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An IoT based Fleet Management System for School Buses

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***Abstract*—It is important for every school to have a responsible and safe transportation service which will help the school authority in efficiently managing their bus fleet thus by avoiding any mishaps. With the efficient data collection and web-based platforms, fleet tracking systems have been around for a while now. When such system is installed on a fleet of school buses, it can report real-time location to the fleet admin with the help of GPS tracking and internet connection. However, the addition of IoT into school buses will make them connected and accessible in real time eventually allowing parents to track the school bus carrying their wards in real-time. This paper proposes an IoT enabled smart solution for tracking of school bus for school authorities as well as parents. With the use of GPS, Microcontroller Unit and WiFi internet connectivity, school fleets are easily monitored and managed on web interface and on android mobile application. School admin is able to monitor all the buses and students in real time on web interface and similarly parents will be notified with their child's location through mobile application.**

Keywords—Internet of Things; Fleet Management System; Vehicle Tracking; School Bus Transportation;

I. INTRODUCTION

Road safety is among the key issue when it comes to School Bus Transportation. School bus transportation departments are in a constant effort for providing safe and secure travel to every student. Though the schools are safe places for the children, the daily travel to the school and from the school causes anxiety for most parents. Connectivity is all that is needed to know the whereabouts and well-being of our loved ones. So, the school bus tracking solutions will be helpful for assuring parents about their ward's safety. And with this new age of IoT we can enhance the traditional school fleet management.

Present days, internet has undergone into a fundamental development of network of interconnected objects. This interconnection between objects has resulted into the paradigm named as Internet of Things. The goal of internet of things is to enable things to be connected anytime, anyplace with any device ideally using any network [1]. In case of Fleet management systems, IoT applications extend to various aspects of Vehicle Tracking solutions powered by IoT devices. IoT empowered Fleet management systems enable vehicle's operations along with technologies that can be used to improve fleet planning, scheduling and other operations [2].

This research proposes an IoT solution through which institutes and parents will be able to monitor movement and safety of the school buses in real time. This application will be helpful for the parents who will be able to track their child's bus location in real time making them easier to get notified when to go to bus stop to drop and pick up as well as the route of vehicle can be monitored. In this way, the fleet positions are well known and safe transportation of children is ensured with the help of this IoT solution.

The designed system is an IoT based school bus tracking system where GPS tracker is used for tracking of school bus, this GPS tracker is connected to the internet through microcontroller unit 'NodeMCU'. The end users such as school authorities are able to locate the school buses on web interface as well as parents are able to track their ward's school bus on an android mobile application.

The rest of the paper is organized as follows. Introduction about the concept of IoT and background of proposed system is described in section I. In section II various researches and related works performed in the area are reviewed. Section III summarizes various technologies which are part of the proposed system. The detailed system design is explained in section IV along with hardware and software designs. Systems results are discussed in section V followed by conclusion and future scope in section VI.

II. RELATED WORK

The most related work regarding the school bus tracking is presented in [3]. A scholar bus monitoring system is developed with the use of PIC18F45K20 microcontroller and the MQTT protocol. The system is further extended to track location and speed with the help of location and speed sensors. All the information is collected on cloud with the help of GPRS of cellular networks. The vehicle tracking system developed by [4] is built on Linux Based embedded microprocessor. The proposed system collects the location details using GPS receiver, GSM/GPRS modem is used for communication between vehicle and server. Further for security purposes a physical panic button, speakers, camera, and biometric sensor are used. All the data is maintained and managed using GUI interface. The vehicle fleet management system [5] has used GPS/GLONASS based vehicle locator Rad100, GSM/GPRS cellular network and 'PayaRadab' web-based software. The system is able to show exact vehicle position as well as taking detailed reports about fuel consumption, speed limits and travelled path. The main feature of the system is its performance and high accuracy. The paper [6] presents real-time vehicle tracking system using GPS and GSM technology. GPS receiver and GSM module are embedded with the microcontroller from ARM7 family. Once the GPS data is collected with the help of GSM, that obtained data is read into GUI application made in MATLAB and locations are viewed on Google Earth. The RFID based school bus tracking solution is presented in paper [7]. In the

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suggested system RFID tags are used at student's entering and leaving of the bus. The microcontroller is embedded with GPS and GSM modules and with the help of these location and student's attendance in the bus is sent to their parents. Along with location and attendance, speed of the bus and driver's alcohol consumption is also checked with the help of alcohol sensor and proximity sensor. If any is found , the necessary action is taken.

III. Related Technologies

There are various technologies and components which contribute to any IoT based Fleet Management System such as GSM/GPRS devices, Microcontrollers, and GPS trackers. User interface can be provided on platforms such as web application, mobile application, SMS or e-mail etc. Some of the technologies that are used in this project are described below.

A. GPS

Amongst these entire devices GPS tracker is a one device which is responsible for bus location tracking. GPS, or Global Positioning System, is a satellite based global navigation satellite system, GNSS that provides location and time information anywhere on or near the Earth. The GPS module used in this system is based on S IM28ML GPS receiver modem Fig.1 by SIMCom [8]. It is a small, high performance and reliable assisted GPS module-SIM28ML. This is a standalone L1 frequency GPS module with the MediaTek MT3337 high sensitivity navigation engine, which allows us to achieve the industry's highest levels of sensitivity, accuracy, and Time-to-First-Fix (TTFF) with lowest power consumption.PS, or Global Positioning System, is a satellite based global navigation satellite system, GNSS that is used to provide accurate location and time information anywhere on or near the Earth. Typically, GPS is able to provide position information to within a few metres, allowing accurate positioning to be made. It is also possible to extract timing information that enables frequencies and time to be very accurately maintained.

Fig. 1. GPS Module with Antenna

B. Microcontroller Unit

The microcontroller unit used for this implementation is 'NodeMCU' Fig. 2 which has in built ESP8266 WiFi module. After establishing the Wi-Fi connection the microcontroller will send location data through this Wi-Fi module. The ESP8266 is a low-cost Wi-Fi chip with full TCP/IP stack and microcontroller capability. This small board is a very low price and allows microcontrollers to connect to a Wi-Fi network and make TCP/IP connections using Hayes-style commands information to within a few metres, allowing accurate positioning to be made. It is also possible to extract timing information that enables frequencies and time to be very accurately maintained.

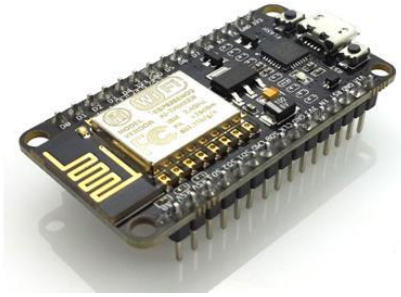

Fig. 2. NodeMCU

C. Arduino IDE

The software used for establishing microcontroller unit is Arduino IDE. It is widely used for programming ESP8266 systems. Arduino is an open source tool for making computers interact with the sensors, switches. It's an open-source physical computing platform based on a simple micro-controller board, and a development environment for writing software for the board [9].

D. Android Studio

The smartphone may not be considered as an IoT device by most people, but it can be actually the first IoT device directly available to the general public across the world. Smartphones applications that are equipped with Wi-Fi or internet are able to communicate and control applications and many different use cases for IoT. Eventually, the mobile app can actually be the primary user interface as they can provide real-time data to be manipulated on site by increasing efficiency. Android Studio is Android's official IDE for developing apps. It is built for Android to accelerate the development and build the highest-quality apps. It offers various tools custom-tailored for Android developers, including rich code editing, debugging, testing, and profiling tools [10].

E. Google Maps API

The Google Maps provides enormous facilities such as searching for places, getting directions from one place to another, viewing and navigating over the places or roads and getting location-based information like traffic, petrol pumps etc. Google provides API service for using their maps in web application that can provide various types of geographical information. Google APIs is a set of application programming interfaces (APIs) developed by Google which allow communication with Google Services and their integration to other services [11]. Google provides various SDKs and APIs for users to use their maps in mobile applications or websites. The API automatically handles access to Google Maps servers, data downloading, map display, and response to map gestures [12].

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IV. SYSTEM DESIGN

The system mainly works into three parts. The first part is establishing the connection between GPS device and Microcontroller unit i.e. NodeMCU. The second part is the communication of Microcontroller with web server. And the third part is user interfacing with the server's data over web interface and also on an android mobile application. The system overview is described in Fig. 3.

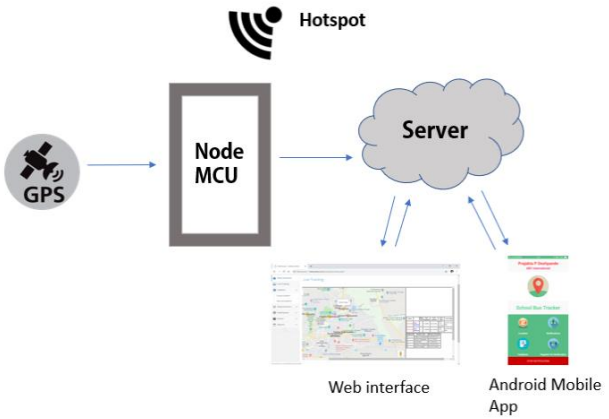

Fig. 3. System Design Overview

The whole system can be divided into two parts for understanding as hardware and software development.

A. *Hardware Design*

Each bus will consist of a system as shown in Fig. 4 individually. Each box will have GPS tracker with antenna on upper side of the box so that it could catch the satellite signals, Microcontroller unit and Wi-Fi hotspot for internet.

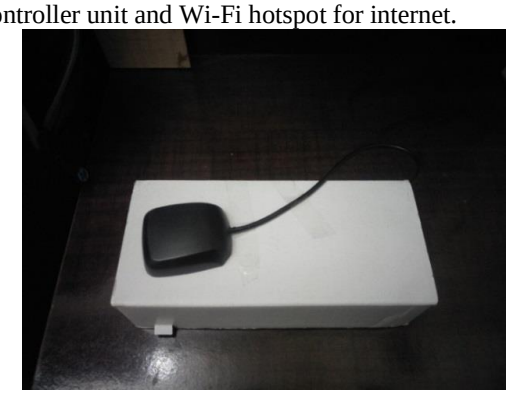

Fig. 4. Tracking System Device

The GPS device SIM28ML is connected to the microcontroller named NodeMCU which uses ESP8266 Wi-Fi module. This inbuilt Wi-Fi chip enables microcontroller to connect to the internet hotspot and then transfer the location coordinates to the web server. The hardware connection between GPS and Microcontroller Unit is established using jumper wires as shown in below Fig. 5. And pin to pin connections [13] are made as follows in the Table 1.

TABLE I. PIN CONNECTIONS

NodeMCU	GPS Device
GND	GND
3.3V	3.3V
D7	Tx
D6	Rx

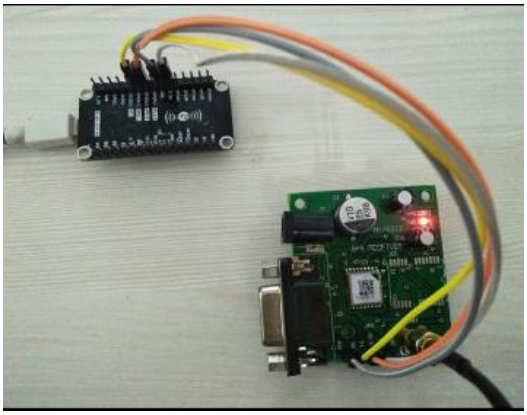

Fig. 5. Hardware Connections

B. *Software Design*

In the developed system, school bus fleet is accessible to the school authority and parents. School authority will be able to view all the buses over web interface while the parents will be able to view only the particular bus in which their ward is registered on Android mobile app. After hardware connections are done go to Arduino IDE and there we need to run setup program for NodeMCU and GPS device. After that the GPS device will start blinking blue LED light which indicates that the connection is successful and it is transmitting and receiving location values to and from satellites. And simultaneously microcontroller will transmit this GPS values to the server through Wi-Fi hotspot internet. The data received on web server is retrieved on web interface and android application and locations are displayed on Google Map.

In this system, web interface is developed using HTML and JavaScript and it will be only managed by the school authority. One admin person will do all the administrative tasks of the system. On the other hand, the android application is only for the parents. Each registered student's parent will have access to the mobile application with their credentials for logging in into the application. After logging in to the application, they can see location of the bus and once the distance between bus and stoppage point is less than or equal to 1km the app will start receiving notifications to come at the stop with 1-minute interval. App user can stop receiving these notifications at any point of time through stop notification link on home page of app.

V. RESULTS

The most important part of the web interface is live tracking of the buses. The admin is able to view online and moving buses, student's stoppage points as well as offline buses if location is not received. The GPS data receiving time interval on server is approximately 10 seconds and accordingly buses are displayed on map. On the other hand, when the bus is within 1km distance from stoppage point, parents will start receiving notifications per minute. With this scenario, parents will exactly get idea about when to be present at the bus stop. The system works very smoothly when high speed internet is there on WiFi Hotspot and parent's mobile phone.

VI. CONCLUSION AND FUTURE WORK

The proposed system describes implementation of school bus fleet management. The main objective of the system is

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notifying exact location information of the bus to parents so that they will be present at the stop at accurate time. GPS, MCU and WiFi with android application are all successfully integrated to develop the system. The system is eventually a solution to ease the worries of parents regarding school bus transport of their children. Also, the system has helped school transport authorities by increasing the efficiency of managing school buses. For the future works the focus will be on making hardware and software design more intelligent for fleet monitoring and controlling as well as adding more facilities in capturing student's data.

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