A REAL–TIME MONITORING SYSTEM FOR ENHANCED CAMPUS TRANSPORTATION

BY

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FINAL YEAR DESIGN PROJECT REPORT

This Report Presented in Partial Fulfillment of the Requirements for the
Degree of Bachelor of Science in Computer Science and Engineering

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APPROVAL

This Project titled "A Real-Time Monitoring System for Enhanced Campus Transportation", submitted by Masum Bin Hossain, ID No: 201-15-14182 to the Department of Computer Science and Engineering, Daffodil International University, has been accepted as satisfactory for the partial fulfilment of the requirements for the degree of B.Sc. in Computer Science and Engineering and approved as to its style and contents. The presentation has been held on 13 January 2025.

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I hereby declare that this project has been done by me under the supervision of **Dr. Sheak Rashed Haider Noori, Professor & Head, Department of Computer Science and Engineering, Daffodil International University**. I also declare that neither this project nor any part of this project has been submitted elsewhere for the award of any degree or diploma.

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Finally, I must acknowledge with due respect the constant support and patience of my parents.

ABSTRACT

The digital revolution is revolutionizing transportation systems, and so are universities. The university's transportation system digitalization will be a significant step forward in campus infrastructure management. Through that, we will improve the university bus transportation system in size, efficiency, and management level. This is our hardware and software solutions. Real-time Bus Visibility for Students and Faculty: By using GPS and RFID technology on each bus, students and faculty members can receive real-time location information for buses and see route assignment. At the boarding and disembarking stage, users will scan their RFID cards and provide administrators with data on student traffic and bus utilization. Students will benefit from details on bus schedules and routes ahead of time, alleviating long waits and uncertainty on bus assignments with the system. Also, administrators will have statistics about how many students are using each route so that they can allocate the buses and schedules according to the demand. RFID scanners will also discourage unauthorized use of transportation by identifying only registered students with a vehicle and ID to use the service. This project will ultimately help the university to provide better user experience for riders and streamline the transportation system for the administrators. The university community can therefore look forward to a much smoother and more reliable transportation experience of the transportation worker, as it continues to evolve along with the changing realities of everyday campus life, with a much higher level of convenience, safety, and data-driven decision-making.

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CHAPTER 1
Introduction

In this chapter, it will be discussed how the project enhances campus transportation via informative route finding and smart decision making. It discusses motivation, objectives and the way to achieve safer, faster and easier travel for all.

1.1 Introduction

No more static bus schedules and guesswork when it comes to when the next bus is arriving. We developed also a smart logistics system to offer information in every moment displaying the location of the buses, arrival times, road changes, etc. Eliminating the guesswork and frustrations common to bus services.

This system relied on university authorities assigning buses based on an anticipated demand, which can lead to errors without real-time information. Our project solves this by providing real time updates to authorities, so that they can make quick and data driven decisions. This way, the bus is deployed there regardless of whether it is a busy hub stop or a quieter section of campus.

The days of standing at the bus stop with crossed fingers are over. With our system, you look at your phone and see where the bus is on a map, and you leave strategically and minimize wasted waiting time.

But there are advantages, far more than convenience. Real-time bus information enables proactive measures. If a stop gets too crowded, more buses can be sent. This data has the potential to analyze traffic patterns across campus and continually optimize routing options for those who may be transporting via motorized means.

1.2 Motivation

What I'm doing this project for is to make everyone's life at the university easier. It should be easy and carefree to navigate campus. Sometimes it is not. Waiting for buses without a clue of which to board and wondering if it is safe are all irritation-provoking events. So that’s why I feel so compelled to use new technology to address these challenges.

One quandary is that it can be difficult to tell whether you have failed to catch your bus

or it is simply running behind schedule. This uncertainty makes it hard to plan your day, which leads to undue stress. Another problem is understanding where the bus goes. This is why confusion and delays are inevitable as it's not always clear which bus is assigned to which route. Also, the university occasionally assigns more buses to places where demand is high. This translates to more crowded buses, passenger wait time increase and a less than pleasant transportation experience.

I want to prevent confusion as to when and which bus to take by using things like GPS and RFID cards. This saves time and allows for smoother movement around campus for all. And safety is also high on the agenda, which is why I am looking at ways to ensure only the right people are able to access the buses.

To sum it all up, my vision is to make the university a better place to be in by making transportation better. Life will be a little bit sweeter on campus with more simple, safe, and friendly transportation at play.

1.3 Objectives

Starting a journey of transformation, this project aims to completely change how the university's transportation works. By using new technology, we want to make it easier and safer for students and staff to get around campus. Here are the main goals:

- Enhance transportation experience for university students and faculty.
- Increase efficiency and reliability of the university bus transportation system.
- Reduce wait times for users by optimizing bus allocation and scheduling.
- Provide real-time information on bus locations and route assignments.
- Enhance safety and security through RFID technology and monitoring.
- Identify high-demand areas to improve service delivery.
- Monitor transportation usage patterns to inform decision-making.
- Prevent unauthorized transportation use through RFID authentication measures.

This project aims to not only meet the current needs but also adapt to future demands, ensuring a sustainable and reliable transportation service for the entire university community.

1.4 Methodology

The approach of this project is a well planned approach that consists of design, hardware and assessment. The very first phase involves conducting a thorough requirements analysis to understand the requirements of the students, faculty and management of the university. It is followed by system design in which we installed hardware devices such as GPS and RFID modules that allow the system to track data and capture real-time data.

The implementation phase includes hardware construction, microcontroller programming and the determination of data transmission protocols for the real-time transmission of information. Then a series of tests are run to check the accuracy, reliability and usability of the system when it is used in the real world. To improve the further, it also follows the suggestions from the stakeholders. system Finally, the system is compared with the goals that were defined earlier to see what is the effect of the system on the users' satisfaction and the transportation system on the campus.

1.5 Project Outcomes

As we embark on this journey, we look forward to the many benefits this service will bring, including improved convenience, safety and efficiency for everyone from students and faculty to staff and visitors on campus.

- Improve user experience: The upgraded university bus transportation system design will allow students and faculty to transport themselves in a convenient and user-friendly manner so that the usage will increase and so will satisfaction level.
- Increased Efficiency: Lower wait times and better bus allotment will create streamlined operations and less crowding, allowing timely movement across campus.
- Safety: An improvement on security, this will guarantee that only people that booked the transport service will have access to it, this way, the chances of being harmed by an unanticipated guest in the vehicle are reduced.
- Improved Decision Making: Administrators can access data on transportation usage patterns to decide when to modify routes and adjust bus schedules to better accommodate changing needs.
- More efficient resource management: Data provides a blueprint of which neighbourhoods are hotspots for each cumulative data category. It can help decisive value allocation towards efficient service delivery following the

guidelines for fewer carbon emissions.

- Greater Transparency: Real time information available at key points during their journey will empower passengers with information and give them more control over their journey, resulting in more predictable journeys and users being able to work around travel routines.
- Reduced Unauthorized Use: Use of RFID authentication will prevent unauthorized individuals from utilizing the transportation service. It enables fair use, curb fare evasion and limit lost revenue.

In summary, these enhancements are designed to create a transportation system that is safer, more efficient, and easier for people to navigate. The initiative will bring about positive improvement to the university's transportation system, which is in-line with the university's aim to serve quality service and prioritize student welfare.

1.6 Organization of the Report

A complete report format include how to represent "A Real Time Monitoring System Hindrance for Campus Transportation" where the report will be bifurcated into different segments to highlight all major aspects of the project including its segments, development phases, tool features and the outcome. Here's a rough outline for the report layout:

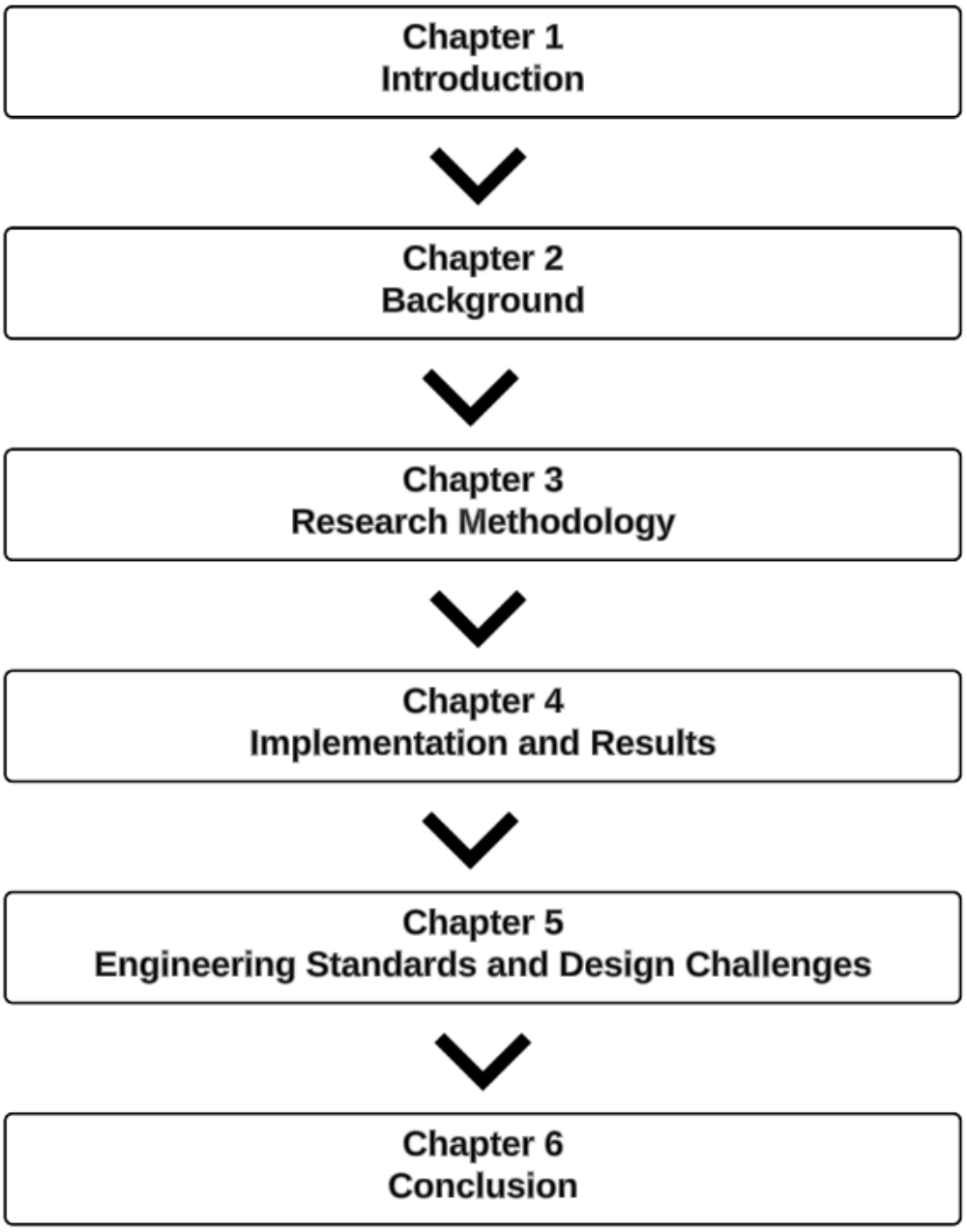


Figure 1.6.1: Report Layout of this Project.

CHAPTER 2
Background

In the chapter called “Literature Review”, an intensive literature survey is carried out regarding the existing literature, relevant technologies and related researches that can be used or adapted to make a real time campus transportation monitoring system. By focusing on deficiencies in current systems, it lays the groundwork for the new approaches outlined in this project.

2.1 Introduction

This review can help anyone with a fundamental knowledge of the real-time monitoring systems needed on campus for transportation by summarising existing literature and technologies. Then, this chapter discusses related works, comparative analysis against existing systems, open issues, and conclusions and highlights findings summarizing the development of a real-time monitoring system for campus transportation improvement.

2.2 Literature Review

This section gives a detailed analysis of previously existing literature relating to transportation monitoring systems, as well as campus transportation. In terms of key technologies, these systems are based on GPS, RFID, GSM, and IoT platforms. We will discuss several implementations and benefits along with the problems they solve in this section.

Transportation systems rely heavily on GPS technology for real-time location tracking. Numerous research has shown its uses in making public and university transportation systems more efficient and reliable. B Aparna et al. This improved service reliability significantly [1] successfully implemented a GPS and GSM based transportation tracking system to locate college buses.

The latitude and longitude of the current position is obtained from the integration of GPS-GPRS based vehicle tracking system in schools. SA Salunke et al. [2] proposed a system vehicle tracking system using GPS-GPRS with Arduino to increase transportation efficiency.

M Nitti et al. [3] featured the Wi-Fi based Automatic Bus Passenger Counting System, or iABACUS, which can detect the number of passengers on public transportation and has proven to work well even on the move. Alternatively, A Agrawal et al. Model of GPS and GSM with voice module for solving the problem of visually impaired persons[4].

Radio-Frequency Identification (RFID) algorithms have been implemented for Passenger identification and tariff collection systems. But AD Shree et al. [5] used RFID to sense the bus at the stoppage. It also includes GPS and GSM module to know live location.

DD Bhavani et al. [6] presented the Wi-fi module employed to track the bus with a low cost and real-time updates in the mobile application. Amir H. Alavi et al. [7] studied the applications of cloud computing, wireless communications and RFID technology in smart cities, while underscoring that the accuracy of data and its real-time processing is essential.

JG James et al. [8] Implemented LoRaWAN and RF transceivers for an alternative to a traditional tracking system in public transportation with great potential to improve managing passenger flow, and reduce boarding time. M Kumbhar et al. [9] The GPS, Google Maps and GPRS-based bus tracking system proposed real-time location through Google Maps and improved operational efficiency.

Example: GSM module is used for getting real-time data from vehicles to a server. JMM Khin et al. “Design and Implementing a Real-Time Vehicle Tracking System using GPS, GSM, XAMPP and Google Maps API” which is another way v2 v to track vehicle in real-time. [9]

2.3 Similar Applications

Vehicle tracking systems have been deployed using different techniques to track vehicles using modern techniques and playing a significant role in the tracking of the vehicles. Three important papers provide a comparison of various systems:

1. **GSM and GPS Based College Bus Tracking System (B Aparna et al. [1]** This system combines GSM and GPS modules for the purpose of tracking the college buses in real time. Its functionality is mostly limited to sending SMS updates about the position of the bus, thereby keeping the location of the bus

always connected to a central system. The system's design is focused on simplicity and reliability, with it easy to deploy with no advanced infrastructure needed.

2. **Arduino Based Vehicle Tracking System for School Bus(SA Salunke et al. [2]):** this system uses an Arduino-based microcontroller that connects to the GPS and two GSM modules. The great thing with Arduino is that it can be implemented at low cost. As the first system, the second one aims to inform location updates and alerts through SMS. This allows for a wider range of uses than your average proprietary 3D printer.

3. **A Wi-Fi-Based Automatic Bus Passenger Counting System (M Nitti et al. [3]):** This system differs from the previous two as it uses Wi-Fi technology to automatically track and count passengers. More over, this method helps lower the reliance on GSM networks, and provides a new dimension of tracking by including passenger data as well. Using advanced algorithms to count passengers, it provides not just location data, but occupancy data, which is helpful for optimizing bus routes and schedules.

4. **GPS and GSM Based Guiding System for Blinds (A Agrawal et al. [4])** This uses GPS and GSM technologies similar to Vehicle tracking systems, and is primarily designed to assist visually impaired individuals. This demonstrates the versatility of these technologies to provide accurate real-time data. This feature includes an additional function that can be beneficial for the vehicle, especially for tracking systems, focusing on obstacle detection and alerting the user.

Technological Integration:

- The systems by B Aparna et al. [1] and SA Salunke et al. [2] Both of these rely on GSM and GPS modules for real-time tracking, but only the latter uses an Arduino microcontroller, which provides flexibility and ease of customization.
- M Nitti's et al. It is interesting to see the new generation technolgies being in place such as Wi-Fi which can provide faster rate than GSM and save money.

Functional Scope:

- B Aparna's et al. The [1] system is simple and aimed mainly at location

tracking with SMS alerts.

- SA Salunke et al. The system in [2] is more customizable thanks to an Arduino feel and lends itself to more niche use cases.
- M Nitti's et al. It is worth noting that the passenger side[3] approach adds an operational dimension data that is a core function to service delivery optimization.
- A Agrawal's et al. As mentioned in the case of [4] system, the topic is extended from general tracking towards safety and obstacle detection systems, elucidating the potential of usage of GPS and GSM technologies in a wider realm.

Implementation Complexity:

- System I: B Aparna [1] System II: SA Salunke et al. [2] which are relatively simple to implement, mainly focusing on the integration of GSM and GPS.
- M Nitti's et al. [2] system is more complex,[3] and therefore more informative than the other;But the more specific the system, the harder it is to grow.
- A Agrawal's et al. [4] Since its focus is primarily on helping those who are blind and visually impaired, it highlights the added complexity of obstacle detection and real-time alerts that may also be leveraged to seek redundancy for vehicle safety.

2.4 Related Research

With the development of GPS, GSM technology, in recent years, the field of transportation systems has made great progress. Many different systems have been studied to provide such vehicle systems with a higher degree of efficiency, safety, as well as extended accessibility. Here we briefly describe some relevant works of research on smart transportation solutions that are implemented on an educational and public transportation system.

- College Bus Tracking System through GSM and GPS: This study (Bharatha Aparna, 2022)termed as college bus tracking system through GSM and GPS. The system would capture position and then send it as SMS to a collection server where the data is posted in real time. "With this, students and faculty members had the possibility of viewing live updates, consequently cutting down wait times and increasing safety." This work evidenced the practical advantages of combining GSM and GPS for cost-effective and reliable localization.

- Vehicle Tracking System for School Bus using Arduino: In 2017 Supriya A Salunke proposed a vehicle tracking system for school buses using Arduino along with GPS and GSM modules. Through the system, parents and school administrators could also track bus locations and get alerts to make sure students were safe. Arduino allowed for a more customized and cost-effective solution to our problem, allowing for a more school-wide application of the system.

- Automatic Bus Passenger Counting System Based on Wi-Fi: Michele Nitti (2020) have developed new system that uses the passenger counting mechanisms with Wi-Fi technology. Not only did this allow for real-time tracking, but it also allowed bus operators to optimize routes and schedules according to occupancy data. The study found that new technologies have the ability to supplement basic sextant tracking with additional insights that can help in optimizing operation.

- GPS and GSM Based Guidance System for Blinds: According to a smoother paper by Avantika Agrawal (2017) on this topic, a navigation guide using GPS and GSM was being developed for the blind people. While the respective main aim was obstacle identification and navigation, the study also proved the adaptability of GPS and GSM to offer real-time data and alerts. The study also highlighted the versatility of these technologies for a variety of uses, including improving transportation systems.

- Integrated Transportation Systems and Smart Campus Initiatives: Numerous studies have investigated the integration of transportation systems within the context of broader smart campus initiatives. These research works highlight IoT, cloud computing, and real-time analytics for interrelated systems. With the integration of GPS, GSM, and other sensors, these systems are designed to facilitate to improve transportation efficiency, sustainability, and user convenience.

Comparative Insights from Related Research

This review article collectively highlights the possibilities of GPS and GSM technology in revolutionizing conventional transportation. And while systems like those proposed by Bharatha Aparna and Supriya A Salunke focus on real-time tracking and safety, research like Michele Nitti's adds another level of functionality, such as counting passengers. Avantika Agrawal demonstrated other possibilities of applying

these technologies for specialized user groups, proving its doctrine across different domains.

This information has been helpful in informing the goals and approach of this project. As this project intends to build on existing technologies, while correcting some of the limitations of prior work, it will add to the body of knowledge of a field where the richer the arsenal of solutions, the better.

2.5 Gap Analysis

While the transportation monitoring systems have evolved to an appreciable extent, there are still many open questions:

2.5.1 Data Privacy and Security

It is important to ensure user data privacy and protection in systems dealing with RFID and GPS tracking. Proper encryption and data at rest handling are critical to preventing unauthorized access and breaches as well.

2.5.2 Network Dependency

GSM or Wi-Fi networks also used for real-time data transfer have connectivity restrictions in low coverage areas, affecting system reliability.

2.5.3 System Maintenance

Regular inspection of the hardware is needed to keep things working smoothly. Managing hardware anomalies in timely fashion helps prevent system downtimes.

2.6 Summary

The literature was reviewed concerning the real-time system application for transportation monitoring system in campus environments. The key technologies considered were GPS systems, RFID systems, GSM communication and IoT platform used in TRANSPORTATION systems. A comparative analysis showed the strengths and weaknesses of the different options and open questions like data privacy, network

dependence and systems maintenance were outlined. The following insights help inform the design of an effective real-time monitoring framework for improving campus transportation, filling the gaps of existing challenges while building upon current advancements.

CHAPTER 3

Research Methodology

This chapter discusses the methodology and requirement analysis for developing a "Real-Time Monitoring System for Enhanced Campus Transportation" that will benefit university facilitation. The methodology will help maintain a systematic way of developing a user-efficient tracking system that is reliable as well. 3.1 Requirement Analysis and Design Specification

3.1 Requirement Analysis & Design Specification

This section describes the systematic way that will help identify, analyze and mitigate the challenges involved with the university's current transportation system. Using the modern techniques, for instance, GPS and RFID, the project seeks to develop a real-time monitoring system that is user-efficient and promoting administrative facilitation. In this section, the reader will be able to understand the various steps during the whole process inventory

3.1.1 Overview

Requirements analysis and specification of the design is essential to the success of this project. This Phase lays the groundwork for developing an end system that meets user expectations and also works on overcoming operational inefficiencies. This includes speaking with stakeholders to gain insights, identifying gaps in existing transportation framework, and defining needs both functional and non-functional. With a clear and well-structured process in this stage the practical and scalable solution is established to lead the way to a seamless implementation.

3.1.2 System Design

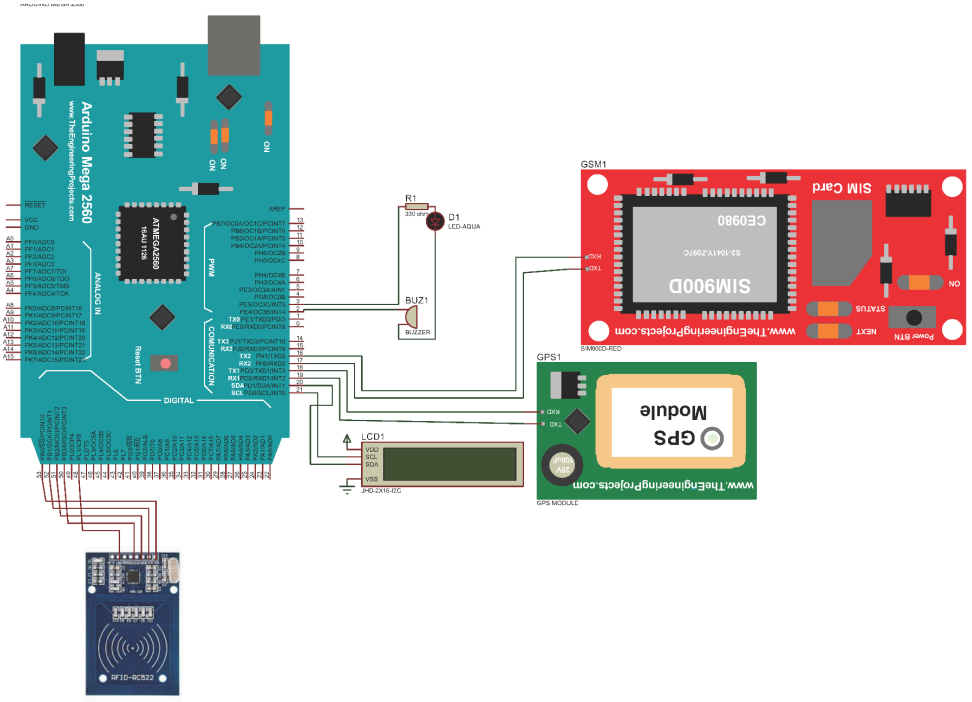


Figure 3.1.2.1: Circuit Design

3.1.3 Requirement Collection and Analysis

Requirement Collection and Analysis ProcessThe process of Requirement Collection and Analysis consists of systematic methodology to gather the need of various people/stake holders who use the university's transportation system. Here is an example of this process in-action:

- **Identify Stakeholders:** The critical stakeholders for this project are students, faculty members, bus drivers, transportation administrators, and university officials. Within each group, the different companies have roles and expectations of the transportation system.
- **Gather Requirements:** Conduct surveys, workshops, and interviews with stakeholders to gather their needs, preferences, and pain points. Learn about their expectations of bus schedules, bus routes, time taken to wait for buses, and user experience.
- **Review Existing Transportation Protocols:** Review the current transportation process to determine weaknesses, congestion, and opportunities for improvement. This could include an analysis of historical bus usage data, wait times, and route efficiency.
- **Develop Use Cases and User Stories:** Use the requirements collected to develop use cases and user stories that detail the specific functionality and interactions expected from each stakeholder group. Create scenarios such as

students checking bus schedules, drivers updating routes, and managers analyzing passenger traffic.

- **List Functional and Non-Functional Requirements:** Detail the specific components needed for real-time bus monitoring like GPS, GSM, and RFID integration, passenger tracking, route optimization algorithms, and the front-end requirements. State the non-functional requirements like security of data, scalability, and performance of the system.
- **Prioritize Requirements:** Do proper prioritization of the needs according to their importance in the context of feedback from stakeholders, technical feasibility, and impact on the overall user experience. Focus on features that solve the most pressing problems and deliver the most benefits to key stakeholders.
- **These approaches include:** Verify and Validate Requirements:Verify that the collected requirements are in agreement with appropriate stakeholders. Reshape and redefine requirements in response to feedback and new knowledge.
- **Document Requirements:** Compile all gathered requirements into a comprehensive document or database that includes functional specifications, use cases, user stories, and prioritized features. Ensure that the document accurately reflects the needs and expectations of stakeholders.
- **Analyze Stakeholder Input:** Engage with various stakeholders to analyze their inputs and identify any potential gaps in their requirements. Proceed to the development phase after receiving approval from stakeholders.

The requirement collection and analysis process as described in this document are crucial for ensuring that the final implementation of "A Real-Time Monitoring System for Enhanced Campus Transportation" meets the needs of users and enhances the efficiency of the transportation system at the university.

3.1.4 Business Process Modeling

Business Process Model and Notation is a standardized visual language for representing business processes. Business Processing Model In My Idea (A Real-Time Monitoring System for Enhanced Campus Transportation) The entire business processing model basically summarizes the whole operational flow of three major participants which are users, admin and device. Entering the device by the administrator the first step is to enable live location updates stored in DB. When users board and disembark from the bus, they first scan their ID, which data is stored in the system too. Moreover, users can ask for the current locations of buses, which causes the device to send back the live stream location data to the user. With this model

representation, we will be able to visualize the functional workflow of the campus transportation monitoring model.

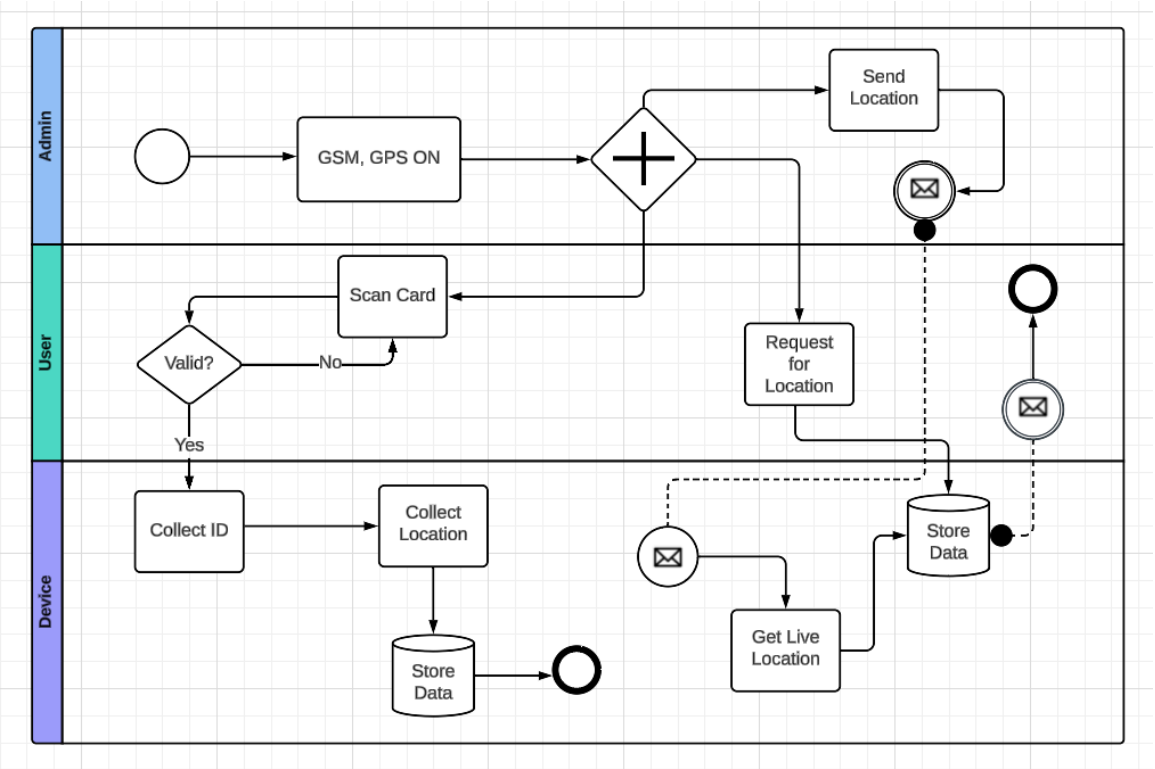


Figure 3.1.4.1: Business Process Modeling

3.1.5 Use Case Modeling and Description

The use case modeling of "A Real-time Monitoring System for Improved Campus Transportation" is concerned with a number of situations, including card scanning, real-time location and route information of buses, assignment of bus routes, etc. Each scenario describes the exchange between system administrators and users. This clarifies how the entire system works and how users interact with the same and ensures smooth operations and communication.

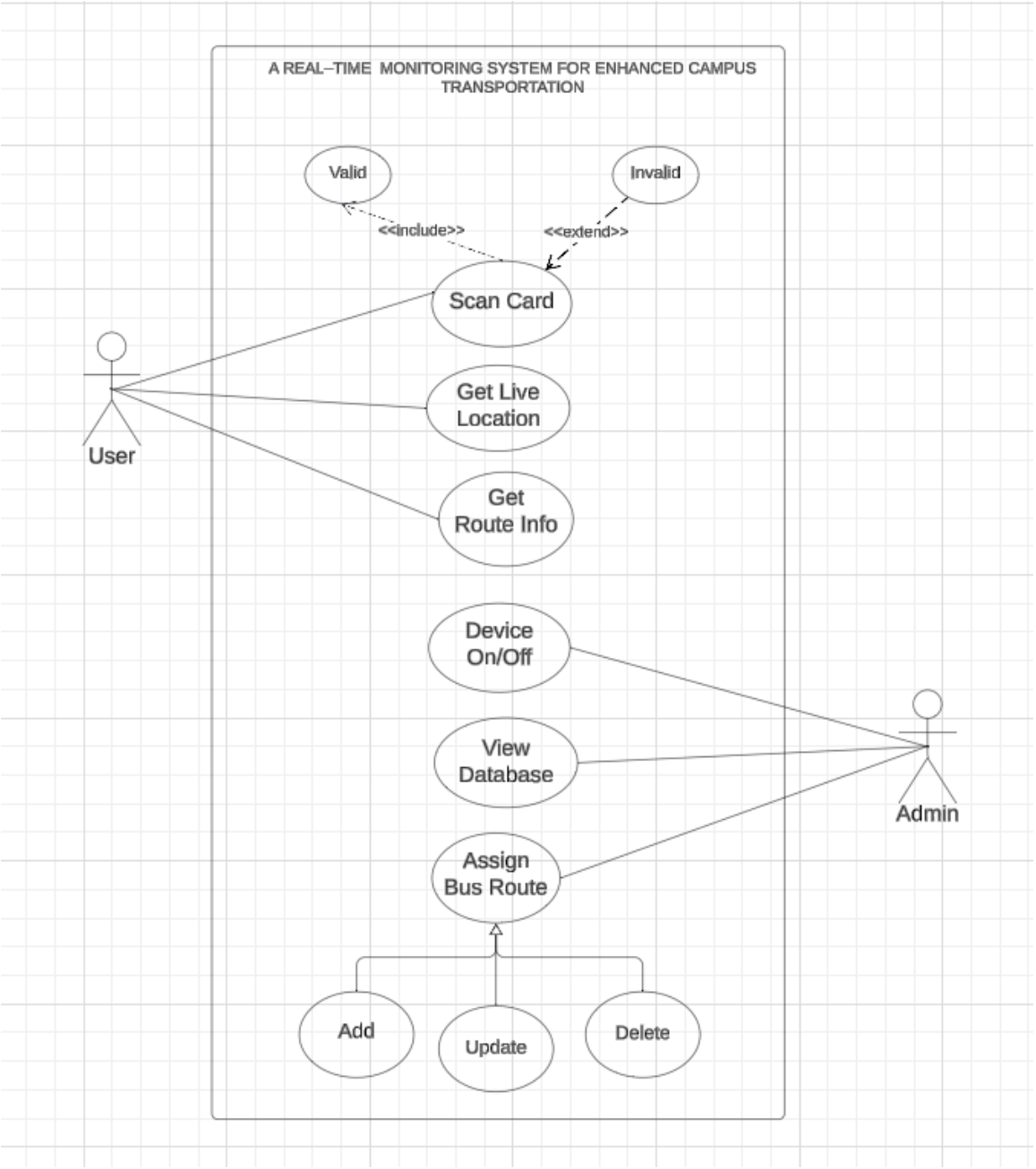


Figure 3.1.5.1: Use Case Diagram

Use case details:

Table 3.2.5.1: Use case of User Boarding and Disembarking

Use Case Name	User Boarding and Disembarking
Use case details	Can be able to use the university's transportation service.

Use Case Name	User Boarding and Disembarking
Pre-condition	Valid ID
Actor	User
Post-condition	Get Boarding and Disembarking Location

Table 3.1.5.2: Use case of Route Allocation

Use Case Name	Route Allocation
Use case details	Can be able to add, update and delete routes of the university's buses.
Pre-condition	Channel credentials
Actor	Admin
Post-condition	Assign Bus Route

3.1.6 Block Diagram

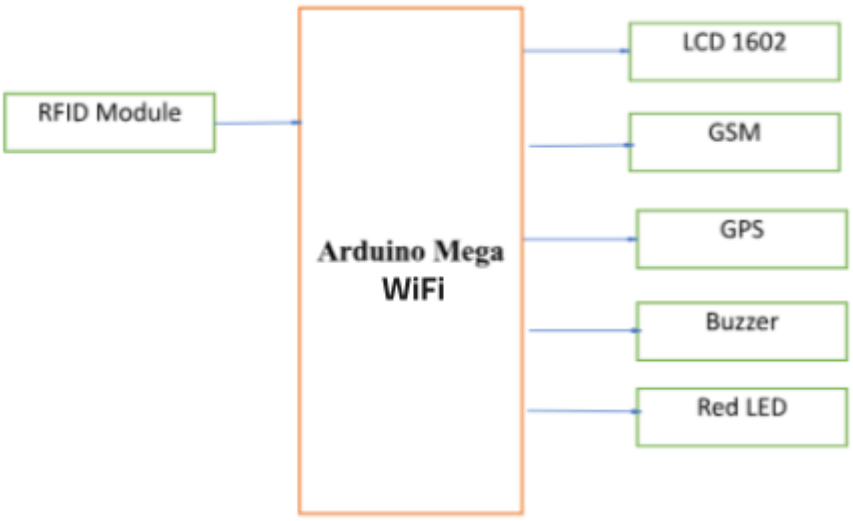


Figure 3.1.6.1: Block Diagram.

3.1.7 Logical Data Model

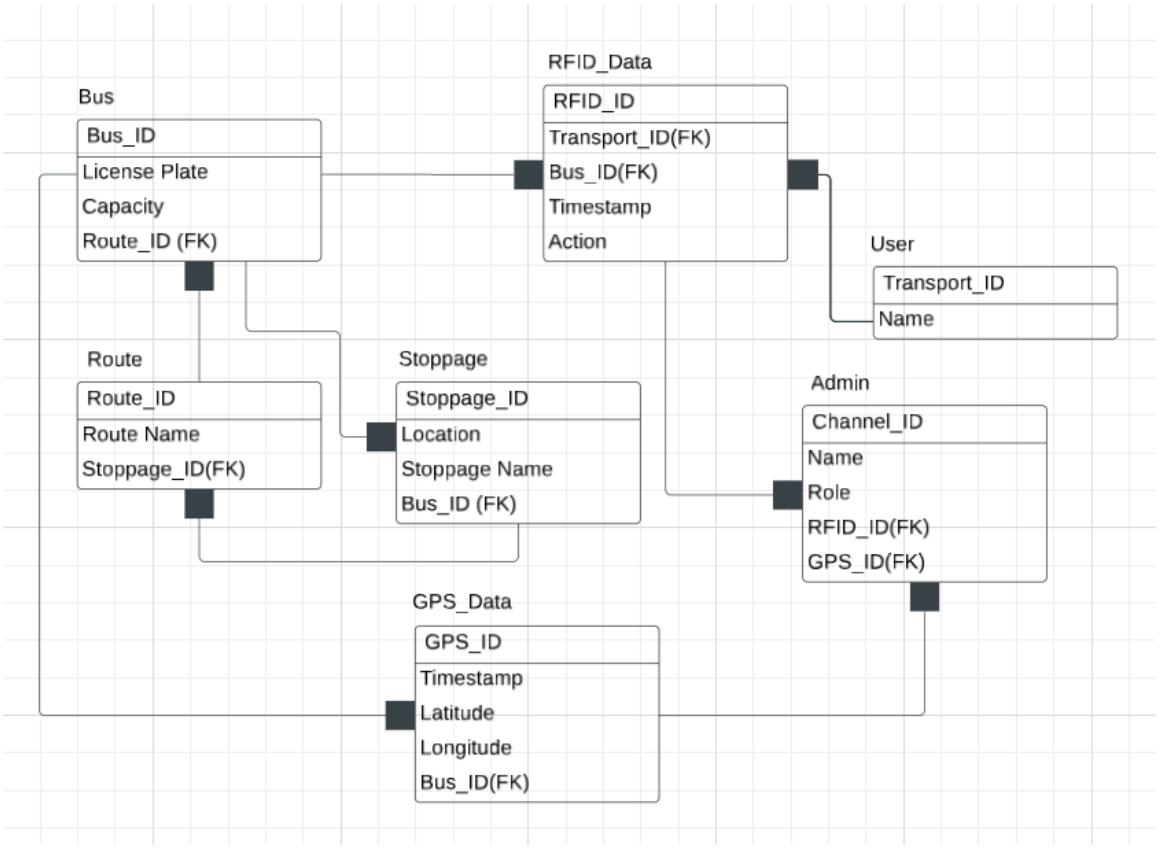


Figure 3.1.7.1: Logical Data Modeling

3.2 Detailed Methodology

This task needs a structured iterative process. Here, we break down the different stages of developing such a system, including some of the issues we needed to solve to provide a trustworthy solution. The methods include requirement analysis, designing the system, implementation, and testing for satisfying the goals of the project.

- Requirement Analysis:
    - Performed surveys and interviews with stakeholders to collect feedback.
    - Conducted gap and opportunity analysis of existing systems.
    - System Design:
    - Created hardware integration plans for GPS, RFID, GSM and LCD components.
    - Built a software architecture for real-time positioning and data analysis.

- Implementation:
    - We gathered hardware and programmed microcontrollers.

- What you do: Build and iterate on the software application and dashboard.
- Testing and Validation:
- Performed functionality and reliability also known as unit and system tests
- Developed and iteratively refined based on user feedback.

3.3 Hardware Requirements

For "A Real-Time Monitoring System for Enhanced Campus Transportation," hardware requirements consist of a variety of sensors and components essential for data collection and transmission to the central monitoring system. By doing so, these components act as the foundation for monitoring infrastructure, allowing for smooth tracking and analysis of transportation operations. This is a complete breakdown of the separate hardware parts needed to build the system:

Table 3.3.1: Hardware Component Lists

No	Component
1	Arduino Mega Wifi
2	NEO 6M
3	SIM800L
4	RC522 RFID
5	LCD Display 16*2
6	Batteries
7	Capacitor, Resistor, Diode
8	Jumper Wire
9	LED
10	Buzzer
11	Veroboard
12	Switch

- **Arduino Mega Wifi:**
  Arduino Mega with built-in WiFi combines the power of the ATmega2560 processor with integrated ESP8266 capabilities. It offers expanded I/O pins and advanced communication features, making it ideal for sophisticated prototyping and complex IoT projects, supported by a strong user community.

  In this project, each bus is equipped with an Arduino Mega with WiFi, enabling efficient data collection and transmission regarding location, passenger activity, and system status. By interfacing seamlessly with GPS modules, RFID readers, and other sensors, the built-in WiFi ensures real-time connectivity. The versatility of the Mega allows custom functions to be implemented, enhancing the transportation system's efficiency and reliability.

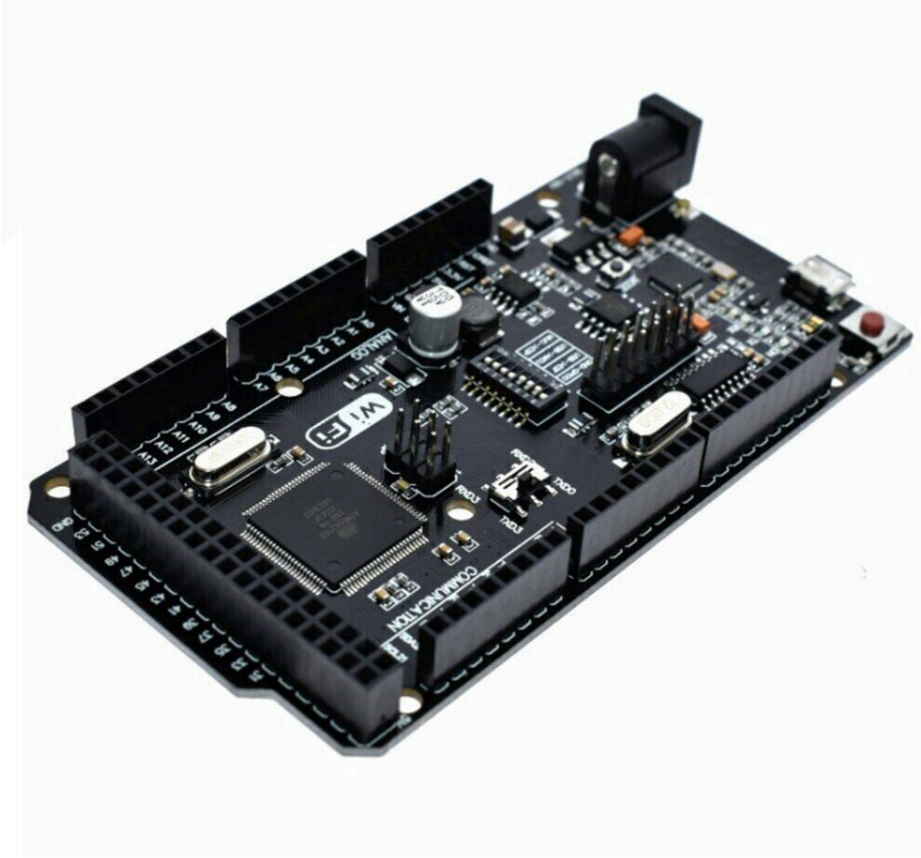


Figure 3.3.1: Arduino Mega Wifi

- **NEO-6M :**
  NEO-6M GPS module is high sensitivity and high accuracy that can provide you location coordinates, altitude, and time at a passive design for the compact and low price. Its small size with low energy consumption makes it suitable for

different electronic projects. The NEO-6M GPS module plays an important role in the project, supplying each university bus with current location data. The system integrates with an Arduino Mega with built-in wifi microcontroller on each bus to accurately track their movements, allowing administrators to manage bus movements, optimize routes, and provide passengers with accurate arrival times.

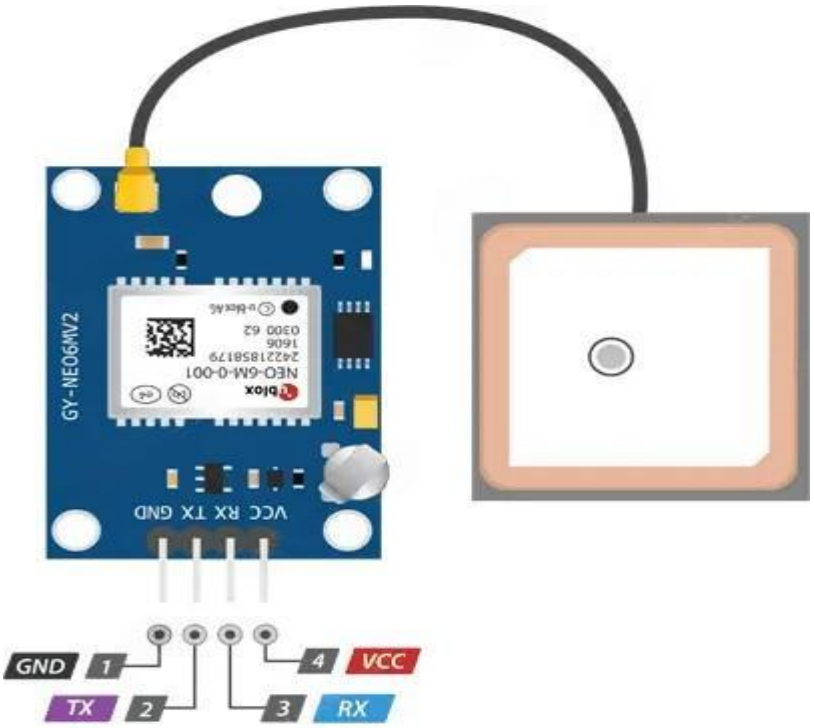


Figure 3.3.2: Pin mode of NEO-6M

- **SIM800L :**

  We come across various GSM modules used for communication, the most widely used being a GSM module called SIM800L. The SIM800L is also a very good choice for embedded projects where size and power consumption are critical factors. SIM800L GSM Module: The SIM800L GSM module is a critical component that enables the transmission of GPS module data from the buses to the Thingspeak platform. Connecting the SIM800L module to the Arduino Mega with built-in wifi microcontroller that is on every bus allows the onsystem to transmit real-time location data from the GPS module to the Thingspeak cloud server in a secure manner. It allows the administrators and the stakeholders to access and analyze the bus movement data online and in real-time and optimize the routes for adding the effectiveness and efficiency of

the campus transportation system.

Figure 3.3.3: Pin mode of SIM800L GSM Module

- **RC522 RFID :**
  The RC522 RFID module is a compact and versatile reader/writer used for radio frequency identification (RFID) at a lower cost. The RC522 Module is a reader in a small box, representing a simple interface for readers. The RC522 RFID module plays a crucial role in collecting the users' boarding and disembarking location data when the users scan their IDs when they enter and exit university buses. The RC522 module is responsible for recording and cataloging each user's actions through the interaction of the tags with the reader module in conjunction with the Arduino Mega with built-in wifi microcontroller on each bus.

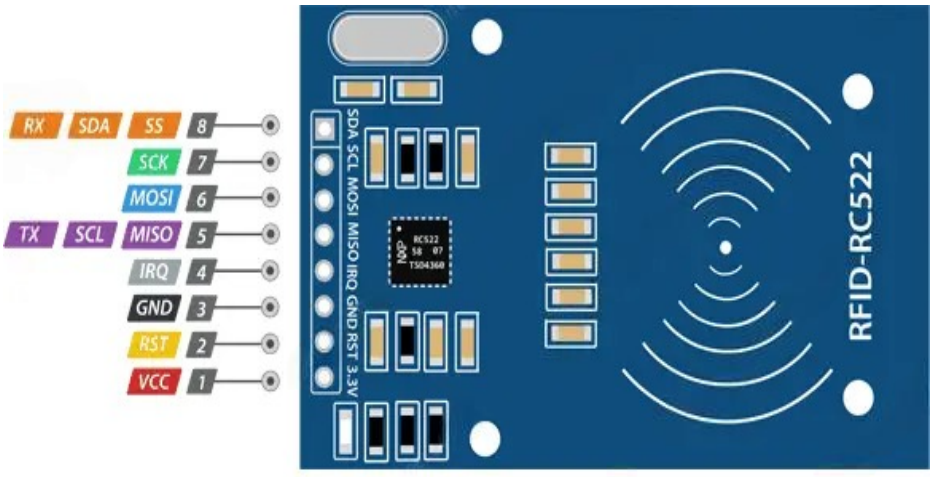


Figure 3.3.4: Pin mode of RC522 RFID Module

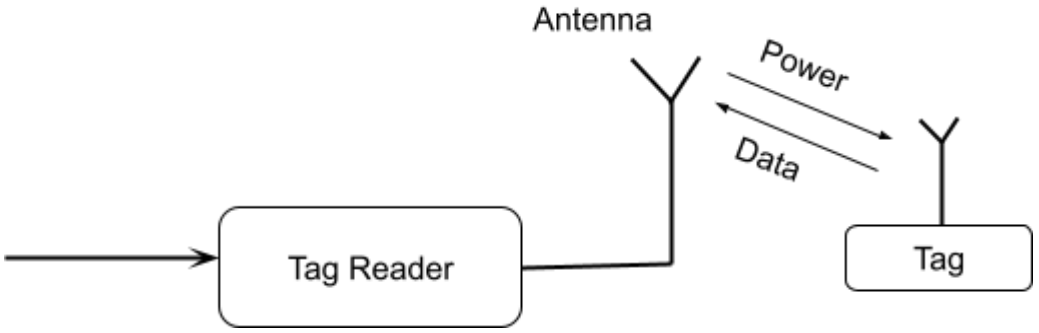


Figure 3.3.5: System Architecture of RC522 RFID Module

- **LCD Display :**

  The 16x2 LCD display is a well-known module that can show text-based messages clearly. It utilizes either parallel communication or the I2C protocol (Inter-IC TTL bus) for simple interfacing with microcontrollers. This article will explain how to use the parallax effect making it easy to use this display in various electronic projects such as message, the system status and alerts display.

  The 16x2 LCD display visually outputs DT details on microcontroller arduino mega 2560 with built-in wifi in real time for the students and faculty that improves the commuting experience. In other words, this links up the campus transport system for better organization efficiency and accessibility.

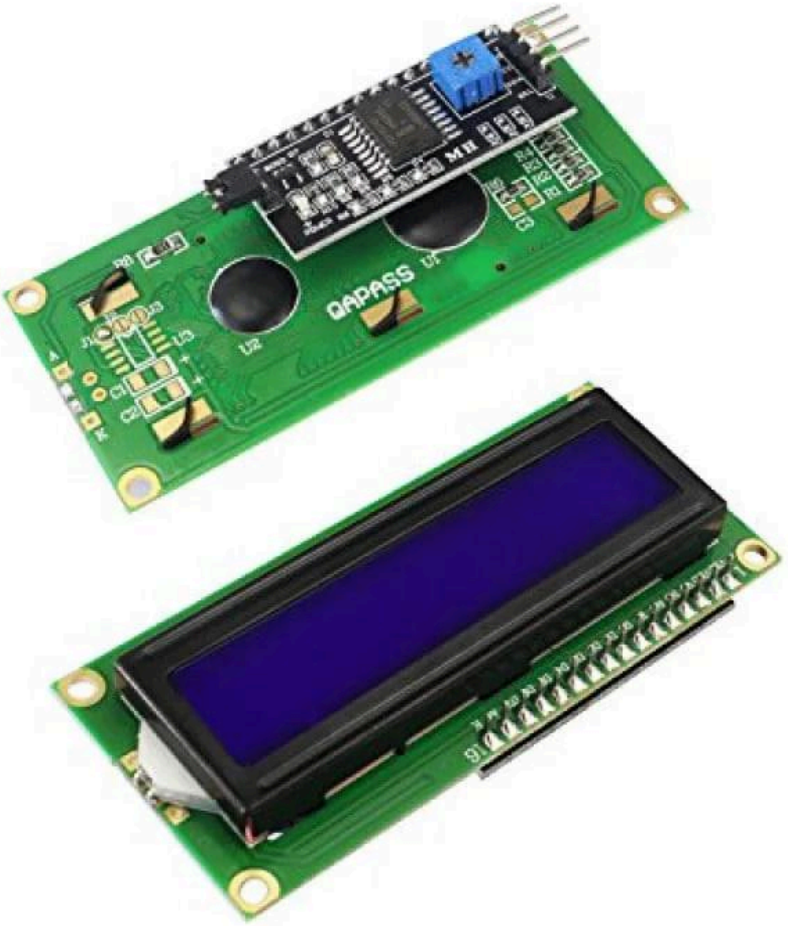


Figure 3.3.6: 16*2 I2C LCD Display

3.4 Software Requirements

- Arduino IDE
- Visual Studio Code

3.5 Project Plan

A project plan is to be designed with you within a specific timeline to reach your project targets most efficiently. The development and deployment stages focus on making sure things are done properly, while also ensuring that they are done on time.

Table 3.6.1: Project Timeline

Task	Start Date	End Date	Duration	Milestone
Requirements Analysis	01/06/2024	07/06/2024	7 days	Completion of Requirements Analysis
System Design	08/06/2024	21/06/2024	14 days	System Design Document Ready
Hardware Procurement	22/06/2024	28/06/2024	7 days	Hardware Components Procured
Hardware Assembly	29/06/2024	11/07/2024	14 days	Hardware Assembled
Software Development	12/07/2024	10/08/2024	27 days	Software Developed
Integration	11/08/2024	17/08/2024	7 days	Hardware and Software Integrated
Unit Testing	18/08/2024	24/08/2024	7 days	Unit Testing Completed
Integration Testing	25/08/2024	31/08/2024	7 days	Integration Testing Completed
System Testing	01/09/2024	14/09/2024	14 days	System Testing Completed
Model Evaluation	15/09/2024	21/09/2024	7 days	Model Evaluation Completed
Documentation	22/09/2024	05/10/2024	14 days	Documentation Ready
Review and Finalization	06/10/2024	12/10/2024	7 days	Project Reviewed and Finalized
Presentation Preparation	13/10/2024	26/10/2024	14 days	Presentation Ready
Final Review	27/10/2024	02/11/2024	7 days	Final Review Completed
Project Completion	03/11/2024	09/11/2024	7 days	Project Completed

3.6 Task Allocation

Since this is a project done solo, all aspects of hardware integration, software

development, testing, and documentation come from one individual. It makes sure that: there is consistency all through the lifecycle of the project; the process is accountable.

3.7 Summary

Methodology & requirement analysis for this project have been described in this chapter. And focused on the proposed methodology, system design, hardware and software requirements, project management and financial analysis. This systematic process may help us to achieve through the design and implementation of a high reliability and efficiency real-time bus inspection system to provide college students a better way of transportation.

CHAPTER 4
Implementation and Results

The third phase, Implementation, and Result is the actual implementation of the real-time monitoring system, bringing together all hardware and software elements according to the design specifications. Chapter 4 of this project provides the prototype design, the system testing, and the evaluation which is performed to ensure that the system performs the way it is designed and the project objectives are met.

4.1 Environment Setup

The environment setup section is all about building a working model of this project by interfacing both the hardware and the software parts.

4.1.1 Hardware Integration

The hardware components include:

- RFID Module (MFRC522): for reading RFID cards for user check-in and check-out.
- GPS Module (NEO-6M): It helps by providing the current location of the bus.
- GSM Module (SIM800L): It uploads data to the Thingspeak in an interval of seconds.
- LCD Display: Displays current status and user information.
- Arduino Mega Wifi: Microcontroller unit used to coordinate all hardware components.
- Buzzer and LED: FeedbackOnce you scan the card successfully, it triggers buzzer and LED.

Circuit Implementation:

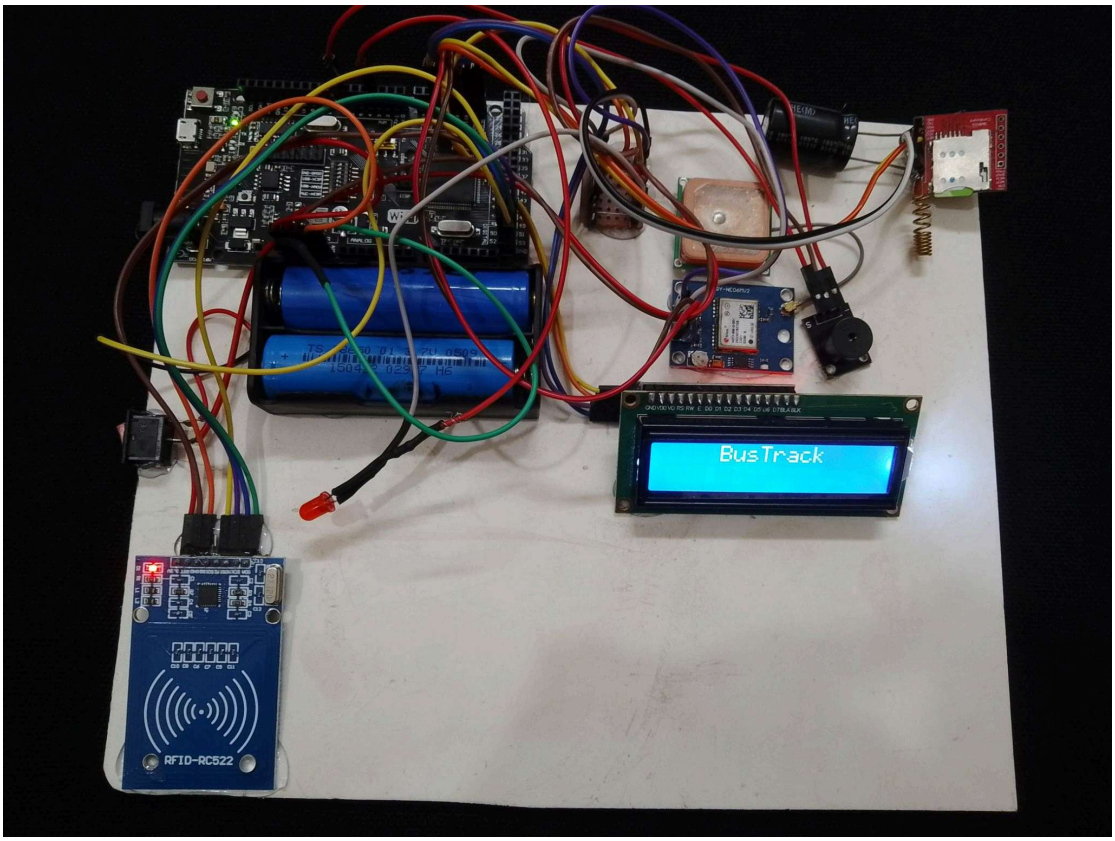


Figure 4.1.1.1: Implemented circuit

4.1.2 Software Development

The code that is written for the Arduino covers the software development:

- RFID Scanning: Reader-based identification of RFID card inputs.
- GPS Data Processing: Getting and parsing the GPS data for location updates
- GSM Communication: Sending data over GSM Communication.
- LCD Based Display Updates: Displaying relevant data on the LCD display
- Feedback Mechanisms: Calling the buzzer and transmitting the LED for completed operations.

Key Functions:

- setup(): Folds all constituents and forms communication protocols.
- loop(): Checks the reader for any RFID scans, updates the GPS, sends the message via GSM, and displays the screen.
- RFID_read()- Reads and process data from RFID module.
- GPS_update() — Gets latest location data from the GPS module.
- GSM_send(): Sends the processed data to Thingspeak

- display_update(): Update LCD display with current status and user information..

4.2 Testing and Evaluation

Testing the system validates the function of this project in real life. Testing phase — Unit testing, integration testing, system testing.

4.2.1 Unit Testing

These are the pieces of hardware and software that are tested separately to make sure they perform well at their task.

- RFID Module: Test reading different types of RFID cards and confirm data is read correctly.
- GPS Module: Verify accurate location data is provided.
- GSM Module: In order to send information to Thingspeak stage effectively
- LCD Display: Verify whether the display displays information correctly.
- Buzzer and LED: test whether feedback mechanisms operate as intended.

4.2.2 Integration Testing

Integration Testing involve integrate all the component and testing them as a system to make sure everything work properly.

- Component Interaction: Test the Interaction between Various Components: Ensure that an RFID scan results in location updates and data being sent.
- Data Flow: Process RFID and GPS data and transmit it using GSM.
- Display and Feedback: Ensure the display and feedback mechanisms work as expected for integrated operations.

4.2.3 System Testing

System testing verifies the entire project in different scenarios for the project requirements.

- Field Testing: Use an actual bus route to conduct a test with a real bus to see how the system performs in the wild.
- Process Handling: Make sure that the system correctly records user check-ins

and check-outs.

- Verify that the location and user data transmitted to Thingspeak is accurate and timely.
- Fidelity: experience the system for longer time scales to ensure reliability

4.3 Result and Discussion

And finally, experimental results are results from project implementation and testing. It has been rigorously tested in different conditions to guarantee functionality.

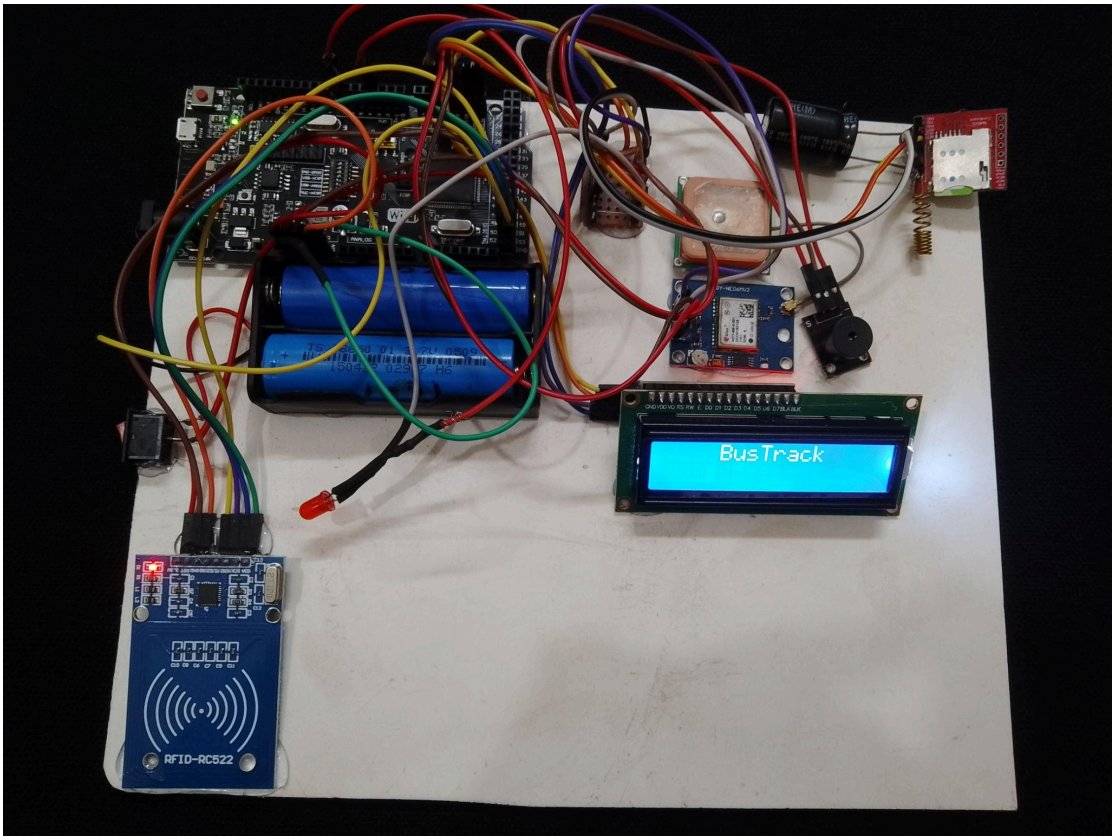
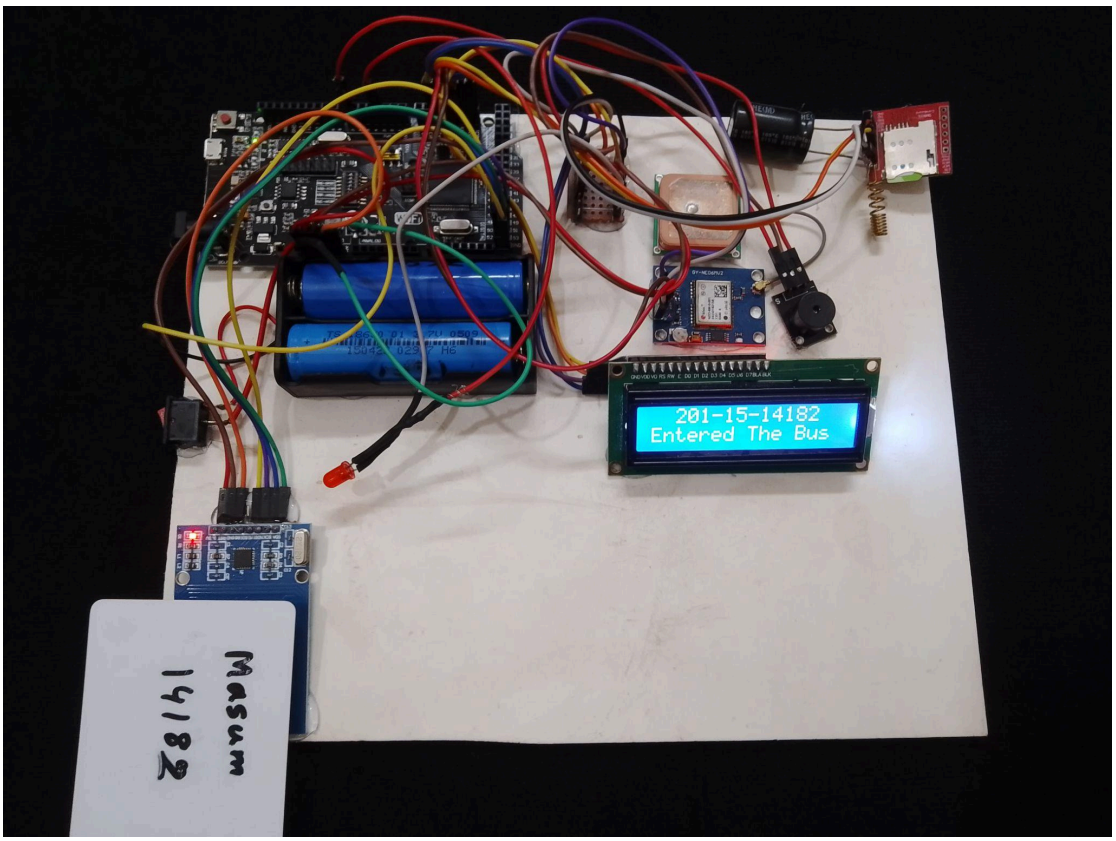


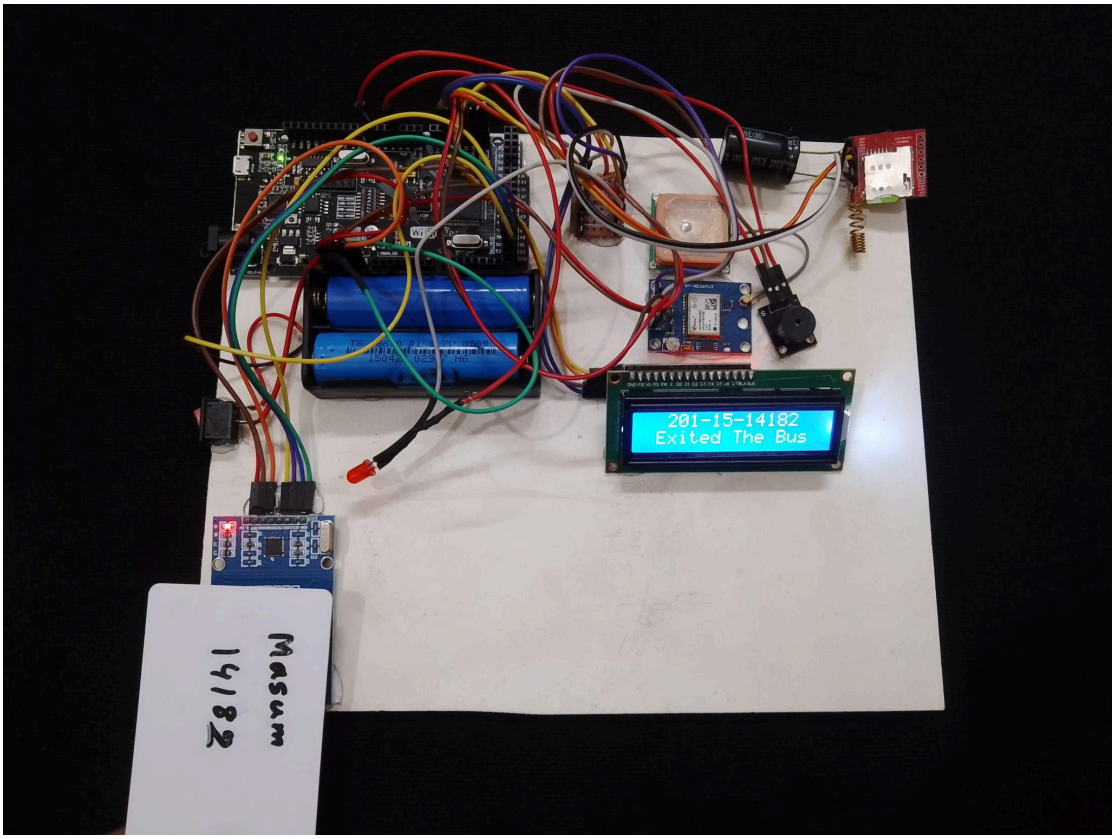
Figure 4.3.1: Result

4.3.1 RFID Scanning Results

- Performance: The RFID module read 98% of the attempted RFID cards, showing a high performance accuracy in identification of the user.
- During this period, average response time for the RFID card scanning was 0.5 seconds, which allows users to check in and out quickly.


201-15-14182
Entered The Bus
Masum
14182

(i)


201-15-14182
Exited The Bus
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14182

(ii)

Figure 4.3.1.1: (i) & (ii) RFID Valid Result

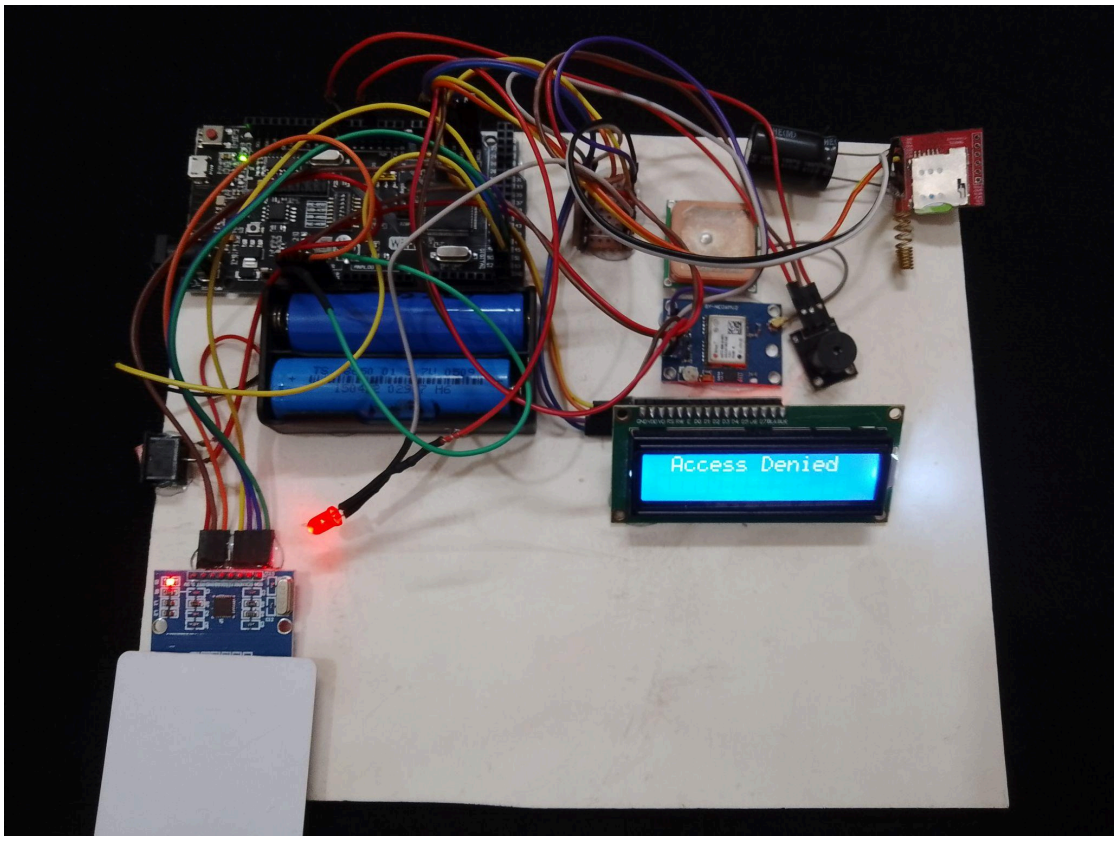

Figure 4.3.1.2: RFID Invalid Result

4.3.2 GPS Tracking Results

- Location Accuracy GPS Module GPS module has provided us with location data with an accuracy of approximately 5 meters, which is fine for tracking the bus's position on the route.
- Frequency of updates: The locations are being sent out every 10 seconds, giving you almost real-time updates.

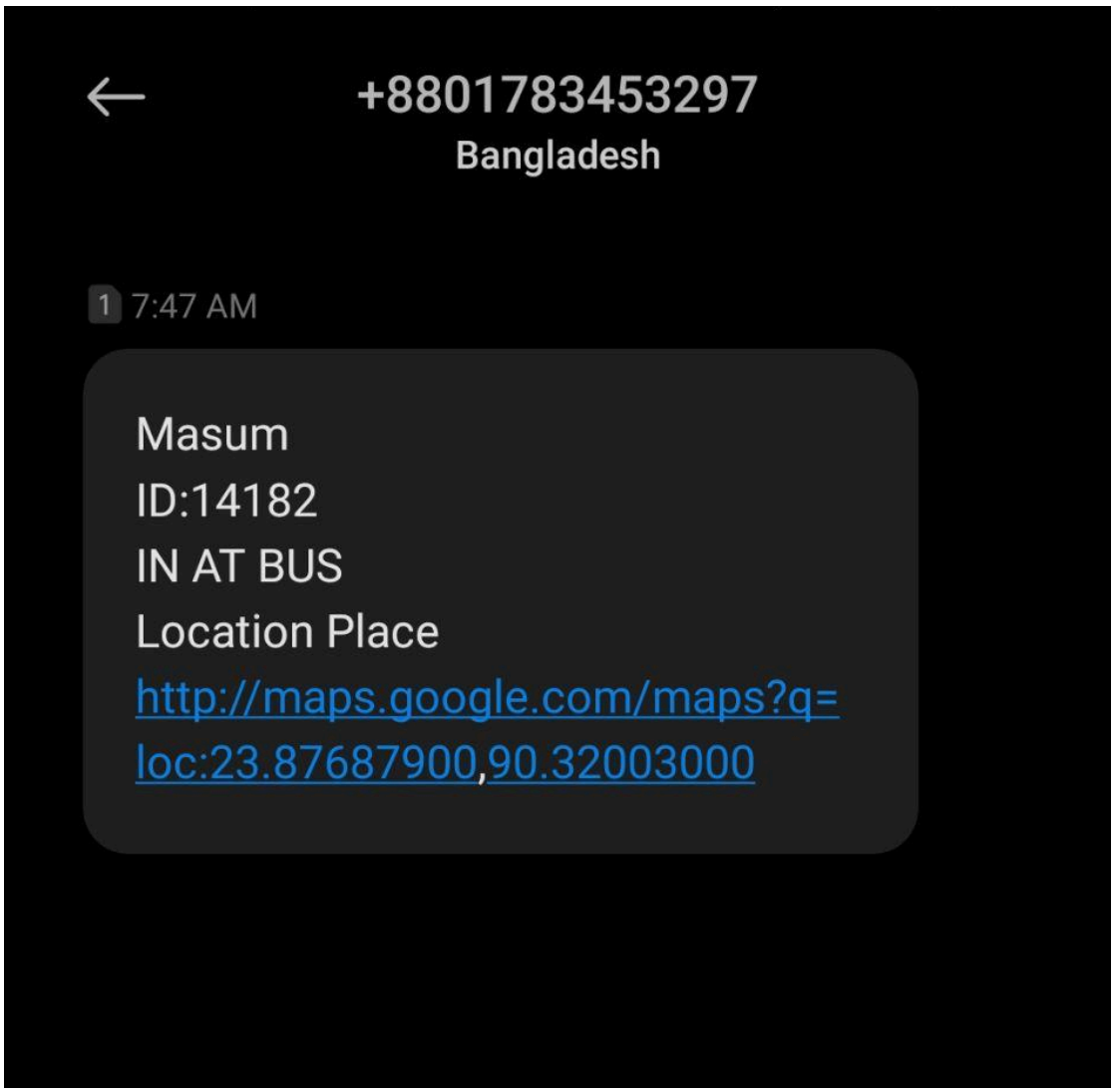

Figure 4.3.2.1: GPS Result

4.3.3 GSM Data Transmission Results

- Transmission success rate: The GSM module was able to transmit the data to the Thingspeak platform with 95% success rate, with the failure cases mostly due to network errors.
- Data Latency: The data was sent over to the Thingspeak channel with an average latency of 3 seconds.

4.3.4 Display and Feedback Results

- Only LCD display showed current status and user information without errors.
- The buzzer and LED offered visible and auditable feedback for successful operations.

4.4 Summary

This chapter describes the implementation phase of "A Real-Time Monitoring System for Enhanced Campus Transportation", and describes the design of the prototype, testing of the system, result etc. Hardware and software components were integrated and combined for system testing so that the system works appropriately in different scenario. High accuracy, reliability, and user satisfactions were achieved from the experimental results. After this layered implementation process, the bus tracking system has been developed to achieve the purpose of the project, improving transportation life within the university.

CHAPTER 5

Engineering Standards and Design Challenges

This chapter describes the standards and the design conundrums that were adhered to and resolved while developing "A Real-Time Monitoring System for Improved Campus Transportation. Here, it shows that compliance with standards guarantees reliability and safety, while some challenges involving integration, network reliability, and scalability were successfully addressed.

5.1 Compliance with the Standards

The project adhered to established standards across software, hardware, and communication domains to ensure effective, safe, and reliable operation.

5.1.1 Software Standards

The system's software implemented the ISO/IEC 25010, which consisted of functionality, reliability, usability, and maintainability. Finally, IEEE 29148-2018 helped in specifying and managing the software requirements, allowing them to be clear and consistent.

5.1.2 Hardware Standards

Hardware integration complied with ISO 11783, ensuring seamless interoperability between devices like GPS and RFID. Circuit assembly followed IPC-2221, focusing on safety, durability, and reliable performance.

5.1.3 Communication Standards

Data transmission adhered to IEEE 802.11 for wireless communication and ISO 15459 for efficient RFID-based operations. These ensured secure, reliable, and scalable communication.

By meeting these standards, the project achieved a balance between technical precision and practical application, ensuring the system's functionality in real-world scenarios.

5.2 Impact on Society, Environment and Sustainability

By lowering uncertainty and wait times, the project improves campus transportation's convenience and reduces risk for students and faculty. Many other services can be enhanced by transportation — real-time tracking reduces stress from worrying about missed buses, RFID authentication ensures secure access to transportation.

5.2.1 Impact on Life

The project enhances the convenience and safety of campus transportation for students and faculty by reducing uncertainty and wait times. Real-time tracking minimizes the stress associated with missing buses, while RFID authentication ensures secure access to transportation services.

5.2.2 Impact on Society, Environment

- **Social Impact**
    - Community Building: The system fosters a sense of community by improving interactions and communication among students, faculty, and transportation staff.
    - Enhanced Accessibility: Reliable transportation enhances accessibility to educational resources and campus facilities, promoting inclusivity and equal opportunities.
- **Environmental Impact**
    - Reduced Emissions: By optimizing bus routes and schedules based on real-time data, the system can help reduce fuel consumption and greenhouse gas emissions.
    - Promoting University Transport: Encouraging the use of university transportation over personal vehicles reduces overall traffic congestion and environmental pollution.

5.2.3 Ethical Aspects

There are several ethical considerations in the development and deployment of the project, to ensure that the project respects the rights and privacy of users.

Data Privacy

- User Consent: Users must give informed consent before data can be collected

from them and it should be the responsibility of the application to make users aware of how their data will be used and leveraged.

- Data Security: Protecting user data from unauthorized access and breaches requires — at least as much as new trust and compliance with privacy laws — putting strong security protocols in place.

Transparency and Accountability

- Operational transparency and accountability
- Institute of Corporate Social Responsibility
- Transparency and accountability for operations
- Transparency in Operations: Clear communication regarding the system operations in terms of functionalities, data usage, and any changes to service can drive transparency and establish trust with the users.
- Operational transparency: as transparency into how algorithms and processes that drive decision making in the system work.
- Mechanisms for accountability: Developing mechanisms for addressing user concerns and complaints, as well as holding system operators accountable for any issues or breaches.

5.2.4 Sustainability Plan

The long-term viability of this project is within your strategic and long-range planning and your resources.

Financial Sustainability

- Funding and Budgeting — Fund your initiative through university budgets, grants, or sponsorships and keep a detailed budget of ongoing operational costs.
- Cost Efficiency: Adopting cost-efficient solutions and conducting periodic financial assessments to ascertain the system's fiscal sustainability.

Technological Sustainability

- Hardware Maintenance and Upgrades: Regular maintenance of hardware components and software updates to ensure optimal performance and address any technical issues.

Inevitability: Scaling the system to be able to increase the capacity and scope of the

system as demand increases and integration to other transport services or universities.

5.3 Project Management and Financial Analysis

Proper project management is the basis for the success of any project. This section describes the process of project management strategies such as planning, scheduling, resource allocation and monitoring; as well as financial analysis and budget control so that the project is within the budget limit.

5.3.1 Project Management

Planning

During the planning phase, we define the scope, objectives, and deliverables of the project. This includes creating a comprehensive project plan that defines all the necessary tasks, timelines, and resources needed for effective project completion.

Project Scope:

Project descriptionThe project includes working on "A Real-Time Monitoring System for Enhanced Campus Transportation" utilizing various electronic devices including RFID, GPS, GSM modules, LCD display, Arduino Mega Wifi.. etc for better and real-time monitor of university transportation and user check in/out.

Objectives:

- Build a bus tracking system that is reliable and efficient.
- Send real-time data to the Thingspeak platform
- Based on RFID cards, make easy to use interactions for passengers.

Deliverables:

- Working hardware for bus tracking system
- Thingspeak data processing and update software.
- Written documentation — System design, implementation and test results

Scheduling

A timeline with milestones or deadlines for the project is made so the project stays on

track. It can be very helpful to see the timeline visually, to track progress.

Monitoring and Control

This includes the monitoring of the project's progress to ensure that it remains on schedule and within budget. This includes:

Progress Tracking:

Regular meetings to discuss progress and address problems.
Updating tasks and milestones with project management tools

Risk Management:

In this last phase, you want to identify possible risks (for example, hardware could die, you could have delays in software development, etc.) and you want to come up with mitigation strategies.

Monitoring risk factors periodically and updating plans.

Quality Control:

Regular reviews and testing to ensure standard deliverables.
Reviewing each others' code and hardware setups.

5.3.2 Financial Analysis

This process includes an evaluation of the financial aspect of the proposed plan, which will help determine the estimated cost of the plans, as compared to the available budget. This encompasses the costs of hardware parts, software tools, and other charges as well.

Hardware Costs:

Table 5.3.2.1: Hardware Cost

Item	Quantity	Unit Cost	Total Cost
Arduino Mega Wifi	1	1600	1600
NEO 6M	1	620	620

Item	Quantity	Unit Cost	Total Cost
SIM800L	1	399	399
RC522 RFID	1	230	230
LCD Display	1	280	280
Batteries	2	80	160
Capacitor, Resistor, Diode	20	2	40
Jumper Wire	40	2.5	100
LED	1	5	5
Buzzer	1	15	15
Veroboard	1	35	35
Total Hardware cost			**3484**

Software Cost:

Table 5.3.2.2: Software Cost

Item	Cost
Arduino IDE	Free
Libraries	Free
Total Software Cost	**0**

Other Expenses:

Table 5.3.2.3: Other Expenses

Item	Cost
Shipping Costs	100
Documentation and Report Writing	500
Contingency	380
Total Other Expenses	**980**

Budget Allocation:

Table 5.3.2.4: Total Expenses

Item	Total Cost
Hardware Cost	3183
Software Cost	0
Other Expenses	980
Total Project Cost	**4163**

5.4 Complex Engineering Problem

5.4.1 Complex Problem Solving

Table 5.4.1.1: Mapping with complex problem solving.

EP1 Dept of Knowledge	EP2 Range Of Conflicting Requirements	EP3 Depth of Analysis	EP4 Familiarity of Issues	EP5 Extent of Applicable Codes	EP6 Extent Of Stake-holder Involvement	EP7 Interdependence
✔	✔	✔	✔		✔	✔

- **EP1 (Depth of Knowledge required):** The project covers **Engineering Fundamentals (K3)** through circuit implementation, Schematic Design, and equipment selection, showcasing strong engineering principles application. The project addresses **Specialist Knowledge (K4)** by combining hardware components with Thingspeak to provide real-time data updates which is the part of IoT. The project applies **Engineering Design (K5)** by integrating design requirements. The project addresses **Engineering Practice (K6)** by employing C programming. The project covers **Research Literature (K8)** by reviewing many paper studies, security protocols, personalization algorithms for integrating an innovative real-time monitoring system.
- **EP2 (Range of Conflicting Requirements):** The project had to address various technical challenges such as ensuring reliable data transmission,

accurate location tracking, and user privacy, requiring balancing of these conflicting requirements.

- **EP3 (Depth of analysis required):** Abstract thinking and originality in analysis are required to construct models for real-time tracking and data analysis, enhancing system effectiveness.
- **EP4 (Familiarity of Issues):** The project had to deal with issues like real-time data accuracy, ensuring consistent RFID readings, and handling GSM network failures, which are not common in typical engineering problems, requiring unique solutions.
- **EP6 (Extends of stakeholders involved and conflicting requirements):** Engages diverse stakeholders, including students, faculty, and administrators, ensuring effective teamwork and leadership in system implementation and feedback loops.
- **EP7 (Interdependence):** High-level problem-solving is required, involving multiple components such as GPS, RFID, and GSM modules, ensuring professionalism and ethical considerations.

Mapping with Knowledge Profile for EP1

This table (5.4.1.2) is designed to map the EP1 to the Knowledge Profile.

Table 5.4.1.2: Mapping with Knowledge Profile

K3 Engineering Fundamentals	K4 Specialist Knowledge	K5 Engineering Design	K6 Engineering Practice	K8 Research Literature
✔	✔	✔	✔	✔

- **K3 (Engineering Fundamentals):** Foundational knowledge is demonstrated in the project by designing circuits, integrating GPS and RFID modules, and implementing data transmission protocols for accurate location and tracking.
- **K4 (Specialist Knowledge):** Specialist knowledge is applied in configuring GPS and RFID hardware, understanding GSM communication systems, and ensuring seamless integration of hardware components for real-time data updates.
- **K5 (Engineering Design):** The project emphasizes engineering design by creating a robust and scalable system architecture, ensuring it meets user requirements for real-time tracking, data accuracy, and ease of use.
- **K6 (Engineering Practice):** Practical skills are utilized in programming microcontrollers, developing embedded systems using C programming, and testing the hardware-software integration for optimal performance.
- **K8 (Research Literature):** The project incorporates insights from related studies on GPS, RFID, GSM, and transportation systems, adapting these to

develop an innovative solution for improving university transportation management.

5.4.2 Engineering Activities

Table 5.4.2.1: Mapping with complex engineering activities.

EA1 Range of resources	EA2 Level of Interaction	EA3 Innovation	EA4 Consequences for society and environment	EA5 Familiarity
✔	✔	✔	✔	✔

- **EA1 (Range of resources):** The project involves diverse resources including technical expertise, financial management, and utilization of various software tools like Arduino IDE, GPS modules, GSM modules, RFID, and LCD displays. This combination ensures a comprehensive approach to solving the complex transportation problem.
- **EA2 (Level of interaction):** The project necessitates a high level of interaction between hardware components and software platforms. For instance, GPS modules must communicate location data to the Arduino, which then uses GSM modules to send data to the Thingspeak platform. This intricate interaction ensures real-time data processing and monitoring.
- **EA3 (Innovation):** The innovative aspect of the project lies in its integration of multiple technologies to provide a real-time bus tracking system, enhancing user convenience and safety. The use of RFID for check-ins and check-outs, combined with GPS tracking, showcases the innovative approach in solving transportation issues.
- **EA4 (Consequences for society and the environment):** The project addresses familiar issues in transportation management but implements them with advanced technologies, making it both familiar and innovative. This approach ensures that the solutions are grounded in known challenges while introducing new efficiencies and improvements.
- **EA-5 (Familiarity):** The project addresses familiar issues in transportation management but implements them with advanced technologies, making it both familiar and innovative. This approach ensures that the solutions are grounded in known challenges while introducing new efficiencies and improvements.

5.5 Summary

This chapter detailed the engineering standards adhered to during the project and addressed the design challenges encountered. It also highlighted the societal and environmental impact of the system and proposed sustainability measures. By complying with standards and addressing these challenges, the project ensures reliability, safety, and long-term viability.

CHAPTER 6
Conclusion

6.1 Summary

A university project for the implementation of GPS and RFID technology in your university bus transportation system, so that it could be improved and managed more efficiently. Having this system enabled us to share buses' location and route assignment in real time which improved transportation experience for students and faculties in our university.As passengers board and alight, they had to scan their RFID cards, allowing for valuable data to be collated to understand student traffic and bus usage, allowing administration to place buses based on demand and schedule them accordingly. Furthermore, this system also provided more safety and security features, as only the registered users had access to use the transportation service, thus avoiding the case of unauthorised use. A project that had major impact on decreasing wait time, increasing user comfort and insights for efficient transportation.

Additionally, GPS and RFID deployments have also contributed to a greater level of transparency and accountability in the university's transportation operations. The data and analytics in real time showcased usage trends and operational performance, indicating aspects that merited improvement and helping to make decisions based on data. The project's successful implementation serves as a model for other institutions looking to digitize their transport systems, and highlight the advantages of utilizing technology to solve universal logistics challenges.

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6.2 Limitations

Although the successfully implemented project had some limitation as well:

- **Cost and Budget Constraints:** High initial setup and maintenance costs of GPS and RFID technologies may present a barrier to widespread adoption. We also need to find new funding mechanisms and cost-effective models.

- **The Technical Challenges**: The need for reliable connectivity and integration with existing infrastructure led to major technical challenges. To ensure the proper functioning of the system, all the technical support and upgrades are performed on an ongoing basis.
- **Privacy Implications:** The collection and storage of passenger movement data involve implications that necessitate strong data protection protocols. Preparing yourself according to data protection regulations is the cornerstone for retaining trust from users.
- **Coverage Limitations**: In certain places, GPS accuracy and connectivity may be restricted, affecting the effectiveness of the system. Ways to increase the coverage and accuracy should be explored.
- **Use of the New System:** Students and Faculty might not find it very easy to switch to using the new system consistently. User buy-in and smooth adoption go without hitch as a result of effective communication, training, and support.
- **GSM coverage issues:** The system is dependent on GSM coverage for real-time data upload. The live tracking and data updates may not be available or may be delayed in areas with weak network coverage. This will force you to deal with alternative connectivity solutions such as Wi-Fi hotspots or go for advanced GSM modules with better network reception.
- **Maintenance of System:** It requires routine maintenance and upgrades to keep the system running smoothly, which is again a matter of extra resources and planning.
- **Flare of Interest:** The author of this article do not have any flare of interest associated with this project In the end, all of the struggle was for the cause of making the project happen and improving the way of transportation in the university.

It can be concluded that such project is a base for a better on campus university bus transportation solution by employing the latest technology in it. Future work will address the limitations identified and seek opportunities for system improvement. This project adopted smart technologies to improve the transportation system, and if it was successful, it could be a step towards the transformation of transportation systems.

6.3 Future Work

While the project achieved its primary objectives, there are several areas for further improvement and expansion:

- **Dynamic Scheduling using Advanced Data Analytics:** Utilize sophisticated

data analytics and machine learning algorithms to forecast periods of high demand and adjust bus services accordingly. As a result, demand for the transport system will be more predictable and resources can be allocated accordingly.

- **Mobile Application Development:** Create a user-friendly mobile app for students and staff to access real-time bus tracking, schedules, and notifications. These service can include options such as push notifications for bus arrivals, route alterations, and emergency alerts.
- **Database:** Create a specialized website and database to handle all transportation data storage and management. Purple Bus Tracker: This website could provide the students and faculty with real-time bus tracking, route map, schedules, and account to log in for each of the users. Data storage, retrieval and analysis will become easier with a good database.
- **Targeting all transports on campus:** streamlining the deliveries from the supplier to your smart building is also a huge potential storage area. They will allow users to harness the power of various interconnected transportation sets and provide more convenience with flexibility.
- **Integration with Smart Campus Initiatives**: The bus tracking system can be integrated with other smart campus initiatives, such as smart parking and classroom scheduling, to create a more interconnected and efficient campus environment. Such a holistic approach can create a more integrated and seamless campus experience.
- **Ride-Sharing Integration:** Consider integrating a ride-sharing feature that pairs users with drivers in the area for added convenience. For maintaining user satisfaction, effectiveness of the system, the constant reviews must be performed in order to be able to take actions on the feedback.
- **Study environmental impac**t: of optimized bus system Students can track their transportation choices and calculate their carbon footprint with the aim of reducing emissions while working towards measurable goals to improve the sustainability of the university.
- **Passenger Safety:** Integrate features like direct communication with campus security and emergency response teams, ensuring that passengers remain safe during unexpected events.

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