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IoT-based anti-theft and remote controlling system for automobiles

[1]Hemant Kuruva, [2]Girish Shiva Prasanna Raju S.

[1,2]Student, IV B.Tech., Department of ECE, G. Pullaiah College of Engineering and Technology, Kurnool, AP, India

***Abstract*—As the vehicle population is growing exponentially, so is the number of thefts associated with vehicles and in most cases, the owner could retrieve his/her vehicle had he known its location. With more than one billion vehicles in use in the world, a smart anti-theft system backed by Internet of Things technology is always a boon to the owners. With more tech enthusiasts exploring new depths of possible applications of this technology, using it for an anti-theft smartphone application is always an innovative approach and acts as a saviour of the vehicle. The main goal of the proposed work is to develop a new technique to locate, track, and remotely control a lost vehicle through a smartphone application, which is further used to switch the ignition on/off and also scream the siren to alert the surroundings. Apart from these functions, the smartphone application features a virtual LCD which displays location coordinates and the speed of the vehicle.**

***Index Terms*—Amazon Web Services, Anti-theft, Electron 3G, Google Maps, GPS, IoT, Remote switching**

I. Introduction

GPS was developed by the US Navy in 1960 for naval navigation. Perceiving the potential of GPS, the US Navy stretched its usage to mainstream navigation applications in the 1970s. Since then, this technology has seen a steep increase in its usage especially in the field of Geopositioning. The degree of reliance on this technology has come to a point where technology giants like Google and Apple Inc. are competing on a public arena to provide users with the best of the navigation services. In developed markets, the penetration of GPS devices is so much that one can hardly find a vehicle not equipped with it. One such application that has been derived from GPS navigation is GPS tracking system which is more a safety feature than a navigation assistant.

A GPS tracking unit is an anti-theft device that uses Global Positioning System to find the location of an object to which it is attached and logs the position of it at regular intervals. A GPS tracking system uses 'Satnav', which is a system that uses navigation satellites to provide autonomous geo-spatial positioning. Satnav employs a wide range of satellites which use microwaves to transmit the information regarding the location, speed, direction and time. The recorded location data can either be preserved in the tracker, or it can be transferred to a database on a computer through the satellite modem embedded in the tracker. It provides the user, the coordinates of a location which can be used to realize a map pointing at the unit's geolocation.

These anti-theft systems have been here around for a while with basic functionalities of tracking the vehicle by geospatial coordinates. On a closer look, there isn't a significant difference between navigation devices and anti-theft systems for vehicles as much of the primary functionality of both these systems is accomplished by the employment of GPS. Internet of Things being a smart technology and the latest in the town, it can be applied in anti-theft systems for vehicles and further the progress in making anti-theft systems more fool proof and reliable.

In the proposed work, the authors use an IoT device which retrieves the location coordinates obtained from the GPS module connected to it and transfers them to Amazon Web Services for further processing and storage. This data is further processed using Google Maps APIs for real-time display of the vehicle's location. The authors also develop a smartphone application which can be used to switch ignition of the vehicle on and off and also scream the siren to alert the surroundings. Apart from these features, the application also has a virtual LCD which would display the location and speed of the vehicle in case of theft.

Electron 3G microcontroller board, based on STM32F205 ARM Cortex M3 and U-Blox SARA cellular modem is used in this proposed work along with MTK3339 GPS module to retrieve the location data, and LIS3DH 3-axis accelerometer to detect the accelerations and decelerations of the vehicle. The location data is stored and processed on Amazon Web Services and displayed effectively on Google Maps using Google Maps APIs.

A. Features of this system

1. Live tracking of the vehicle on Google Maps with high accuracy.
2. Switching the ignition of the vehicle on and off remotely using smartphone application.
3. Switching the siren on and off using a smartphone application.
4. Showing colour changing paths on the map based on the vehicle's speed and acceleration.

II. Literature review

Vehicles have been in use since time immemorial and having said that, there had been a gradual development in making them safer and more secure. This quest was first quenched

when Joey B. Adkins invented 'Electronic key anti-theft system' in 1984. This system has a circuit which can restrict unauthorized access and hence successfully avert an unwarranted invasion. Later on, the automotive technology leaped ahead and more advanced systems have been designed. Further development has seen the introduction of GSM into automobile anti-theft arena. G. S. Prasanth Ganesh, B. Balaji and T. A. SrinivasaVaradhan have described a new way to track the lost vehicle by tracing the nearest GSM towers as in [1]. Vinoth Kumar Sadagopan, UpendranRajendran and Albert Joe Francis have devised a way to detect an unauthorized access into the car by requesting a unique code and failure in providing it would disable the fuel injection of the car, lock the car and send an SMS alert to the owner as demonstrated in [2]. As the technology developed, so did thoughts, and P. Bagavathy, R. Dhaya and T. Devakumar came up with an innovative approach to detect an unauthorized access to the automobile using Facial recognition and alerting the owner through SMS as in [3]. Reference [4] shows two crucial technologies, i.e. GPS and GSM, integrated into a single anti-theft system by Jian-Ming H,Jie Li and Guang-Hui Li. They used a C8051F120 development kit and a vibration sensor to alert the owner by using SMS through GSM and location data obtained from GPS. Anti-theft systems were further enhanced by Wan Lili and Chen Tiejun as they proposed a new method of equipping an anti-theft system with speed sensor and vibration sensor apart from GSM module as shown in [5]. Internet of Things being a recent trend, this was first proposed to be embedded into an anti-theft system by Zhigang Liu, Anqi Zhang and Shaojun Li as in demonstrated in [6]. They described that an intrusion could be detected by using PIR sensors mounted inside the car and an alert can be sent along with location information to the owner through an Android application.

Regardless of a substantial advancement in anti-theft systems based on GPS and GSM technologies, Internet of Things being latest in the market couldn't penetrate into this area much deeper. The proposed work fulfills the lack of ability to control the ignition of the engine and to scream the siren through an Android application. Apart from this, the smartphone application also features a virtual LCD which can provide live updates of the whereabouts and the speed at which the stolen vehicle is traveling, to the user live. The proposed work also accomplishes the map visualization of stolen vehicle on Google Maps.

III. Components and Hardware Implementation

Fig. 1: Block diagram of the primary circuit of the IoT-based anti-theft

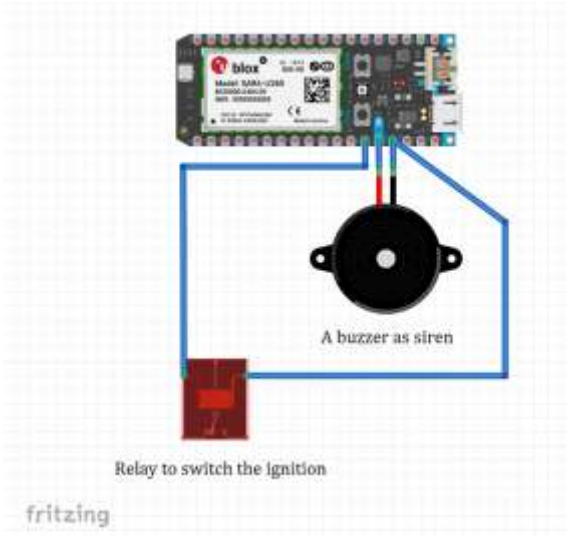

Fig. 2: Schematic diagram of secondary circuit consisting of a buzzer and relay connected to Electron

Fig. 1 shows the block diagram of primary connection and Fig. 2 shows the schematic diagram of secondary connection which incorporates a buzzer and a relay

A. *Major blocks of the model*

1. Particle Electron based on STM32F205 ARM Cortex M3.
2. MTK3339 GPS Module
3. LIS3DH 3-axis accelerometer
4. Amazon web services
5. Google Maps APIs
6. Switching Ignition and Siren

B. *Components' details*

1. Particle Electron 3G

Fig. 3: Particle Electron 3G

Particle Electron is a small scale development kit for developing 3G cellular-connected electronics projects. It comes with a proprietary SIM card which is compatible in 100 countries, and ships bundled with a 1 MB per month data plan for three months. The Electron kit comes with Particle's development tools and cloud platform which are used to manage and update the IoT devices which the developers create using Electron.

It is based on STM32F205 ARM Cortex M3 microcontroller, equipped with 1MB Flash memory and 128KB of RAM. Its cellular modem is based on U-Blox SARA U-series. On board, it has 36 pins, of which 28 are GPIO pins (D0 – D13 &

A0 – A13) and the other being TX/RX, 2GNDs, VIN, VBAT, WKP, 3V3, RST.

Dimensions of the board are 2.0" x 0.8" x 0.3" as stated in [7].

2. MTK3339 GPS module

Fig. 4: MTK3339 based GPS module from Adafruittaken from [8].

MTK3339 chipset is a high-quality, low-power GPS module that can track up to 22 satellites on 66 channels. It has a top-notch receiver with a very high sensitivity (-165 dB tracking) and a built-in antenna. It can perform a maximum of 10 location updates per second for high speed, high sensitivity logging, and tracking. Power usage, at 20mA during navigation, is considered to be extremely low for a GPS module of that efficiency.

Two exceptional features about MTK3339 is the external antenna functionality and the built-in data-logging capability. The module has a standard ceramic patch antenna that helps it in attaining a high sensitivity of -165 dB, yet, when a bigger antenna is needed, an external antenna can be attached to the ANT pad. The module automatically detects the active antenna and switches over to the external antenna swiftly.

The other great feature of MTK3339 is the built-in data logging capability. Equipped with a microcontroller inside, the module, along with some empty FLASH memory and the newest firmware allows sending commands to perform internal logging to the FLASH. The only thing that needs to be done is to have a microcontroller send the "Start Logging" command.

After sending 'Start Logging' command to the microcontroller, the module goes into sleep mode and does not wake up to transmit any information to GPS to keep power consumption in check. The module logs longitude, latitude, time, date and height data every 15 seconds. The internal FLASH has enough memory to store about 16 hours of location data, and it automatically appends data so as to prevent accidental data loss in case of power failure. As the functioning is hard-coded into the module, there is no possibility of changing what is logged and how often it is logged and yet the existent arrangement covers many of the basic GPS data logging requirements. Information retrieved from [9].

3. LIS3DH 3-axis accelerometer

Fig. 5. LIS3DH 3-axis accelerometer taken from [10].

The LIS3DH is an ultra-low power high performance, 3-axis linear accelerometer which falls under 'nano' family. It is capable of communicating over digital I2C/SPI serial interface. The device possesses ultra-low power operational modes which facilitate power saving.

The LIS3DH has full scales of ±2g/±4g/±8g/±16g which can be dynamically selected by the user. It is capable of recording accelerations with data rates ranging from 1 Hz to 5 kHz. To check the proper functioning of the sensor in real-time applications, LIS3DH comes with self-test capability. The end user has the liberty to program its threshold and timing of interrupt generators.

The LIS3DH comes with an integrated 32-level FIFO buffer which gives the user the ability to store data and eventually reduce the intervention caused by the host processor. It is fabricated in land grid array (LGA) package and is rugged enough to withstand temperatures ranging from -40 °C to +85 °C.

4. Amazon Web Services

Amazon Web Services is a cloud services platform, offering, cloud storage, content delivery and many other services to help businesses grow. AWS cloud products and solutions can be used to build highly advanced applications and at the same time increase the adaptability, scalability, and reliability.

It has three modules:

i. AWS API Gateway

API Gateway creates API which consists of a set of resources and methods. A resource is a logical entity that can be accessed through a resource path using the API. A resource can have one or more operations that are defined by appropriate HTTP verbs such as GET, POST, and DELETE. A combination of a resource path and an operation identify a method in the API. Each method corresponds to a REST API request submitted by the user of the API, and the corresponding response returned to the user. API Gateway integrates the method with a targeted back end by mapping the method request to an integration request acceptable by the

back end and then mapping the integration response from the back end to the method response returned to the user.

ii. AWS Lambda

AWS Lambda is a computing service where a developer can upload the code, and the service can run the code on the developer's behalf using AWS infrastructure. After the developer uploads the code and creates a Lambda function, AWS Lambda takes care of provisioning and managing the servers that he/she uses to run the code.

iii. AWS DynamoDB

Amazon DynamoDB is a proprietary NoSQL database service that provides high performance with outstanding scalability at the same time retaining its reliability. DynamoDB grants the user the ease of offloading the administrative bottlenecks of managing and scaling a distributed database so that the user can feel the peace of mind in the provision of hardware, conFig.uration, replication, software patching and cluster scaling.

DynamoDB can be used to create database tables that can store and recover any amount of data. DynamoDB has the capability to serve any level of traffic with no hiccups. Tables' throughput capacity can be scaled up or down without performance degradation, and AWS Management Console can be used to monitor the utilization of resources and performance data.

5. Google Maps APIs

Google Maps APIs let the user transform maps according to his/her requirements. They are sets of methods and tools which are used for building software applications. Apart from customizing the maps these tools can be used to embed Google Maps onto webpages.

6. Switching Ignition and Siren

Digital pins available on the Particle Electron are used to switch the Ignition and siren. A customized application is used to control these pins over the cloud. Regarding connection, Pin D6 is connected to a relay which is used to switch the ignition of the vehicle in which the equipment is installed, and Pin D7 is connected to a buzzer which acts as an emergency siren to alert the surroundings of the vehicle.

Fig. 2 demonstrates the connection of relay and buzzer to the Electron.

IV. Software Development

A. *Setting up Particle Electron*

The Electron is registered with Particle's cloud servers. The process is relatively easy. This can be done online, using a 3G connection hence no hurdles would be encountered in connecting the Electron to the local wireless network. A browser is needed with a connection to the internet and the kit plugged into any powered USB connector.

Use the Particle command line interface to connect, program, and interact with Electron over USB from a computer running on Windows. Install Node.js and Particle drivers on the PC. Open a command window and type the following code to install particle CLI:

npm install -g particle-cli

Log into Particle Sign in and complete the setting up process.

B. *Compiling and Uploading firmware*

Compile the firmware and use either USB or OTA (Over The Air) to upload it to the Electron. Import the main code and all the necessary libraries into the IDE (integrated Development Environment, i.e. Particle Build or Particle Dev).

1. Open the .ino source code file into Particle Dev/ Particle Build.
2. Also, open AssetTracker.cpp and AssetTracker.h (gets Latitude and Longitude in degrees, separately).
3. Compile and flash in one of the following methods:
   i. Paste everything online into Particle Build > Select the electron > Click compile > Click flash
   ii. Open Particle Dev > Create new project folder> Copy all the three files into the project folder > Select the electron > Compile > Flash

C. *AWS and Google Maps APIs*

Set up Amazon Web Services and Google Maps with the source code.

1. AWS API Gateway receives the call from Particle with the data in the payload
2. AWS Lambda extracts and processes the data
3. AWS DynamoDB stores the data

D. *Creating application to control Ignition and siren*

Blynk is an environment which provides an interface to create customized applications to interact with IoT devices. Blynk application is available for both Android and iOS.

Install Blynk application on the device from the device's app market. Develop a new app to control Ignition and Siren and to display location and speed data. To do this, Click 'New Project' > Name the new project > Select 'Particle Electron' as the Hardware Model > Select 'Email auth token' > Click 'Create'.

Two buttons are added, mapped to D6 and D7 pins on the Particle and named as 'Ignition' and 'Siren'.

Authenticate the Blynk application using a unique authentication key specific to a project.

V. Results and Conclusions

Fig. 6 shows the screenshots of the application developed and Fig. 7 shows an example of a short trip visualized on Google Maps using the 'IoT based GPS tracker and remote controlling system for automobiles'.

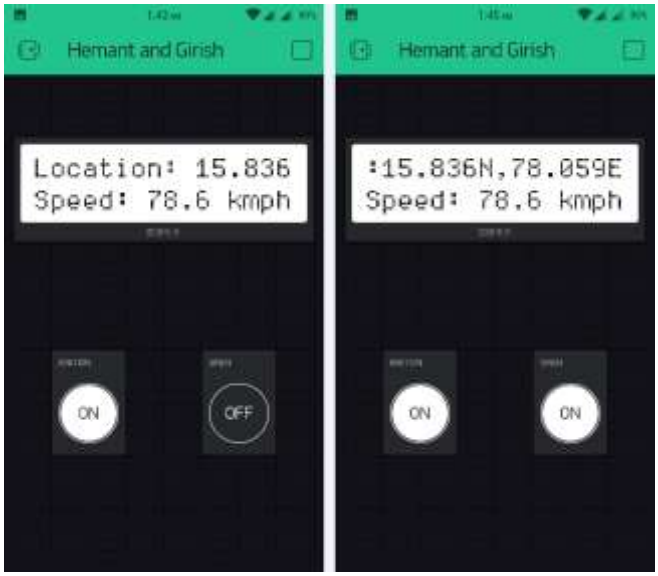

Fig. 6. A screenshot of the remote controlling smartphone application developed by the team

As it is very evident from the screenshots, there are two groups of software objects in the application i.e. virtual LCD and virtual buttons. The LCD provided in the smartphone application provides two kinds of data, one being location coordinates and the other being speed at which the vehicle is traveling. The first button provided in the application is used to toggle the ignition of the vehicle and the second is used to toggle the siren fit into the vehicle. As the ignition relay of the proposed circuit is connected in series with the main ignition switch, the robber cannot override the control of this smartphone application. And, as the siren is attached to the chassis of the vehicle, it's always a herculean task to dismantle in case the owner turns the siren on.

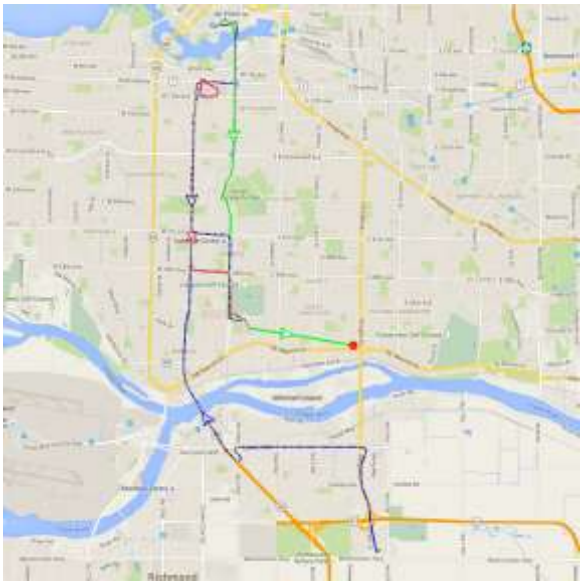

Fig. 7. Google Maps result obtained from a test run.

The proposed work developed a new technique to locate, track and control a stolen vehicle through a smartphone application. This innovation, which can track the stolen vehicle apart from remote controlling, made use of Google Maps APIs and the database service provided by Amazon Web Services. Being an IoT-based innovation, the proposed work also demonstrated how a smartphone application should be developed using Blynk libraries, to control remotely a lost vehicle, which can be used to switch the ignition on/off and also scream the siren to alert the surroundings. Apart from these functions, the smartphone application also features a virtual LCD which displays location coordinates and the speed at which the vehicle was traveling. With this system installed in the automobile, an unauthorized access can be easily traced in real time with accurate turn by turn directions on the map providing the user, the ability to control the stolen vehicle remotely. The proposed work ensures that the owner is always safe and secure about the vehicle and the belongings inside.

VI. Acknowledgment

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