# IoT Based Smart School Bus Monitoring and Notification System

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***Abstract*— It is important for every school to have a trustworthy and secure transportation service to ensure the safety of the students. It helps the school administration to effectively manage their bus fleet and potentially reduce mishaps. This is where vehicle monitoring takes effect. The proposed system provides real time information about various parameters of the vehicle like the location, the route, the speed, the list of passengers, the adherence of drivers to schedule and much more. The system further allows the parents to be notified when their ward alights or boards the bus. In this system, we make use of RFID and GPS technologies and connect them to a remote server over WiFi using an ESP8266 microcontroller. An Ublox 6M GPS module is used to find the current geographic coordinates of the vehicle's location as well as the speed it is going at. An MFRC522 RFID reader identifies each student as they board or alight the vehicle by reading the id from their RFID tags. The system uses the ESP8266 to upload the information from the peripherals to a database in the web server. The information can be accessed by the parents through a mobile application and this helps them track their wards effectively. The school administration can also access the application to ensure student safety and contact a driver or a parent. The application also allows the administration to be informed of emergencies or complaints.**

***Keywords—Vehicle Tracking; ESP8266; GPS; IoT; RFID; Smart Systems.***

## I. Introduction

The commute of students from home to school and back has always been a source of concern for parents. Students often get on the wrong buses and get off at the wrong stops. Bus drivers may not be able to identify all the students and will not know in time if a student is missing. Parents have no way of knowing if their ward is safe until the evening when the bus returns.

While some schools have already implemented GPS tracking of buses using GSM[5] and other means, they do not ensure absolute safety. Some of these devices do not give real time information whereas some are too expensive to be a ubiquitous solution. A tracking system that do not identify individual students may also lull the guardians into a false sense of security. The proposed system describes a low cost comprehensive school bus monitoring device that tracks the location, the speed, the people onboard, adherence to route and schedule and other information pertinent to school buses.

Real time tracking of the bus allows the children to have more time for activities instead of waiting for a delayed bus and the notification system ensures the individual safety of each student. Moreover, educational boards like CBSE has also started advocating the necessity for school bus monitoring systems[1], thus making an affordable and reliable solution the need of the hour.

The tracking is achieved by reading the geographic coordinates of the bus from the GPS[5] module and uploading it to a MySQL database in the remote server over WiFi using the microcontroller. This information can then be accessed by a user base that includes the parents, bus drivers and school administration through a mobile application which takes the location from the database and plots it on a map.

The notification system alerts the parent when the id from their child's RFID tag is read by the RFID reader, which causes the microcontroller to invoke a server script to push notifications to the parent's mobile[7]. Thus the bus and the students onboard will be monitored accurately throughout the commute.

## II. Components

The proposed prototype used the following hardware components:

### *A. GPS Tracker [3]*

The Ublox 6M GPS performs the following functions:-

- Continuously monitor the bus by reading parameters like the speed, the geographic location and the route in real time which is uploaded to the server by the microcontroller and viewed through a mobile application.
- Read the geographic coordinates and time as each student boards and alights the bus which is included

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in the push notifications to the respective parents.

### B. RFID Reader [2]

The MFRC522 RFID Reader is used to identify each student uniquely by reading the student's ID from the ID card. The ID card of each student is embedded with RFID tags.

### C. ESP8266 Microcontroller [4]

ESP8266-12f is a WiFi chip and microcontroller that is used here to read the sensor data(GPS and RFID readings) and upload it to a MySQL database hosted on a remote server. It further invokes scripts to push notifications to the parents as input from the RFID is received. In addition, it verifies the validity of the input before it uploads the data to the database.

## III. Software Specification

In this prototype, the front end development was done using Java, XML and embedded C in Android Studio and Arduino IDE wherein the android application was built using Android Studio and hardware functionality using Arduino IDE respectively. The backend database were developed using PHP and MySQL. The push notification service was implemented using cURL requests to the Firebase Cloud Messaging service.

## IV. Proposed System Design

Ensuring the safety of school children during their commute to and from school requires making the school journey entirely transparent and accountable. The proposed model conceptualizes a comprehensive monitoring system which would track the bus continuously in real time.

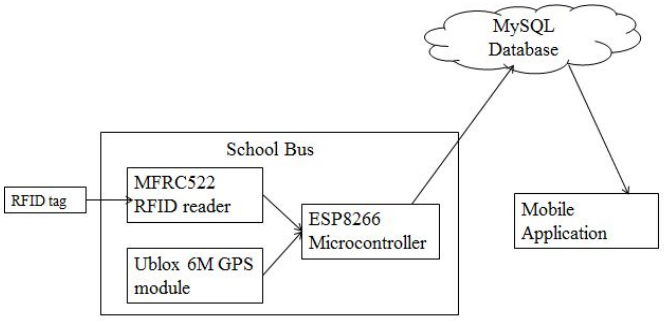


Figure 1. Block diagram

The functionalities of the proposed model includes tracking the location, the speed, the list of passengers onboard and the route of the bus and plotting these information on a map integrated using the Google Maps API, to the user interface of an android application which serves the administration, parents and drivers, to monitor the bus and the students within[6]. The system will also identify each student as they board or alight the bus and push notifications to the respective parents' mobile device with the time and location of the event. Figure 1 shows the overall block diagram and the flow of the system.

The hardware assembly is kept at the entrance of the school bus. The two main sensor integrations to the microcontroller are the GPS system and the RFID reader. The GPS system obtains the coordinates of the current location of the bus while the RFID reader uniquely identifies each student entering the bus by means of the RFID tag embedded in the student ID cards. Both these readings are fed to the ESP8266 microcontroller[4]. Figure 2 shows the circuitry that connects the sensors to the microcontroller.

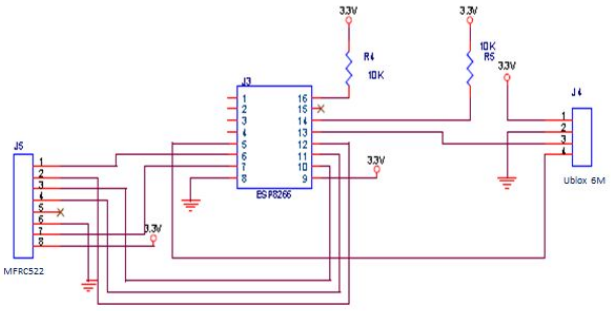


Figure 2. Circuit diagram

The GPS module has mainly two functions. It continuously reads the geographic coordinates of the bus's current location as well the speed it is going at, which is subsequently read by the microcontroller[5]. This data is continuously uploaded to the status datatable in the MySQL database that is hosted on a remote server via an HTTP POST request using WiFi along with the bus id and the timestamp. The WiFi connectivity is assumed to be provided by a WiFi adapter placed onboard the bus.

The RFID reader reads the unique id embedded in the passive tag of each student as they approach the entrance of the bus where the hardware ensemble is placed[2]. This is read by the microcontroller which invokes a PHP script on the server which uses a toggle to change the status of the student to either onboard or offboard, finds the device id of the corresponding parent and pushes a notification message including the location and time from the status datatable to the smartphones of the respective parent via an android application, using the Firebase Cloud Messaging service.

The front-end mobile application for the proposed model works on the Android operating system[7]. The application can accommodate three types of users, administration,parents and drivers. On signing up, a unique device id is generated using Firebase Registration Service and stored in the database

with login credentials. A Google Map API is integrated to the application UI to plot the location and route of the bus.

A parent can scan the database for their child using the unique id provided for each student and choose to follow them. This would allow the parents to view the information of the bus their child takes, like the location, route and speed, plotted on map and contact the bus driver or the administration and get notified whenever their child boards or exits the bus. Firebase Cloud Messaging service is used to push the notifications using a cURL request in the PHP script that is invoked each time the hardware ensemble reads an RFID tag[6]. The Firebase token corresponding to the respective parent is fetched from the database and the notification is pushed to their device as can be seen in Figure 3.

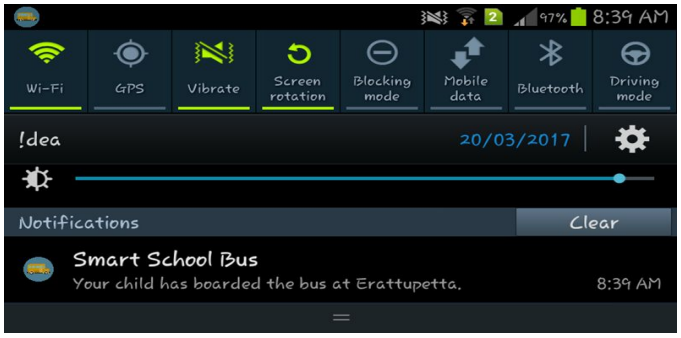


Figure 3. Parent Message Notification

The application allows the administrators to add or update student information and bus schedules, view information of all buses, the list of students on board and the driver details and contact parents and drivers. A toggle variable marks students as on or off board when their RFID tags[6] are read. Drivers have the provision to contact the administrators or emergency services as well as view the details of their bus stored on the database.

The administrator can modify details like that of the buses, drivers and students. They can view details including the current location and speed of each bus and also the list of the passengers onboard each bus. The bus driver can view the route, speed, location and the scheduled stops of his bus and can further contact the administrator and emergency services like the ambulance or the highway police directly from the mobile application using the touch interface. The proposed model assumes that a WiFi Dongle provides the required internet connection on board the bus.

Figure 4 shows the online status database table with fields to store the location coordinates, bus id, the speed and the time of entry. This table is constantly populated by the data read from the GPS module by the microcontroller. The mobile app on loading will immediately send an HTTP POST request to this table to arrange the entries by entry id in the descending order and fetch the latitude, longitude and speed values corresponding to a bus id[7], encoded as JSON in the POST request.

| FIELD NAME | DATA TYPE | SIZE | DESCRIPTION |
|---|---|---|---|
| id | Integer | 10 | Primary key, Auto-increment |
| busid | Integer | 10 | |
| latitude | Decimal | 10,6 | |
| longitude | Decimal | 10,6 | |
| speed | Float | 10 | |
| time | Datetime | | Current timestamp |

Figure 4. Status Database Table

The value of bus id would vary with the user type. The query from a parent would retrieve the data from the column which matches their child's bus id whereas the query from a driver would equal the id of the bus he drives.The id field is set to auto increment so that the values retrieved by the query will be the last known information about the bus.

## V. User Interface

The user interface of the android application is implemented for the three modules i.e. admin, driver and parent. Each of parent, admin and driver has to login using their unique password and username. Figure 5 shows the login and sign up screen which appears when the mobile phone application is run in an android device[7]. In addition, it shows the three roles in which a user can sign up which would consequently determine the type of functionalities they will receive. All three types of users are directed to a Google Map activity after login with customized menu options[6]. The map plots the route covered, the last known location and the speed of the bus. The settings screen which is also shown in Figure 6 is common to all three types of users for account management. The admin's menu gives the option to view students which lists all the students who take a particular bus and their attendance, as seen on the right.

## VI. Results

The completed system meets all the specifications and provides all the functionalities identified in the design phase. Using this system, the parents can easily track the school bus and ensure it is moving at safe speeds, hold the school authorities accountable for delays or deviations, be updated on the changes in schedule and contact drivers or authorities if necessary. Working parents can rest at ease knowing when their kids reach safely even though kids aren't allowed phones.


Figure 5. User Login & Admin Panel

Admin can see the location of all buses, see the list of passengers onboard, add new students, update bus schedule and route, contact drivers etc. The drivers can contact admin and other emergency services easily if required.The locations were continuously and accurately uploaded to the database. The GPS[5] showed an initial delay ranging from 30s-60s to start finding the location. The cards were read accurately and the notification was sent in less than 20s. As can be seen in Figure 6, the data from the hardware ensemble is uploaded every 3 seconds which is near real time.

## VII. Conclusions

The smart school bus app is a user friendly tool for parents to check up on their kids and school administration to monitor the drivers. In summary, this project has built a school bus security system that provides comprehensive security to the commute. The system has real time tracking, student identification, and provision to monitor excess speed, detours, unscheduled stops, delays, accidents and student absence.The development is complete. The system has passed alpha and beta testing phases successfully and is ready for implementation. The functionalities are better and more accurate than those provided by the Arduino based systems as notifications can be instantly cleared whereas GSM systems spam the message inbox. While Raspberry Pi based or biometric identification based systems are real time and highly accurate, they are very expensive to be considered a ubiquitous solution for schools everywhere. The entire system was built under a cost of 15USD as opposed to GSM systems or Raspberry Pi systems which cost over 50USD.

Options

| | id | busid | latitude | longitude | speed | time |
|---|---|---|---|---|---|---|
| Edit Copy Delete | 342 | 101 | 9.680974 | 76.772496 | 0.69 | 2017-03-18 10:15:53 |
| Edit Copy Delete | 341 | 101 | 9.681196 | 76.772388 | 0.69 | 2017-03-18 10:15:51 |
| Edit Copy Delete | 340 | 101 | 9.681355 | 76.772313 | 0.57 | 2017-03-18 10:15:48 |
| Edit Copy Delete | 339 | 101 | 9.681587 | 76.772281 | 0.37 | 2017-03-18 10:15:46 |
| Edit Copy Delete | 338 | 101 | 9.681778 | 76.772324 | 0.17 | 2017-03-18 10:15:40 |
| Edit Copy Delete | 337 | 101 | 9.681958 | 76.772356 | 0.57 | 2017-03-18 10:15:36 |
| Edit Copy Delete | 336 | 101 | 9.682074 | 76.772431 | 1.61 | 2017-03-18 10:15:34 |

Figure 6. Sample data from status table

## VIII. Future Scope

This software could be modified and developed for future use. Provisions for detecting theft,restricting entry and verifying assigned passenger list on id can be added. The range of the RFID reader is as low as 3 cm and hence impractical for commercial purposes.The RFID can be replaced with a better reader or more reliable identification methods like biometric identification. The HTTP connection is not encrypted and hence easily susceptible to hacking, which can be made secure in future revisions.

## IX. References

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