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GPS Based Location Monitoring System with Geo-Fencing Capabilities

[1]Reshma Thube, [2] Akshada Thube,[3] Prajwal Kute,[4]Prof. N. S. Kothari
[1]Student, [2]Student, [3]Student, [4]Assistant professor
Department of Electronics and Telecommunication Engineering.
Samarth Group of Institutions College of Engineering, Belhe, Pune, India

Abstract: *This paper presents a study on GPS Based Location Monitoring System with Geo-fencing Capabilities. This system provided a high- security system that prevents vehicles from being stolen. It also issued an alert to the user based on the boundary of the location by using the Internet of Things (IoT). In this study, the system could easily monitor and track the location of the vehicle and was able to issue an alert when the vehicle exited the geofence area. This system was separated into two parts which were the hardware and software. The hardware parts were the ESP8266 NodeMCU and GPS module while Google Maps and IoT platform were the software parts. The admin could monitor the vehicle via the computer, and the notification alert was sent to the registered email of the admin when the vehicle exited or entered the geofence area. The prototype system was tested by moving the vehicle around the geofence area. The results showed the correct location of the vehicle and email notification alert when it exited or entered the boundaries. The location accuracy of about 95% compared to the real map on the mobile phone.*

Index Terms - GPS Location Monitoring; Geo-fencing; Internet of Things; vehicle tracking.

I. INTRODUCTION

Security systems and navigators have always been a requirement of a human's life. The developments of advanced electronics have brought revolutionary changes in these fields. Equipment theft is a severe problem in many industries including transportation and construction, especially for more significant businesses [1]. There is no solution in monitoring the movement of the vehicle, and we do not know the current condition and position of the vehicles. The GPS - based vehicle tracking system is one of the most obvious ways to keep track of the vehicles. The Global Positioning System (GPS) is a system based on Global Navigation Satellite System (GNSS) that provides reliable location and time information at all times in any weather condition on earth [2]. We want to solve the location tracking problem by using GPS based monitoring system with a geo-fencing capability to track the vehicle. This system comprised of a few major components which combined satellite communication components to communicate the location of the vehicle to a remote user. Geo-fencing enabled remote monitoring of geographic areas surrounded by a virtual fence (geo-fence), and automatic detections when it tracked mobile objects that entered or exited these areas [3]. Geo-fence apps and tools monitored the devices or other physical objects that entered or exited the established geo-fenced area and provided administrators with alerts when there was a change in the status of the device [4].

II. RELATED WORK

In the recent decade, Vehicles tracking, and navigation are becoming the most important requirements of the people [5]. The GPS device globally used for the tracking and navigation purpose, like military, civil, farming and transportation. The easily and continuously tracked by used web services, RFID and GPS. The GPS data is accumulated by a mobile application. This application sends data location to a central server named EPCIS Gateway. The creators displayed a scenario in which a vehicle is prepared with a mobile device that has GPRS and GPS recipients. Hence, the application can communicate with the EPCIS Gateway to transmit location information and business context data. This data was put away in the database by EPCIS Gateway and accessible through web administrations so that other applications can get to and utilize this data for various purposes proposed in [6]. A hybrid model for tracking and tracing by used GPS and wireless sensor networks to get the vehicle and cargo positions. This system architecture consisted from three components: Firstly, a Hybrid Network Infrastructure integrated technologies GPS, Wi-Fi, RFID and ZigBee to perform the entities tracking, while GSM/3G, Wi-Fi and ZigBee were used for communication between the components. Secondly, Intelligent Monitoring Devices to motion detection, RFIDs and communication through ZigBee networks. Lastly, the Central Server provided services so that different logistics applications are developed proposed in [7]. However, according to [8] the Hybrid model did not display how the area data was modeled. So, it isn't conceivable to know how the data was spoken to perform a persistent following. a realtime tracking system that provides accurate localization of the tracked vehicle with low cost, used the GM862 cellular quad band module for implementation. A monitoring server and a graphical user interface on a website are also developed using Microsoft SQL Server 2003 and ASP.net to view the proper location of a vehicle on a specific map.

The paper also provides information regarding the vehicle status such as speed and mileage proposed in [9]. Some of the studies used Geofencing technology that allows monitoring location of specific objects' in a specified area [10]– [13]. There are many applications of this technology in e.g marketing (messages sent to possible clients, if are in a specific distance from a shop), fleet or asset management (alerts of route or placement changes) [14]. The basic concept is that for a specified set of regions, a geofencing system tracks user location and triggers events when entering or leaving any of given area. The regions can have any shape, but usually, only circular geofences are implemented. Geofencing is as accurate as location accuracy provided by used sensors, either build in the mobile device or connected externally. The location is usually determined using a GPS receiver, but Wi-Fi network-based location or RadioFrequency Identification (RFID) can be also used for this purpose. In this study, we proposed a GPS Based Location Monitoring System with Geo-fencing Capabilities to provide an efficient location of the vehicle on the map by integrating several communication technologies consisting of the hardware and software system. Besides, this system would make it easy for the user or administrator to monitor the vehicle and achieved high accuracy of positioning and navigating within 10 m distance.

III. VEHICLE SECURITY PROBLEM

The rate of vehicle theft is very high all over the world, and the situation is even worse in developing countries. Therefore, protection of vehicles with an intelligent, reliable, effective and economical system is significant. The existing technologies for vehicle security have some limitations including high false alarm rate, easy deactivation, and high cost. The safety of the vehicle is exceptionally essential. Therefore, the need for security and monitoring is developed. One of the various problems that we face, for example in critical condition (when the vehicle is stolen), is that one is confused about what he or she needs to do [15].

IV. SYSTEM DESIGN

The system design consisted of the hardware and software components. The hardware components were ESP8266 NodeMCU, a GPS module, and a WiFi receiver. the software components were IoT cloud used by the admin to monitor the location of the vehicles with the implementation of geo-fencing capabilities. The IoT cloud also provided a platform to the admin to access the information and store the data on this platform. The data collected by the GPS was transmitted to this platform through the NodeMCU signal from the GPS. Then the NodeMCU sent a signal to Ubidots cloud containing the latitude and longitude format via "Ubidots Token" that insert to the source code. The data was continuously taken from the NEO 6M GPS Module which was connected to the ESP8266 NodeMCU. The Ubidots provided the map widget to view the location that interfaced with Google Maps. The Ubidots platform showed the latitude and longitude of the device. After that, geofencing was implemented on Google Maps by drawing the area boundaries of the specific area to monitor the vehicle. Usually, the admin or developer can define the bounding of the geo-fence area. So, in this system, a vehicle was determined to be at a particular location if it was within this geofence.

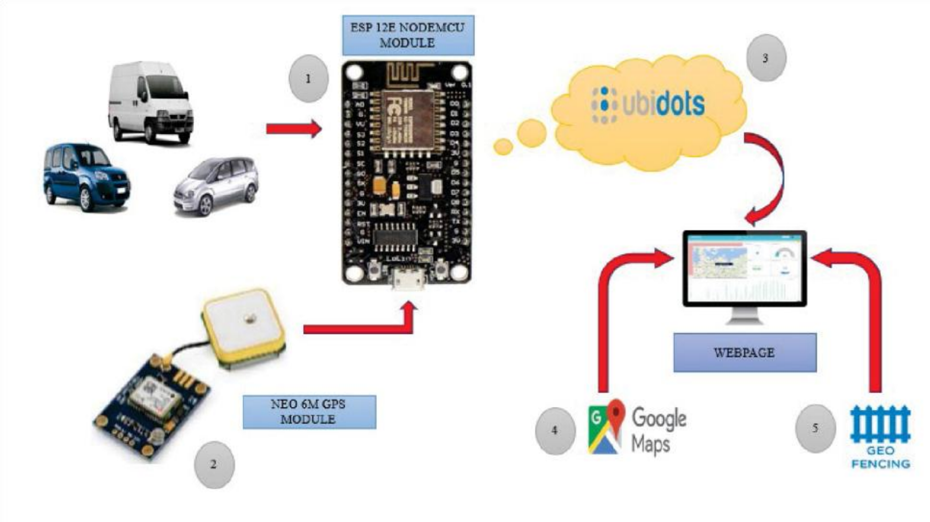

FIGURE 1. System architecture

V. GPS CIRCUIT DESIGN

The NodeMCU used only four pinouts to connect to the GPS module. The pins VCC 3.3V, GND, D6 and D7. D6 and D7 were connected to the Tx and Rx of the GPS module. D6 received the signal from the GPS while D7 transmitted the signal to the NodeMCU. This GPS module worked excellently with NodeMCU to get an accurate signal and send data to the cloud server. This combination of circuit produced a stable signal with precise latitude and longitude.

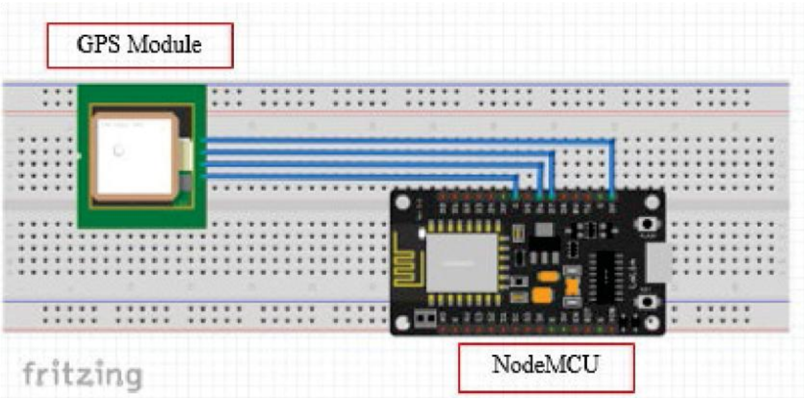

FIGURE 2. GPS circuit design

VI. RESULTS AND DISCUSSION

The system has been tested for its reliability, functionality, stability, and accuracy. The results were separated into two parts which were the hardware and software. The hardware components used were the ESP8266 NodeMCU module and GPS module. For the software, Ubidots IoT cloud was used as a platform for this system. The hardware was tested for its efficiency, functionality, and compatibility with the software. The whole system was then tested for the stability of the hardware and software interfacing with one another. The system was tested in real-time to make sure that the functionality of the hardware and software was in a stable condition. The following pictures show the final implemented circuit which represents our system design.

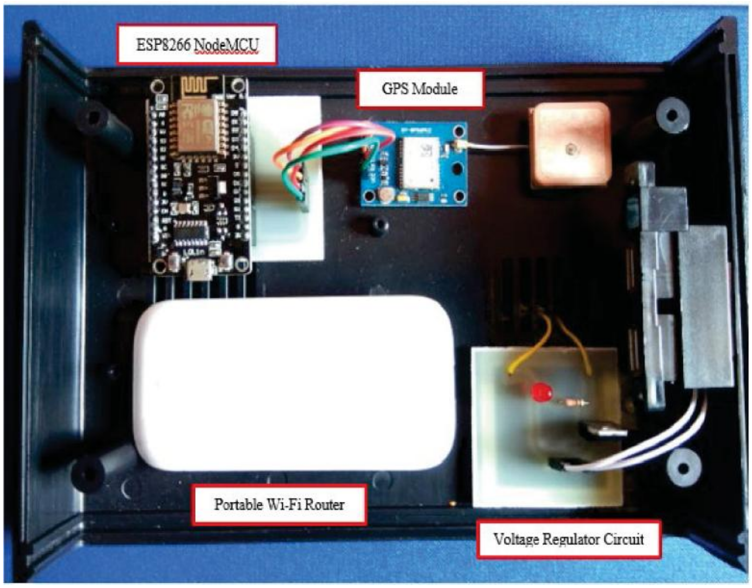

FIGURE 3. Main system design

In the early stages of the project, a combination of NodeMCU and GPS module was tested in order to access their compatibility with one another. Each of the devices had its function, and it needed to verify if the combination had been working efficiently. Completed code with the GPS library was compiled and uploaded to the NodeMCU by using Arduino IDE. Once the codes were uploaded, NodeMCU initialized the comparison to the GPS module. To ensure if the GPS module had been initialized with the satellites, the LED on the module blinked every two seconds and continuously received the signal. After the GPS module received the signal, it transferred the signal to the NodeMCU in Serially. In the serial monitor, the latitude and longitude appeared, and it showed that the GPS had been successfully verified by the NodeMCU. Geofencing was tested for its functionality and efficiency in real time situation. The testing was done around the UTHM area based on real scenarios at different locations to analyze the data. The testing was based on the real-time situation involving the movement of the car within the area of the geofence. Figure 4 represents the first page of the Ubidots IoT platform consisting of two parts which are the username and the password for security purposes.

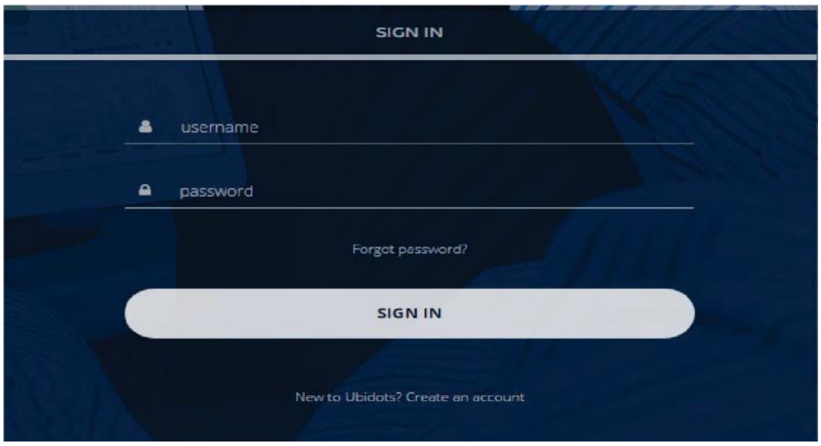

FIGURE 4. The first page of the Ubidots IoT platform

Figure 5 shows the dashboard in Ubidots Platform that consists of few parts which are the information of the vehicle with its current location on Google Maps as well as the time and date.

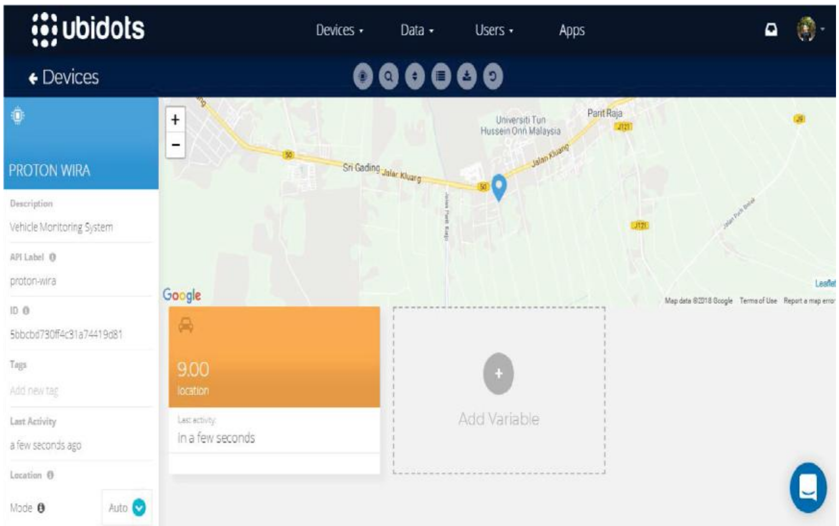

FIGURE 5. Ubidots dashboard

The test commenced at the UTHM library as the first location before moving to another place. The location was within the geofence area that was created in the Ubidots platform. It consisted of two scenarios in different areas to show the accurate result of the Geo-fencing capabilities. Figure 6 shows the location of the car where the test commenced at the UTHM library. The map was taken by the Ubidots platform using the Google Map. The position of the vehicle was at the latitude of 1.85778 and the longitude of 103.082634. When the car exited the boundaries, Geo-fencing was triggered, and the system sent an email notification alert to the user. Figure 7 shows the location of the car when the geofence was triggered. The location was out of the geofence. The position of the vehicle was at the latitude of 1.8526 and the longitude of 103.0868. The email is shown in Fig. 8 which contains the last location of the car when it exited the geofence.

FIGURE 6. Location of the car

FIGURE 7. Location of the car out of geofence

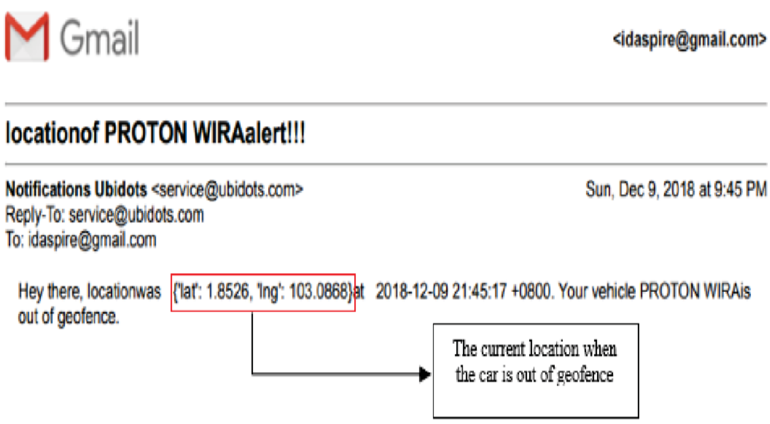

FIGURE 8. Email notification alert from Ubidots

VII. CONCLUSION

The proposed GPS Based Location Monitoring System with Geo-fencing Capabilities provided an efficient location of the vehicle on the map by integrating several communication technologies consisting of the hardware and software system. The position of the vehicle was displayed on Google Maps using the Ubidots platform. The system could help to reduce the problem of vehicle theft and provide an accurate tracking system.

This system has been tested, and it showed excellent results that can be used for positioning and navigating the vehicle with an accuracy of 10 m. Geo-fencing showed accurate results of maximum security that controlled the movement of the vehicle when it entered or exited the virtual area. Besides, this system would make it easy for the user or administrator to monitor the vehicle. The GPS Based Location Monitoring System was built successfully. However, this system could be made more robust by using a more accurate GPS unit. The results of this project showed that the developed system provided many advantages and benefits to the owner's vehicle especially to the university which has a lot of vehicles to be monitored.

Finally, this project has proven its efficiency because it provided a location accuracy of about 95% compared to the real-map on the mobile phone. The project has been successfully developed for a vehicle monitoring system with Geo-fencing capabilities. The designed system is accurate, flexible and customizable for customer needs.

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