

IoT-based Public Transport Management System

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Abstract – In the world that is running on technology, we still are lagging behind when it comes to our public transport management. Everything around us is digitalized and designed in such a way that our time is not wasted and also the things around is being automated. In this kind of scenarios it is also important to take into consideration, the public transport system. This paper mainly focuses on helping the public transport management in order to digitalize all the possible things and help passengers in saving their time while waiting for buses for hours and also kind of digitalize the payment gateway using the RFID technology. The main feature in this paper is the bus tracking and cashless payments of fare, and enables passengers to travel in a new city easily and in a convenient manner from one place to another. It also deals an issue of buses which are overloaded with passengers. Since it is a design which is IoT-based internet plays a major role in this project. The project uses Google firebase cloud storage in order to store few data. This project not only focuses on the passenger point of view but also on transport management too, where it helps them save in case of any danger faster.

Keywords—ESP32 Wi-Fi Module, Microcontroller, Passenger Count, Relay, QUESTAR GPS, RFID Module, Smoke, Fire, Power Supply, Arduino IDE, Google Firebase, MIT App.

INTRODUCTION

Bus Transport especially Public buses for example, Bangalore Metropolitan Transport Corporation (BMTc) in Bangalore similarly in many other districts or states have their own transport boards, and these are the transport that most of the population use as a daily means of transport from their home to office or say one place to another. While the public transport has been a very important part of most of the population it is important to take into consideration about the issues faced in the transportation and find a solution towards betterment of the means of transport so that many people will be influenced to use public transport than any other means like two-wheeler or four-wheeler which is also an addition towards a green city as it reduces emission of harmful gases into the atmosphere and help us to maintain a good environment for us and our future generations. Almost all of us might have travelled in public buses at least once in a lifetime, we have observed various issues while travelling from one place to another be it more than the allowed number of passengers inside a bus, or few passengers escaping from taking their tickets sometimes and also us waiting for hours for a bus without having a proper knowledge of the arrival of buses in that stop. Not only these, there are many more issues faced from passengers which will be dealt in further sections. While this is about the passenger point of view, it is also important to consider the transport authorities point of view in order to build a smoother and safer travelling support to passengers. By which it means the safety of the passengers inside the bus should also be considered in case of emergency situations like fires, or any harmful gases inside the bus or in that case even bus breakdown. Since nowadays, we have come across many bus fire cases and few buses without proper fuel emitting harmful gases into the nature. Also it introduces cashless payments for the fare through their transportation. This project introduces a safe, secure, and digital transportation to the passengers and encourages them to use buses just like how people use metro as their means of transportation. Overall this project proposes one of the best ways to both the transportation authority and also its passenger easy and on-time transportation facilities.

BACKGROUND

A. *Rationality behind choosing the project*

As students we travel using the public transportation as a mode of transport from our home to college and vice-versa. While travelling we came across various issues in our perspective as well as the transportation authorities. Since not only college students there are daily wage labourers who are dependent on public transport for travelling from one place to another in order to carry out their daily work. When this was the situation it made us implement something that would favour passengers as well as the transportation authority in helping everyone maintain a smoother transportation and also making it cost-effective for implementation on a larger scale as it is a transportation for over a huge amount of people across different cities. Travelling is the most important part of a human's life. It is important for a person to travel across different places to carry out their works in a regular basis. The people who use transportation regularly will be aware of the happenings with the bus timings and as well as the fares and the density of population travelling in that direction and they plan their time accordingly. But when it comes to a new-comer to a city, it becomes very difficult for him to figure out the route and also it becomes a tedious job for him or her in waiting for a correct bus and of course it usually takes a lot of times for few buses to arrive since their frequency of arrival is very less. Not only to passengers, has it also become tough for the authorities to help passengers carry out transportation in a smoother manner. In case of bus fires or any other emergency situations it is important for the authorities to bring to their notice about the issue and also try to minimize the effect of it as much as possible with this project implementation. It also helps authorities find out the location where the bus is in that particular time and helps them to contact nearby support in order to save many lives. In addition to all this, this project also helps the transportation department to increase the frequency of the buses in that particular direction in order to help or encourage people travelling that way regularly have a good and non-congesting travel to the destination.

LITERATURE SURVEY

B. *Ni Ni San Hlang, Ma Naing, San San Naing [1]*

The above mentioned authors have published a paper with title "GPS and GSM based Vehicle Tracking System". This paper focuses on the vehicle tracking and detecting it in order to avoid if any theft has happened. It mainly uses Global System for Mobile Communication (GSM) and also Global Positioning System (GPS) for tracking a vehicle and locating it in its position. It helps in the security of the vehicle and helping to easily find it in case of any theft of the vehicle. The hardware is placed in a manner in which it is invisible to everyone. And if there is a theft of vehicle the vehicle owner will be able to track it based on the latitude and longitude of the vehicle and it is continuously monitored.

C. *Dr. M. V. Vyawahare, Shriya Lambat, Mayuri Belsare, Kritika Latwe, Richa Vairagade [2]*

A project with title "IoT-based School Bus Monitoring and Security System" was the project of the above mentioned authors. They have used the modern available technologies for implementing the tracking system for use in the monitoring and management of school buses. This system tracks the movement of buses from a location it is present at that particular time. The module used here for tracking is the Global Positioning System (GPS) Module which returns the latitude and longitude fetched by it from the satellites. While the number of accidents from day-to-day is increasing and also there is a heavy traffic network that is built up, it is important to ensure the parents about their child's safety and security. This project is implemented in such a way that even parents will be able to track their child's bus location.

D. *Umar Farooq, Tanveer ul Haq, Muhammad Amar, Muhammad Usman Asad, Asim Iqbal [3]*

These researchers implemented a project called "GPS-GSM Integration for enhancing public transportation management services". This paper mainly gives out a solution for enhancement of management services for public transportation using GPS and GSM in Punjab province of Pakistan. Their system had mainly four modules, they are: Bus station module, In-bus module, Bus stop module and the Base station module. This module was mainly built by observation of a poor transportation services in the areas of Lahore, Pakistan. This module would be installed in every bus stops in order to make it an easy and efficient use by every passenger, by letting them know the location of buses which are arriving near that stop.

E. *Komal Agarwal, Kranti Dive [4]*

The above mentioned authors implemented a project for bus management system with title "RFID based Intelligent Bus Management and Monitoring System". In this implementation they have made use of RFID Card Reader in order to track the location of the buses which are meant for public transportation purposes. The logic behind this is whenever the bus leaves from its base station, there will be an RFID tag at that station and this tag reads the RFID reader present inside the bus. This data present in the tag that is read at base station is sent to the base station using the GSM Module. And at every bus stop there will be a module installed and it displays the data that is received from the base station. The main microcontroller used in their project is AT89S52, and the language is assembly language using Keil software.

F. *Akshay Sonawane, Kushal Gogri, Ankeet Bhanushali, Milind Khairnar [5]*

The above mentioned researchers built a "Real Time Bus Tracking System". This system was mainly to let the user to track the bus that they require for transportation through an android application. Hence, it reduced time of the user in waiting for their bus and also the system provides the information about the approximate arrival time and distance of the bus.

G. *Khalifa Salim, Ibrahim M. Idrees [6]*

The authors above created a model named "Design and Implementation of Web-based GPS-GPRS Vehicle Tracking System". Here, they tried to use a web-based GPS-GPRS for their vehicle tracking system and implemented it. This model was built by keeping an enterprise in mind. Hence, this model enabled the enterprise owners to locate the target vehicle on Google maps. Here, both the present and past locations were stored in the device hence it helped the owners in tracking the vehicle with the detailed journey of it. The GPS data was sent through a method in HTTP protocol, and the data at server was stored in a separate database and retrieved when needed.

H. R Maruthi, C. Jayakumari [7]

Maruthi and Jayakumari built an “SMS based Bus Tracking System using Open Source Technologies”. They mainly designed this model to track buses through the interface as an application by making use of a GPS transceiver. This system managed and controlled the transport through a tracking device in order to find out the scheduled vehicle and also its current location through the SMS by use of a GPS tracking device. The key feature of this project was a WAMP server and also along with it an application for tracking the buses which is written in PHP with MYSQL for their database in order to store any necessary information.

I. Jay Sarraf, Ishaani Priyadarshini, P. K. Pattnaik [8]

They designed a “Real Time Bus Monitoring System” to implement it as a system for tracking the frequent travelers using buses as a primary mode of transportation using a GPS (Global Positioning System) and also GPRS (General Packet Radio Services). As the name suggests it will help the passengers to see the location where the bus is currently at and also helps them by displaying the arrival time of the buses to the nearest bus stop of the user. The mobile application will display the current location of the bus and also the ETA (Estimated Time of Arrival) and the same can also be received by the help of an SMS.

J. Gaurav Chheda, Niket Gajra, Manal Chhaya, Jithesh Deshpande, Saylee Gharge [9]

These authors designed a system called “Real Time Bus Monitoring and Passenger Information System” which was also to monitor the buses and provide the current location of the buses. Basically, this model was built focusing more on Mumbai city. It uses a GPS in order to collect data of the current location of the bus. It also used few software to use the data collected by GPS and to interface it with the map to make it a pictorial representation. This system also used RF devices in order to transmit as well as receive data of the location. This paper mainly focused on bus tracking goal.

K. K Jain, Raul Goel [10]

These two authors developed a model named “GPS Based Low Cost Intelligent Vehicle Tracking System (IVTS)”. This was a low cost model also an intelligent tracking IVTS system which used the GPS for tracking the vehicle and also to detect the navigation of these vehicles. This model focused in general to not just buses but all vehicles. It mainly consisted of three unit. Firstly, In-Vehicle unit which will be placed in the vehicle. Secondly, the communication link for establishing the communication between the user and the vehicle and to connect them virtually. Also thirdly, the Base Station which will be placed in the base station of the vehicle. It enabled users to track the location of the vehicles wherever it goes. Hence, by this it is understood that the two main features of the system are tracking and navigation of the vehicles.

OBJECTIVES

- To track the public transport vehicle here, bus using the android application as a software interface.
- To design a cost effective model for tracking and monitoring the location of the bus
- To monitor bus in case of any fire, smoke or breakdown and intimate the administrator of the bus to carry out precautionary measures.
- To build a wireless system in order to help all the passengers and track buses easily through their mobile internet.
- To detect the passenger count and let passengers know the count of passengers inside the bus for them to make plans accordingly.
- To design a cashless payment gateway to pay the fare to passengers of all age.

METHODOLOGY

L. Block diagram

The block diagram of the IoT-based Public Transport Management System is shown in the below Fig 1. The block diagram consists of the following components:

1) *ESP32 Microcontroller*: Microcontrollers and also Microprocessors are the devices which controls and performs specific or desired operations required by the users.

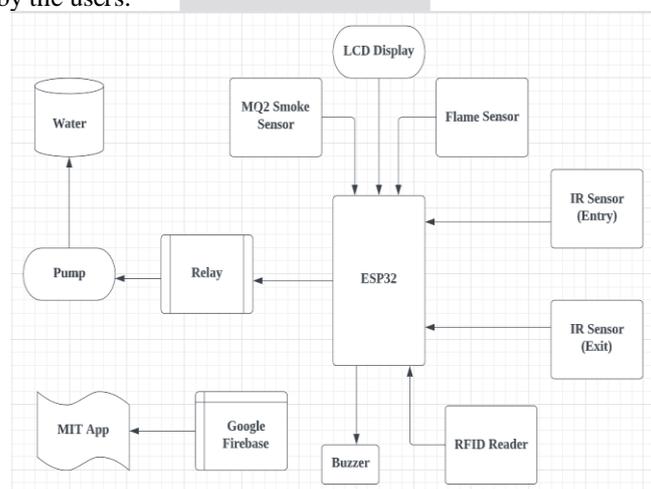


Fig 1. Block Diagram

The Microcontroller used in this project is ESP32 Microcontroller. This system is the heart of the project. Using this Microcontroller we can program the other devices and interface them in a convenient manner. It is easy to understand about the ESP32. It has many ADC (Analog-Digital) pins which helps us to interface many sensors with analog readings while compared to other microcontrollers like Arduino UNO, Raspberry Pi etc., It is a low-cost device and an easily replaceable as it is available in the local market itself. *This controller supports Wi-Fi which is a key feature which is not present in Arduino UNO and even if present in Raspberry Pi it is costlier in price. This Wi-Fi is connected using our hotspot name and password and all the data can be transmitted and received using an interface that facilitates it. In this system we are using Google Firebase as a cloud storage which is helpful in monitoring and storing the live data received from the microcontroller which in turn receives it from the sensors that are interfaced with it. The Microcontroller also supports various communications like Serial Communications like GSM, GPS, Bluetooth etc., also SPI (Serial Peripheral Interface) communications, and as well as I2C Communication. It consists of 10-bit ADC which means there will be 0 to 4095 values for analog devices. In this project we have interfaced various sensors as provided in the block diagram with the ESP32 Microcontroller. Since it supports open source software, Arduino IDE, it helps us build our logic using this software in Embedded C Programming language. Initially the ESP32 is fed with the Wi-Fi name and password, and it is programmed in such a way that it gets connected to the provided Wi-Fi and later perform its functions. We have also used Google firebase, hence its authorization ID and password is also fed in order to send the desired and collected data from various components in the project to cloud through which the app collects the same data and displays it to the user.*

Hence, this Wi-Fi module is considered as the heart of the project as it is the main microcontroller which performs all the desired operations of the programmer.

2) **Power Supply:** The entire management system is powered up using the 12V adapter or even. This power supply is designed in such a way that we get additional pins giving out the same voltage like 12V, 5V, 3.3V, and GND. In the Microcontroller we just have one 5V and one 3.3V and two GND pins. But in reality we may need many of these pins while interfacing various components. Hence this external power supply is used.

3) **RFID Module:** This module helps us in making cashless payment gateway for the public transportation. Its full form is Radio Frequency Identification Module. It is a wireless device which works on the use of Electromagnetic fields. Its tag gets activated whenever the radio wave signals that it transmits are sent back to the antenna present in it. It consists of four pins: 5V, GND, TX and RX. 5V and GND are for powering the device and TX and RX is for Communicating with the Module. Whenever the card is tapped by the user for fare payment or by the driver or conductor for stage addition, the waves transmitted by the module is received back the corresponding operation takes place. And every RFID is identified using an unique ID.

4) **GPS (Global Positioning System):** The GPS Module that we have used is QUESTAR GPS. This is one of the most accurate sensors that is being developed so far. It powers up by the supply of 5V. We use the transmitter of this module in order to continuously receive the tracked satellites that are present and give an accurate data of positioning. It is basically for the systems that require better performance in locating the geographical areas. This module initially when powered up tries to catch the signals from the satellites and before the exact location is detected, it connects to the nearest three or more satellites and provides more accuracy in position of upto 10 to 12 meters.

5) **IR Sensors:** Since passenger count is also an important feature of the project, we decided to use the IR sensors in order to detect the number of passengers inside the bus. Basically we will have to place the two IR sensors in the bus, one in the entry door step, other on the exit. If there are no separate ways for entry and exit then the IR sensor for entry is placed in the lower step and exit on the upper step. Which sensor sends the signal first will be used to calculate the number of passengers inside the bus.

6) **Smoke sensor (MQ2):** This sensor is basically used to detect the air quality of the bus. It is powered by 5V and the analog output of the sensor is used to read the values from the sensor. Basically this sensor senses most of the smoke present in the air. This is for sensing the amount of Carbon-di-oxide in the air. When smoke enters inside the sensor there will be voltage variation inside it and according to that the sensor will give an analogous value in analog digits. These values are compared with and without smoke and later a threshold is set and the device is programmed to detect the smoke content in the air.

7) **Flame Sensor:** This sensor is used to detect the fire or flame if present. It is powered up using 5V and the readings from it is taken through the digital output pin of the flame sensor. It is also important to monitor the physical conditions of the bus, since we faced a bus breakdown due to fire in Bangalore. In order to minimize such accidents we used this flame sensor which detects fire when it is yet to be spread throughout and an immediate alert is created using the buzzer module and hence the device helps in early detection of fire.

8) **Relay:** The relay is used to turn the water pump on in case of emergency or accidents like fire. The relay input voltage depends on which type it is. The relay that we use is JQC-3FC(173)DC12V. This relay uses 12V DC supply in order to power on. So this has two connections for the output. One is NO (Normally Open), and the other NC (Normally Closed). The NO pin is suitable for our functionality since it is open circuit and when we want we can close the circuit and power the device on the other side of the Relay.

9) **Water pump:** This is a DC submersible mini water pump it requires 12V supply and it is connected to the microcontroller through relay. It is a pump which we use in order to protect from fire as much as possible. This pump is mainly connected to a water pipe and kept inside the water tank and whenever there is accidents like fire, suddenly the water is ejected out in order to reduce the intensity of the fire.

10) **Buzzer:** Buzzer is a simple and a small digital device which gives out sound whenever a 5V is passed as an input to it. When there is fire and smoke present in the bus it is used to give an alert sound which is a beep.

M. Software Components used:

1) **Arduino IDE:** IDE in its name stands for Integrated Development Environment. As we know, Arduino IDE is an open source software to program arduino and similar microcontrollers. The version used for this project is 1.8.13. This software runs the logic of the microcontroller only by installing the necessary libraries. We need to write the code in the software using

embedded C or C++ and just compile it and upload to the microcontroller by selecting the COM port to which the ESP32 is connected to. The main feature of this software is it works on a wide range of Operating Systems (OS) like, Windows, MAC OS X, and Linux. It also provides us a Serial Monitor in order to view our output by the baud rate that is desirable to us.

2) *Embedded C*: This is the programming language used to program the ESP32 Microcontroller. It is a simple and easy to understand language. It is similar to C programming as it also uses all the syntax and semantics as that of C language. The difference in it is it allows Input and Output Hardware Addressing and also fixed arithmetic operations etc.,

3) *Google Firebase*: Google Firebase is a web and also mobile app development platform which is developed by Google. Firebase's architecture is integrated with the Cloud storage. It captures live data from the ESP32 module using Wi-Fi technology and stores live data in it. It provides upto 1GB of free storage per account, which is more than enough for storing the data from the microcontroller. It need not be created by every user, instead a bus should have its own firebase account.

4) *MIT application*: In general words, it is an application which can be created by a non-programmer too. MIT in the title stands for Massachusetts Institute of Technology. It helps us to create and build a visual application for android devices using data stored in the google firebase. It is a environment which allows everyone to build and develop a fully working apps for their android devices in less than 30 minutes. In this project we used the firebase credentials in order to collect the data that is sent by the microcontroller to the firebase and this details are fetched by the MIT application that is created and the same is displayed in the app.

Here, we have built two applications, one is for user and the other for the admin the user app is called the Bus User and the later is called as Bus Admin. The user app will have the details such as number of stages, passenger count, and location of the bus and its arrival time. While the admin app consists of the details like, smoke, fire, passenger count, and location of the bus.

OUTCOME OF PROPOSED RESEARCH

The completed model consists of all the components present in the block diagram and are interfaced with the ESP32 microcontroller. The power of 12V from the adaptor is used to power up the system. When the system is powered up the entire systems starts functioning and are continuously monitored. Firstly the GPS performs its functioning. Whenever the GPS gets proper signals it starts sending data about the location continuously in loop. Later the Smoke and fire are monitored continuously inside the bus. If there is any smoke or fire detected immediately an alert is passed by the buzzer and precautionary measures can be taken and also the fire alert will be sent to the administrators of the transport system in the application as shown in the below Fig 2.



Fig 2. Admin and User Application

Later comes the passenger count. The passenger count can be programmed in two ways: one is when there is separate ways for entry and exit, and the other way is when there is a same way for both entry and exit by programming in the required manner. The programming done is here for separate entry and exit doors. Next is the RFID tag functionality is executed. The RFID reads cards continuously and stores the data until it gets its turn to transmit the card ID it received. When the stage card is tapped there will be a stage updated and also there will be deduction of Rs. 5 in the card of the passenger. The same functionality repeats in loop and is continuously monitored and displayed in the google firebase and in turn the application.

The below Fig 3. and Fig 4. Indicates the user and admin application respectively.



Fig 3. Bus User



Fig 4. Bus Admin

The Fig 5. Represents the alert notification in the application to the admin application for emergency situations like smoke and fire.

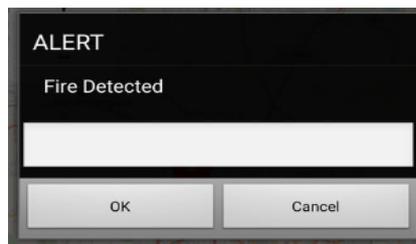


Fig 5. Alert notification for fire

DRAWBACKS AND FUTURE SCOPE

The proposed model does all the functionality in a correct manner but the used storage can be an advanced one in future and also in the system a different logic can be used to make cashless payments in an efficient manner. The model can become advanced by implementing a fare calculation system and also the ETA (Estimated Time of Arrival) as well as distance from the current bus stop.

SUMMARY

The presented concept and model will help the transportation of the passengers to go in a smoother way and also helps them to go to bus stop on time. It eradicates the time that the passenger has to wait for a long time to catch a bus in a different city. It also helps the administrators of the transportation system to increase the frequency of the buses in the areas where the passenger count is always high so that it adds to the revenue of the transportation department. Overall this project helps in creating an easy and a smooth transportation for passengers from one place to another.

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