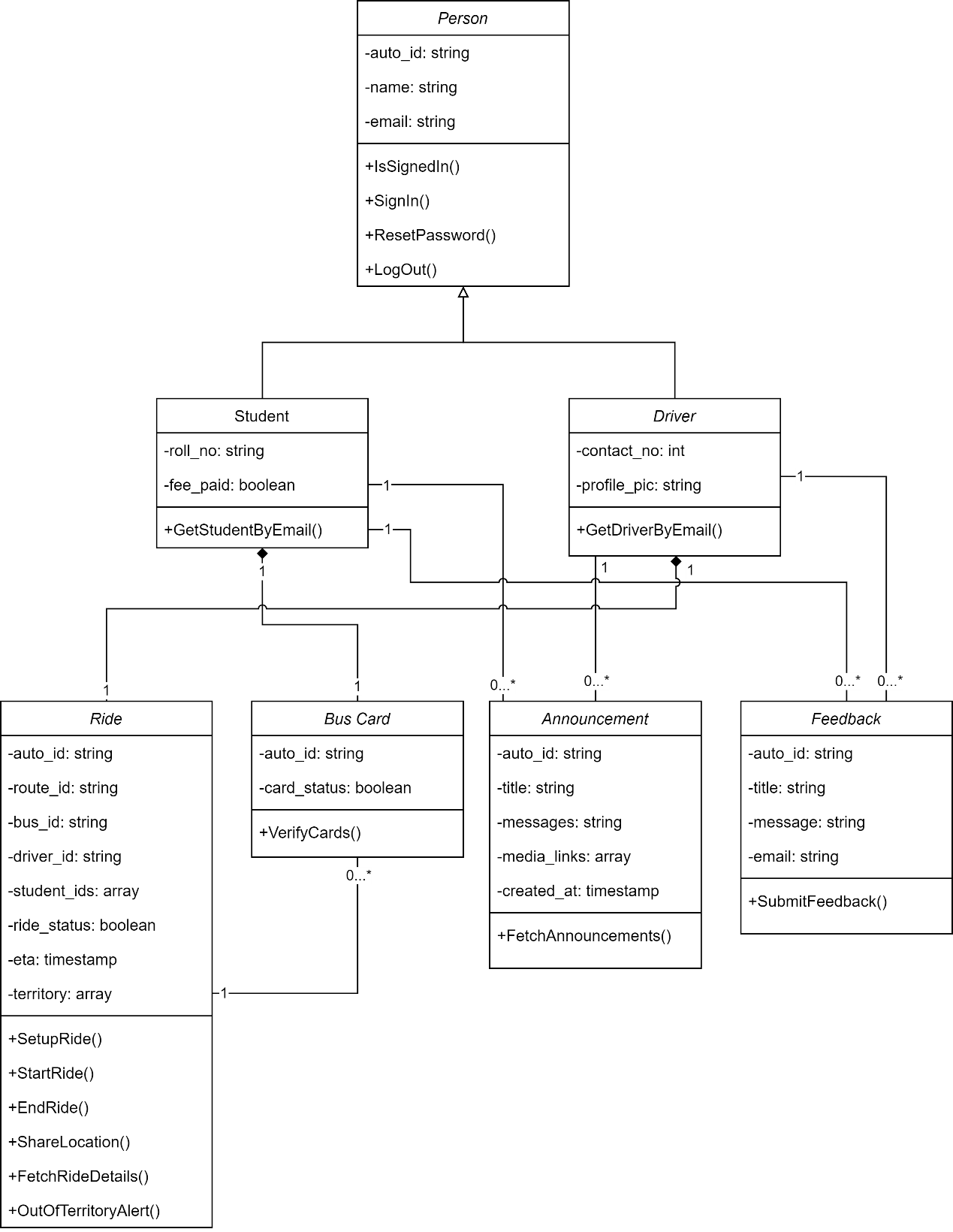


Figure 20 Class diagram of mobile app

### 5.4.2 Admin panel

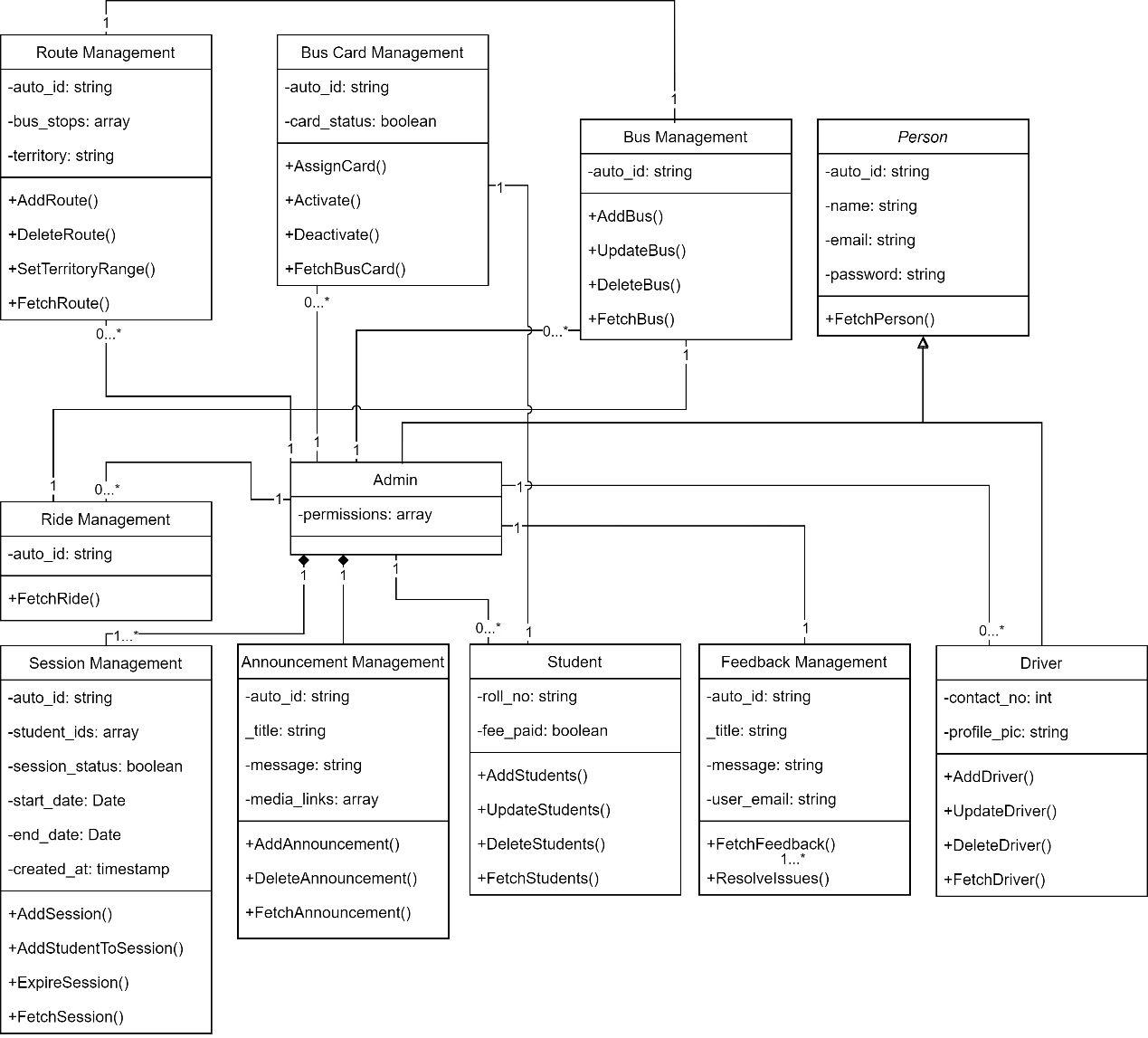


Figure 21 Class diagram of admin panel

# CHAPTER 6

# System Implementation

The successful execution of the NTU Ride Pilot (NTURP) system was made possible through the structured and phased implementation of both its **Mobile Application** and **Admin Panel**, supported by a robust backend and real-time geolocation capabilities. This chapter outlines the tools, technologies, and implementation process used for developing the NTURP system, including the specific functions and modules integrated into each application component.

## 6.1 Technologies Used

To deliver a secure, real-time, and scalable solution for educational transportation management, the following technologies were used:

| **Technology** | **Purpose** |
| --- | --- |
| **Flutter** | Cross-platform development of the **mobile application** for students and drivers. |
| **Firebase** | Backend services including **authentication**, **real-time database**, **cloud storage**, and **push notifications**. |
| **Mapbox** | Used for **live GPS tracking**, **route visualization**, and **location mapping** in both mobile and admin panel. |
| **React.js / Next.js** | Frontend framework for the **admin dashboard**, allowing intuitive management and monitoring. |
| **Cloud Firestore** | NoSQL database storing data such as users, rides, cards, complaints, and announcements. |
| **Firebase Cloud Messaging (FCM)** | Push notification system to deliver real-time alerts. |

## 6.2 Mobile Application Implementation

The NTURP mobile app, built using **Flutter**, caters to three types of users: **Students**, **Drivers**, and **Conductors**. Key implementation features include:

### 6.2.1 Authentication Module

* Uses **Firebase Authentication**.
* Role-based login (Student / Driver / Conductor).
* Secure token generation and session management.

### 6.2.2 Ride Management

* Drivers initiate rides.
* Start/Stop functionality triggers live location updates using Mapbox.
* Student cards are scanned via RFID (NFC-compatible phones or QR codes).
* Data logged includes student ID, route ID, timestamp, and bus number.

### 6.2.3 Live Tracking

* Mapbox integrated to:
  + Show real-time location of buses to students.
  + Display moving bus marker and current location info.
* Firebase updates live coordinates at defined intervals during an active ride.

### 6.2.4 Complaint Submission

* Drivers and students can submit complaints via a structured form.
* Data stored in Firestore and made accessible to admin in real-time.

### 6.2.5 Notifications

* Push notifications sent to:
  + Students: ride updates, delays, announcements.
  + Drivers: route change alerts or admin instructions.
* Integrated using **Firebase Cloud Messaging (FCM)**.

## 6.3 Admin Panel Implementation

The **Admin Dashboard** was developed using **React.js / Next.js**, designed to provide clear visibility and control over NTURP's key modules.

### 6.3.1 User Management

* Add, edit, or remove **students**, **drivers**, and **conductors**.
* Assign roles and generate credentials linked to Firebase Auth.

### 6.3.2 Bus & Route Management

* Add new buses with capacity and driver assignment.
* Define routes using Mapbox’s geolocation interface.
* Set route start/end points and coverage area (geo-fencing).

### 6.3.3 Ride Monitoring

* View live bus movement on a **Mapbox map**.
* Access complete ride history including timestamps, route, and driver.

### 6.3.4 Session Management

* Create academic sessions and associate students.
* Automatically deactivate expired sessions and cards.

### 6.3.5 Complaint Handling

* View list of complaints submitted by users.
* Change status (e.g., Pending, Resolved) and add resolution notes.

### 6.3.6 Announcement Broadcasting

* Create text-based announcements to be sent via notification to all app users.
* Option to target either drivers, students, or both.

## 6.4 Database Structure

The system uses **Cloud Firestore** as a backend NoSQL database. Key collections:

* /users – Stores role-based profiles (student, driver, admin).
* /buses – Bus information, capacity, driver assignment.
* /routes – Route start and end points, waypoints.
* /rides – Logs of each ride (time, students onboarded, route taken).
* /cards – Student bus cards with session expiry.
* /complaints – Records of complaints and resolution details.
* /announcements – Admin notices to be pushed as notifications.

## 6.5 Deployment Strategy

* **Mobile App** deployed via **Google Play Console** for Android devices.
* **Admin Panel** hosted via **Vercel** or **Firebase Hosting**.
* Firebase used as a backend-as-a-service (BaaS), enabling minimal infrastructure maintenance.

## 6.6 Security Measures

* All communications secured using **HTTPS**.
* Firebase Authentication restricts unauthorized access to backend resources.
* Role-based access ensures only authorized users access sensitive functions.
* Session tokens are encrypted and refreshed periodically.

## 6.7 Summary

The NTURP system was implemented using a modern tech stack optimized for real-time performance, security, and cross-platform compatibility. The integration of **Flutter**, **Firebase**, and **Mapbox** allows for scalable and cost-effective deployment, while maintaining ease of use and robust transport tracking features. The modular design ensures that additional features can be added in the future with minimal disruption.

# CHAPTER 7

# System Testing

System testing is a critical phase in the software development life cycle aimed at verifying that the entire NTU Ride Pilot (NTURP) system functions as expected. This chapter outlines the **testing strategies, techniques, tools, and test cases** used to ensure that the system is robust, secure, and user-friendly. It includes both functional and non-functional testing to validate core modules like RFID-based authentication, GPS tracking, session management, complaints, and notifications.

## 7.1 Testing Approach

NTURP follows an **incremental testing approach** using Agile methodology, where components were tested sprint-by-sprint after each module’s implementation. The following test types were conducted:

| **Type of Testing** | **Description** |
| --- | --- |
| **Unit Testing** | Testing individual functions like login, card verification, and ride start. |
| **Integration Testing** | Verifying interactions between modules like GPS tracking + Firebase logging. |
| **System Testing** | Validating complete workflows from sign-in to ride monitoring and complaints. |
| **User Acceptance Testing (UAT)** | Conducted with sample admin and student users to gather real-world feedback. |

## 7.2 Testing Tools and Environment

| **Tool/Platform** | **Purpose** |
| --- | --- |
| **Flutter DevTools** | Debugging mobile app logic |
| **Firebase Console** | Monitoring authentication, database, FCM delivery |
| **Mapbox Debugger** | Route and location validation |
| **Postman** | Testing backend APIs (e.g., login, card validation) |
| **Browser Dev Tools** | Admin panel testing and UI checks |

## 7.3 Test Cases

Below are representative test cases for core NTURP functionalities:

**✅ Test Case 1: Student Login**

| **Field** | **Description** |
| --- | --- |
| Test Case ID | TC-01 |
| Module | Authentication |
| Input | Valid student email & password |
| Expected Output | Redirect to student dashboard |
| Status | ✅ Passed |

**✅ Test Case 2: RFID Card Verification**

| **Field** | **Description** |
| --- | --- |
| Test Case ID | TC-04 |
| Module | Ride Management |
| Input | Tap of valid RFID card during bus boarding |
| Expected Output | Student entry recorded, access granted |
| Missing Data | ❗ **NFC scan screenshots or test logs** |
| Status | ✅ Passed |

**✅ Test Case 3: Live Location Update**

| **Field** | **Description** |
| --- | --- |
| Test Case ID | TC-07 |
| Module | Live Tracking (Mapbox) |
| Input | Driver starts ride |
| Expected Output | Live location updates every 5 seconds |
| Missing Data | ❗ **GPS trail screenshots or exact Mapbox responses** |
| Status | ✅ Passed |

**✅ Test Case 4: Admin Announcements**

| **Field** | **Description** |
| --- | --- |
| Test Case ID | TC-09 |
| Module | Notification/Announcements |
| Input | Admin publishes a new message |
| Expected Output | FCM sends push notification to all users |
| Status | ✅ Passed |

**✅ Test Case 5: Submit Complaint (Student App)**

| **Field** | **Description** |
| --- | --- |
| Test Case ID | TC-11 |
| Module | Complaint Management |
| Input | Student submits complaint |
| Expected Output | Entry stored in Firestore and visible to admin |
| Status | ✅ Passed |

## 7.4 Bug Reporting & Resolution

All encountered issues were logged in a shared tracking document. Each bug was recorded with:

* **Bug ID**
* **Description**
* **Severity (High/Medium/Low)**
* **Status (Open/Resolved/Closed)**
* **Assigned Developer**

Example:

**Bug ID:** BUG-05 – Map not loading on student app.  
**Cause:** API key restriction.  
**Resolution:** Updated Mapbox key with public access token.  
**Status:** ✅ Resolved

## 7.5 Performance Testing

Performance testing was conducted on core Firebase modules:

* **Auth response time**: Average 350ms
* **Database write latency**: < 200ms (under free tier conditions)
* **Live location sync**: Stable update at 5-second intervals for rides

❗ **Missing Data:** Graphs of latency or stress test benchmarks can be added if available.

## 7.6 User Acceptance Testing (UAT)

Pilot testing was conducted with 5 students and 2 staff members:

* Ease of login and card scanning confirmed
* Ride tracking worked smoothly in local campus area
* Suggestions included:
  + UI spacing adjustments
  + Add ride summary in history

## 7.7 Summary

The NTU Ride Pilot underwent thorough testing from both technical and user perspectives. All functional modules were validated and shown to perform as intended in both isolated and integrated conditions. While most test logs were retained during development, artifacts such as **NFC scan logs, GPS trail visuals, and real notification screenshots** may be added manually for a complete documentation set.