Digitalization of College Bus Transportation System

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***Abstract*— The purpose of this paper is to present an automated ticketing system for a college transportation system based on the identification of passengers. The system digitalizes the bus tickets by using college ID cards and tracking the bus location. Digitalizing the bus ticket involves several modules, from reading the NFC chip in the ID card using an RFID reader to debiting the ticket amount from the passenger's account from the campus management system. This system allows the passenger to pay the bus fare on a daily or monthly basis by counting the sign-in & sign-out recorded. Using the user-friendly system, the bus fare is automatically determined based on the passenger's journey between sign-in and sign-out. In order to make passenger and transaction identifications as precise as possible, Radio Frequency Identification (RFID) cards and GPS are used. Compared to paper-based ticketing, cards are much more convenient since they are reusable. Each RFID card has a unique ID that is stored in a database online along with personal information. Accessing the database allows for identifying the traveler, checking his account, and deducting the fare. As fare calculation is done by evaluating position with GPS module and via internet, a change in fare causes no confusion. Thus, human errors and efforts are reduced. The RFID reader used is MFRC522. NodeMCU ESP322 is used as the control unit, and programing is done using C# language. GPS module NEO-6M is used for the purpose of distance measuring. Another critical focus is the development of an app for viewing the location information of the college bus. Access for obtaining the location information of the bus is permitted to the staffs, students, PTA& management for security purposes.**

Keywords—college bus, GPS, RFID, smartphone application, college ID card, MFRC522, NodeMCU

I. INTRODUCTION

Radio Frequency Identification (RFID) technology has emerged as a highly effective solution for real-time tracking in the transportation industry and has found widespread applications across various sectors, such as manufacturing, warehousing, logistics, retail, healthcare, and public transportation. By allowing non-contact reading of data, RFID technology facilitates the automatic identification of items, eliminating the need for manual scanning and enabling a more efficient and streamlined identification process. RFID technology's versatility is becoming increasingly popular as it offers several advantages over the traditional Bar Code system. For instance, RFID readers can read tags even when concealed, eliminating the need for manual handling of items for scanning purposes. This makes RFID technology an efficient and reliable option for tracking and identifying objects.

During school hours, traffic jams are a common problem that is often aggravated by the presence of personal cars transporting students. Parents who have their own private vehicles may avoid using public transportation or traditional school buses to transport their children, whereas those who rely on public transportation may have to take multiple routes to get to the school. Alternatively, some parents may choose to send their children to school alone, but they may feel anxious because they do not receive regular updates on their children's whereabouts. In addition, situations may arise where students skip school or spend time outside the institution, leaving their parents with no means of locating them. During school hours in metropolitan areas, traffic situations often deteriorate, and implementing a sustainable solution to provide safe school buses could have benefits for both parents and students, including reducing traffic congestion.

II. LITERATURE SURVEY

RFID technology has been the focus of many research studies exploring its potential for automated bus ticketing systems. Some tracking systems have already been implemented for public bus transportation using RFID. In this section, we will provide a brief overview of various studies that have explored the use of RFID and agent technologies for public transportation.

Each day's bus operation may be affected by different unforeseen circumstances, e.g., traffic conditions and lack of depot dispatch schedules. Providing passengers with real-time information about bus stops, estimated arrival times to

take into account the amount of traffic on a given route, and passenger counts shall be required in order to enhance transport reliability. [1] The proposal in this report consists of a GPS tracking system for Public Transport buses, which will allow users to receive such information through an Android application. Furthermore, detailed bus data such as route numbers, stops, time or frequency shall be included in the Android application.

The population growth in India has led to increased crowding at public bus stops, with people waiting for extended periods and rushing to board overcrowded buses upon arrival, resulting in accidents and theft. The lack of accurate information about bus schedules exacerbates this issue. To tackle this problem, an IoT-based bus tracking system [2] that employs RFID technology to monitor bus locations and Thingspeak web servers to provide real-time data about bus locations and available seats through an Android app is developed. By using this system, commuters can make informed decisions about whether to board the current bus or wait for the next one, which reduces waiting times and overcrowding at bus stops while also minimizing the risks of accidents and theft.

The production of paper for tickets in public transport systems results in the felling of a significant number of trees globally every day, leading to deforestation and contributing to climate change. A smart ticketing system utilizing RFID technology [3] has been proposed to address these environmental concerns by digitizing public transportation and eliminating the need for paper tickets. RFID tags are carried by passengers and tapped on readers installed at both ends of the bus, while GPS modules calculate the distance traveled to determine fares deducted from rechargeable RFID cards. This system is compatible with popular microcontrollers like Arduino Uno and Raspberry Pi, and keywords include PTS, RFID, and GPS.

This paper introduces an innovative design for an IoT-based bus tracking system that operates in realtime.[4] A mobile phone application has been developed as part of this system to allow users to accurately determine the bus's location and the estimated time of arrival at their bus stop. High-frequency RFID tags are installed on buses, while RFID receivers are located at bus stops. The NodeMCU is utilized to gather RFID data on the bus's real time location, which is then uploaded to the cloud. Users can then access this cloud-based bus tracking data in real-time through the mobile app, keeping them informed about the bus's current status and whereabouts.

The Smart Bus System is a sophisticated technology designed to enhance the efficiency and convenience of bus transportation for passengers. It offers an automated ticket booking feature that eliminates the manual ticketing process, reducing time and effort for passengers and the bus operator. [5] The system uses RFID technology to record passengers' entry and exit instances, while the GPS module installed in each unit tracks the bus's location to calculate fares based on distance traveled. Furthermore, the system provides a mobile application called S-Bus, allowing passengers to manage their E-wallets and book their tickets online, with the added benefit of live tracking of the bus location.

Given a large proportion of middle- and lower-income groups dependent on public transport, developing countries must address the problem of overcrowding in buses. [6] A system of RFID tracking and management for mass transport may be designed to deal with this problem. Each bus shall be equipped with a unique RFID card which is monitored by radio frequency identification terminals at the stops. These receivers are in contact with the Low Power Wireless Communication Network, which will send real-time updates to the Cloud server. The data from the cloud server can be accessed through a simple web page or application that assists passengers in locating the nearest approaching bus and helps to schedule authorities in closely monitoring bus routes.

In order for schools to guarantee the safety of their pupils, it is imperative that they provide a high-quality and safe transport service. The school administrations are able to effectively manage their bus fleets and thus minimize accidents by means of vehicle monitoring. [7] Realtime information on a number of vehicle parameters such as its location, route, velocity, passenger list and driver's schedule is provided in the proposal. In addition, parents may be notified when their child has boarded or disembarked from the bus. The system is equipped with an ESP8266 microcontroller which enables RFID or GNSS technologies to be connected to a remote server via WiFI. A Ublox 6M GPS module will determine the vehicle's position and speed, while an MFRC522 RFID reader identifies each student by reading their RFID tags as they board or leave the bus.

Ensuring reliable public transportation is crucial in today's world, where millions of people depend on buses for their daily commute. However, the problem of long waiting times at bus stops still persists. [8] The objective of this paper is to utilize the Internet of Things (IoT) technology stack to offer a resolution to this issue. By providing real-time and accurate bus locations and estimated arrival times based on current traffic conditions, the proposed solution can increase the overall reliability of public transportation. The system uses existing network-enabled devices on the bus, such as the e-ticketing system or an Android tablet, to capture and transmit the location data to servers. Users can access this data through Representational State Transfer (REST) APIs via an Android app, SMS, or web portal. It is proposed to use Message Queue Telemetry Transport (MQTT) as an alternative to the HTTP-based REST backend as it is lightweight, data-efficient, and scalable. The paper also includes the implementation of both the backend and front-end of the tracking system and highlights the improvements made.

Reckless driving is a serious traffic offense that endangers the lives of innocent individuals and often leads to accidents resulting in injuries or fatalities. [9] To solve this problem, a solution was proposed to implement a disciplined online payment service using an Android application on the bus. The fare will be calculated by scanning QR codes in and out of the bus using the app, and passengers can signal when they need to disembark by pressing a buzzer, which will activate an LED light beside the driver to ensure that the bus stops at

the correct stop. The system also includes two safety features: driver drowsiness detection and bus lane detection. If the driver is drowsy or driving in the wrong lane, the Pi camera in the front detects the anomaly and turns on an LED to remind the driver to drive safely. The ultimate goal of this system is to prevent reckless driving and to reduce the drastically increasing number of traffic accidents.

Buses are a crucial mode of public transport in India, with millions relying on them daily in metropolitan cities. However, there is a need to modernize and adapt to technological advancements in the era of Digital India and a Cashless Economy. [10] This solution proposes a smart application that reserves tickets digitally, allocates seats to passengers, and enables cashless payment, promoting digitalization and smart city initiatives. Passengers can access seat availability and booking options via the application, which is integrated with the device installed at the bus stop. The algorithm efficiently assigns seats, provides expected waiting times, and generates an e-Ticket acknowledgment for the bus conductor to verify. Our solution aims to provide a hassle-free and efficient system for public transport, contributing to a smarter and safer city.

III. Methodology

The smart bus system using RFID works by installing RFID readers on the buses and RFID tags on the passengers' ID cards. When a passenger boards the bus, they tap their smart card on the RFID reader, which instantly registers their presence and marks their boarding location using GPS. Similarly, when the user taps the smart card on the RFID reader while exiting the bus, the location will be identified. This allows the calculation of the charges for the student's trip by comparing it with the prices fixed for specified distances. The boarding and exiting locations, calculated fare for each trip, as well as the time of boarding and exiting, can be viewed on the mobile application developed. This technology allows for quick and easy fare collection, reducing the time and effort required for both passengers and transit operators.

Intelligent bus systems can also provide students and teachers with real-time bus timetables and delay information via mobile applications. This allows passengers to reduce waiting time at bus stops.

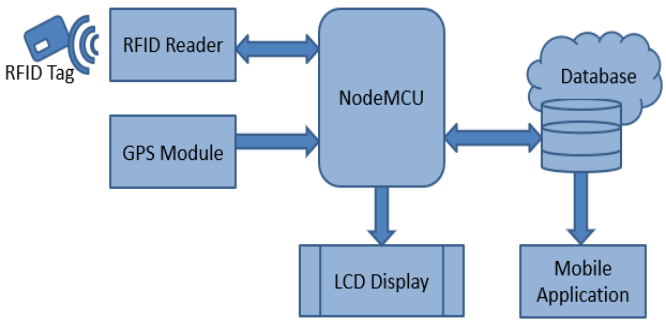

Fig 1. The architecture of proposed system.

The architecture of the system proposed in this paper is shown in Fig 1. The overall functionality of the system depends on the interaction between the hardware components on the bus, the database and the mobile application. The RFID reader and tags are used to sign in the user into the system. The inputs taken by the RFID reader are sent to the NodeMCU microcontroller, which then authenticates the user after verifying with the data stored in the database. The GPS is used for obtaining the boarding and disembarking locations of the user as well as for the real-time tracking of the bus. The latitudes and longitudes obtained by the GPS are stored in the database as they will be used for the computation of the distance traveled which will help in calculating the total fare for the journey.

The NodeMCU is the hardware component that acts as the controller for this proposed system. It transfers the data between the GPS, RFID reader, LCD display and database. The LCD display is used for displaying details like sign-in, sign-out, distance traveled on the trip etc. The database stores the necessary details for fare computation, user verification, and details to be shown on the mobile application. The mobile application shows the basic information about the student, the total fare as well as the fare for each individual trip, the boarding and exiting point, along with time and a real-time map for bus tracking.

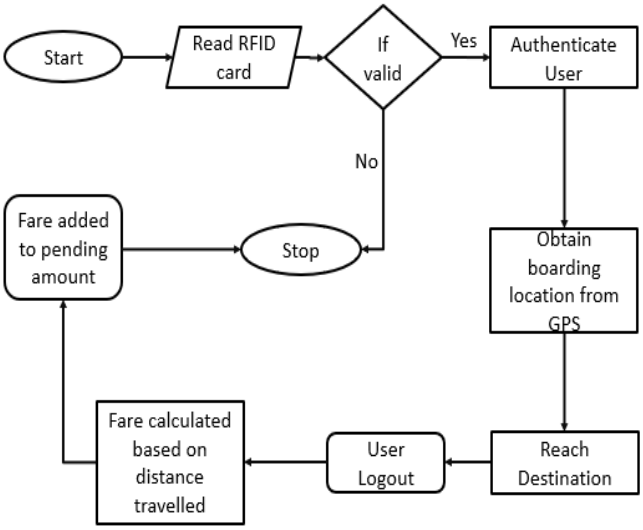

Fig 2. System Design

Overall, a smart bus system using RFID technology can provide a range of benefits, including improved fare collection, efficient bus tracking and route optimization, and enhanced passenger experience through real-time information.

The components and programs used in this system include:

A. MF RC522 RFID Reader

The MF RC522 is a highly integrated contactless reader/writer module for 13.56 MHz frequency. The MF RC522 module communicates with a host controller through a serial interface using the SPI (Serial Peripheral Interface) protocol. It supports both I2C and SPI interfaces and has a maximum operating distance of about 10 cm. The module can be used to read and write data from and to RFID tags and cards. The MF RC522 module consists of an antenna, a

control unit, and an interface. The antenna is used to transmit and receive RF signals, while the control unit manages the communication with the RFID tag or card. The interface allows the module to communicate with the host controller.

Fig 3. MF RC522

B. NodeMCU ESP322

The ESP32 microcontroller is a powerful chip that has Wi-Fi and Bluetooth connectivity, a dual-core processor, and various peripherals such as GPIO, UART, SPI, I2C, and ADC. The NodeMCU board provides access to all these features through the pins on the board. It has a built-in USB-to-serial converter, which allows easy programming and debugging of the ESP32 microcontroller. It can be programmed using the Arduino IDE or the ESP-IDF (Espressif IoT Development Framework), the official development framework for the ESP32 microcontroller.

Fig 4. NodeMCU ESP322

C. Neo-6m GPS

The NEO-6M is a compact, low-cost GPS module commonly used in a variety of applications such as vehicle tracking, location services, and outdoor navigation. The NEO-6M GPS module uses the u-blox 6 positioning engine, which provides accurate position, velocity, and time information to the user. The module supports up to 50 channels and can receive signals from GPS, GLONASS, and QZSS satellite constellations. The NEO-6M module communicates with a host controller through a serial interface using the NMEA protocol. The module is compact and lightweight, with a small form factor of 25 x 25 x 4 mm, making it easy to integrate into a wide range of devices. It operates on a voltage range of 3.3V to 5V and consumes only 50mA of power.

Fig 5. Neo-6m GPS

D. LCD Display

The operating voltage of the LCD is 4.7-5.3V, and it contains two lines that can display 16 characters each. The required current is 1mA without a backlight, and each character can be embedded in a 5×8-pixel frame. This LCD is available with a blue or green backlight. The display can show a variety of characters, including letters, numbers and symbols. There are many libraries and sample codes for working with 16x2 LCDs on various microcontrollers and breadboards.

Fig 6. LCD Display

E. Thingspeak Webserver

ThingSpeak is an Internet of Things (IoT) platform that allows users to collect, store, analyze and visualize data from connected devices. It provides users with a simple and user-friendly interface to connect devices, collect data and analyze it in real-time. Once data is in ThingSpeak, users can use the platform's built-in tools to visualize it in real time using charts, graphs, and gauges. ThingSpeak's MATLAB Analysis and Visualizations app can be used to perform more advanced analysis of the data, including machine learning algorithms,

statistical analysis, and predictive analytics. ThingSpeak also allows users to create custom applications and integrations using its API, making it easy to integrate with other services and platforms.

F. MIT App Inventor

MIT App Inventor is an integrated web application development environment maintained by the Massachusetts Institute of Technology (MIT). The platform allows users to drag and drop components onto the canvas and then customize those components using a block-based programming language. Using a graphical interface much like the Scratch and StarLogo programming languages, users can drag and drop visuals to create apps that can be tested on Android and iOS devices and built to work as Android apps.

IV. Conclusion

In conclusion, the integration of RFID reader and tag technology in college student ID cards and the use of an Android application to provide travel information and GPS details is a powerful solution to digitalize the college bus transportation system. This research paper has shown that this approach can significantly enhance the efficiency, safety, and convenience of college bus transportation. By utilizing the RFID reader and tag technology, the college can track bus movement, monitor student attendance, and ensure the safety of students during transportation. Additionally, the Android application can provide real-time travel information and GPS details to students, faculty, and staff, allowing them to plan their schedules and reach their destinations on time. By implementing this solution, colleges can improve their transportation infrastructure and provide a more reliable and convenient service to their community. Therefore, this technology has significant implications for the future and its adoption can have a positive impact on the college's overall transportation experience.

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