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Microcontroller-Based Vehicle Tracking System Using GPS and GSM
Module: A Mini Review

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ABSTRACT

The level of poor economic situations in Nigeria has made people conscious of their vehicles, aged parents, younger ones and valuable belongings. Lots of car owners both personal and commercial are in fear of consistent increase in security challenges, excessive reports of vehicle stealing, kidnapping for ransom on the high ways on daily basis, as a result, are in constant search for efficient system to monitor their vehicle at any point in time. There are many systems that have been developed to reduce these problems by introduction of an effectual vehicle tracking system which is developed for tracking the movement and location of any device embedded vehicle at will, with the aid of microcontroller which employs IoT (Internet of Things) technologies to communicate with either Smartphone or personal computer. This paper reviews some existing works and explores in details to compare some of these systems, the technologies utilized, successes achieved, and gaps deserving further improvement in such systems.

Keywords: global positioning system (GPS), global system for mobile communication (GSM), radio frequency identification (RFID), microcontroller, automation, internet of things (IoT) and tracking system.

1.0 INTRODUCTION

Vehicle tracking systems were primarily used in shipping industry owing to the curiosity of people to monitor the where about of their belongings at any given time. Presently, with advancement in technology, automated vehicle tracking system finds application in different avenues to locate and display vehicle positions in real-time. Research revealed that vehicle tracking systems specifically are finding enhanced use in a series of smart transportation systems and implementations (Jien et al, 2004). Tracking systems are of vital use in the present world, owing to their usefulness in tracking, monitoring of stolen vehicles and various varying applications (Jainyang et al, 2008). The usefulness of tracking systems has drawn interest of researchers to tirelessly seeking the best approach in problem solving. This paper reviews relating carried out researches and extensively explores some different technical approaches adopted by distinct researchers in solving on-motion tracking related issues, identifying the successes achieved, gaps needed to cover and systems flaw.

2.0 LITERATURE SURVEY

GPS stands for Global Positioning System; it is used to detect the latitude and longitude of a

specific object position and its exact time. It provides this information anywhere on the earth (Patil et al, 2018).

GSM stands for Global System for Mobile Communication, developed by European Telecommunication Standards Institutes (ETSI). It describes the protocol for second Generation digital cellular networks (Shinde et al, 2017).

Vinita and Sukhdip 2020, explored the capabilities of IoT (Internet of Things), Challenges, applicability and opportunities in various fields not excluding its use in vehicle tracking systems. IoT is defined by Tulasi et al (2021) as the most known technology of the modern society used to transform physical objects into smart things improved with functions like decision making, sensing and computing.

Vehicle tracking systems are not only used for vehicle security or its whereabouts, it is also used in fleet management for profit gains. It aids in efficient scheduling or route planning to enable businesses cover huge job loads within a specified time (Patil, et al, 2018).

Niraj et al 2022, were able to efficiently develop a smart tracking system in a vehicle installed sensors that transmits the vehicle's information to a server using GPS, GSM, microcontroller etc.

The careful combination of GPS and GPRS by June and Nyein 2018, develop a consistent and real-time tracking system that is customizable, flexible and accurate for wide range of applications.

Nwukor (2020), develop a system with the capability to mobilize and demobilize a vehicle in real-time environment. A car owner can easily know the whereabouts of his car's location by just sending a command on his cellphone. This is achieved using GPS/GSM, microcontroller, crystal oscillator etc.

The increasing cases of vehicle hijack, petrol tanks diversion, vehicle theft, kidnapping and lots more inspired Peter et al 2018, to develop and implement a vehicle tracking system to mitigate these vices, which was achieved through the combination of GPS module, GSM modem, microcontroller etc.

That a client gets to know the situation and distance covered by its vehicle at any moment of time, Shraddha and Saideep 2021, designed and implemented a smart vehicle tracking system that employed GPS, GSM technologies with a microcontroller as the heart of the system. The system uses area administration method to process vehicle displacement and take up area covered and transmit the data to the client.

Following the desired need to protect and safeguard human lives and properties, Tulasi et al 2021, based on the principles of IoT, Digital Image Processing (DIP) and Artificial Intelligence (AI) proposed a Vehicular Safety Device (VSD). GPS and GSM modules were inculcated in the system design to provide real-time location to track and monitor vehicle movement. The system was efficiently applied for safeguarding human lives for a better future.

The importance of women safety and security, Hussain et al., (2016), developed a system capable of protecting women from harassment. This were possible using Radio Frequency Identification (RFID) and GPS, information received from RFID

tag is transmitted to a microcontroller, which then send the information through GSM modem to stored contacts and location is tracked through the GPS.

Deepa et al 2023, used ESP-32 microcontroller together with GPS, Wi-Fi, cloud, android application etc to design a tracking and speed warning device that could upload vehicle data to the clouds allowing certain predetermined decisions to be made.

Htwe and Hlaing (2019), used combination of Arduino UNO, GPS, GSM etc to develop and implement a vehicle tracking system to locate and monitor the whereabouts of the vehicle and be able to estimate its time of travel as well as other uses like anti-theft etc.

Chen et al., (2010), designed a vehicle tracking system that sends GPS input to a desired mobile/laptop through GSM module using mobile communication. Through this, the location of the vehicle can be tracked and monitored in real-time to ensure safety of the vehicle, travel time and covered distance.

Rodrigo et al (2013), proposed a prototype that could provide the exact position of a vehicle. The prototype model for vehicle location tracking is name SWTRACK. A distribution company uses the system to track the location of their respective vehicles, and sends an alarm message through the device to drivers that attempt to deviate the scheduled or planned route.

Abid and Ravi 2012, proposed a tracking unit that could be a tag and with a GSM module an information could be transmit to a remote user to determine the precise location of an object. This system consists of GPS and GSM module together with a microcontroller that is set up in the vehicle. Through SMS the precise location of the vehicle can be reported. The location of the vehicle can be monitored from anywhere using this system.

Next are four (4) detailed review of some selected microcontroller-based vehicle tracking systems.

The first detailed paper discussed is a system that was designed and implemented by SeokJu et al (2014), to provide features as follows:

- i. Reception of a vehicle's geographic positional coordinates and its assigned Identity (ID) from a device planted in the vehicle in real-time employing GPS module.
- ii. Transmission of received vehicle's location and ID information to a web server at a predetermined time interval using the GPRS/GSM module.
- iii. Designed database where tracked vehicle location information can be store for future reference.
- iv. A user with the aid of a developed smartphone application can access a vehicle's location from the database and monitor its movement on Google maps in real-time.

The first paper then discussed a vehicle tracking system developed using GPRS/GSM/GPS module and a coded smartphone application to give the exact location of a vehicle in real-time. The System track and monitor a vehicle with information received from a vehicle embedded device controlled by a microcontroller, gathered information when processed, automatically displays the vehicle location on Google map. The

methodology adopted involved a hardware and software design.

The hardware design includes: i) Atmega328 microcontroller which is the brain that controls the vehicle tracker system. The microcontroller is programmed, compiled and then saved in the microcontroller's flash memory. ii) GPS module, which is an acronym for Global Positioning System, it is used to provide information such as positional coordinates, time, speed and more, anywhere on Earth. In this work reviewed, it is adopted to serve as an in-vehicle device. iii) GSM/GPRS module, which stands for Global System for Mobile Communications/General Packet Radio Service, provides network connectivity between the in-vehicle device and a remote server for transmitting the vehicle's information.

Where the software design includes: a program code written to control the microcontroller, and then a free web hosting service utilized for a web server design using PHP, where tracked information is stored, and can be accessed at any time.

The Figure 1 shows the vehicle tracking system layout, which depicts how the project is implemented.

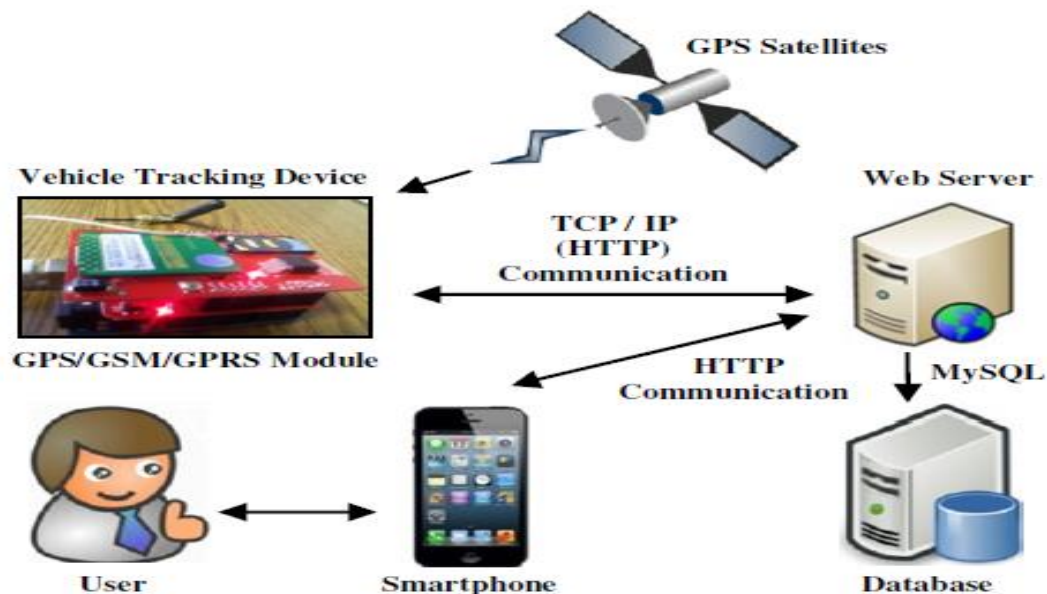
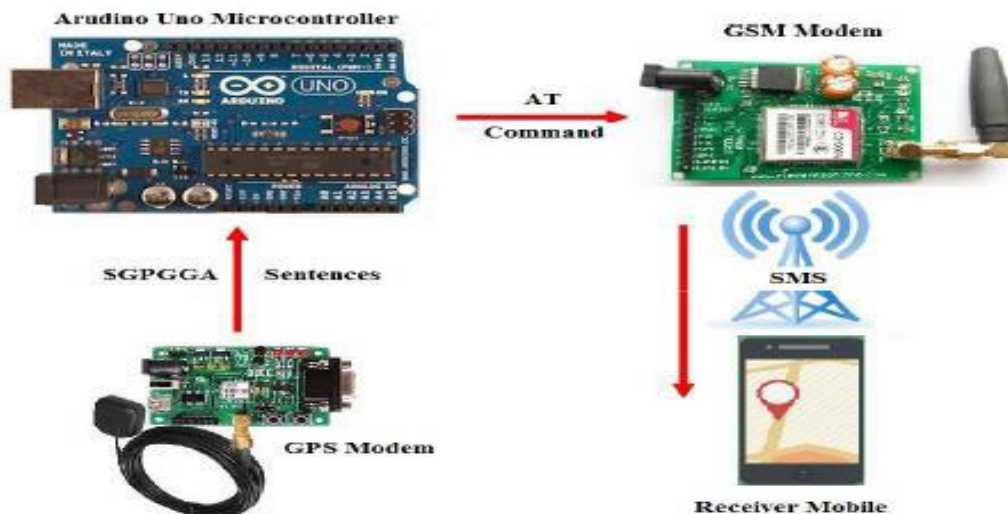


Figure 1: The Proposed Tracking System Layout (Source: SeokJu et al, 2014)

The GPS module receives coordinates in terms of latitude and longitude from the satellites. The microcontroller then uses the coordinates received by the GPS to generate location information of the vehicle. The vehicle's location information, together with its ID are transmitted to the web server with the aid of the GSM/GPRS network, where it is stored in the database using a GET method. The location of the vehicle can be viewed on a Google Map in the smartphone.

The paper then concludes that the developed vehicle tracker system was able to practically demonstrate its efficient performance in tracking a vehicle's location anywhere at any given time. This work is limited to vehicle tracking and monitoring.

Al-Balushi et al, 2017 research work termed, tracking and accident detection in automobiles using GPS and GSM technology is considered next. This system is developed as a result of poor reporting of the exact location of accident cases that sometimes claim precious human lives. The system can sense collision using vibration sensor, it also performs the following function; provides information of real-time navigation of vehicle location, update of geographical coordinates, vehicle fuel shutdown in case of theft, and sends google link in SMS (Short Message Service) for fast location tracking. The hardware design consists of power supply section, GSM, GPS, and ATmega328P microcontroller. The integration of these sub-systems makes up an in-vehicle device.

**Figure 2: Automatic GPS And GSM Based Tracker and Accident Detector System (Source: Al-Balushi et al, 2017)**

The microcontroller is the heart of the entire system. It receives and processes the positional coordinates from the GPS module. The GPS receiver receives and decides the movement message provided by the positional GPS satellite, processes the vehicle coordinates (which are in form of latitude and longitude), convert it to SMS by GSM communication controller, and send the SMS to monitoring center using GSM network. The block diagram of the in-vehicle device is as

seen in Figure 2. The microcontroller is controlled by a program stored in it through the host PC using USB Type B cable. However, it is important to note that ATmega328P microcontroller used in this work differ from the type used in the previous paper, in that it features a USB-to-serial converter.

The complete system is shown in Figure 3. It contains the entire connection of Arduino board together with GSM and GPS system.

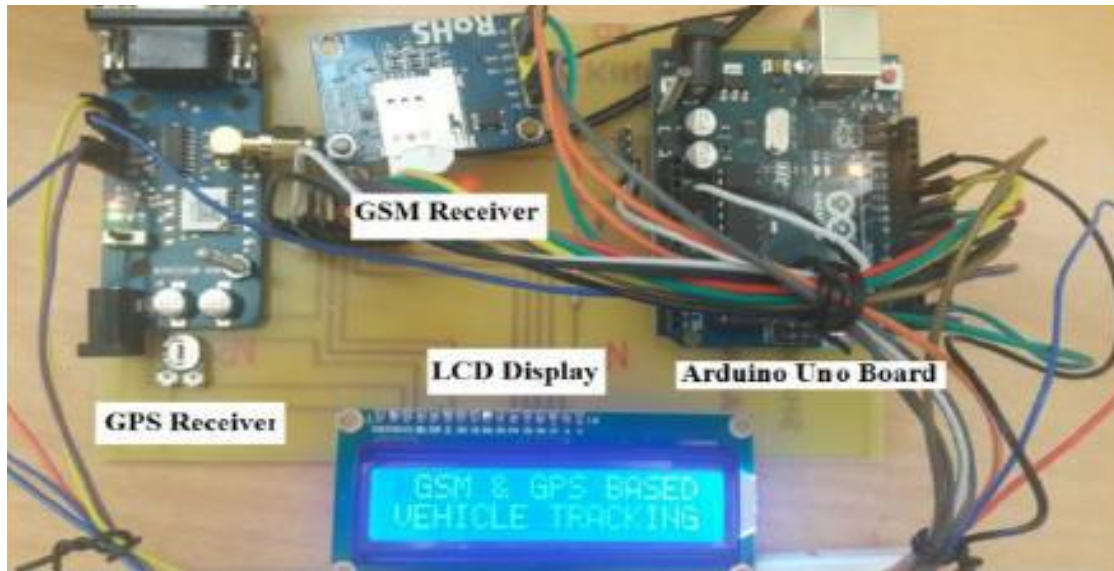


Figure 3: Powered Up Status Of The System (Source: Al-Balushi et al, 2017)

The paper in summary presented a successfully built vehicle tracking system, that could provide information of real-time navigation of vehicle position, allow user to control state of vehicle engine (ON/OFF), and aid in saving the lives of accident victims and vehicle recovery in case of theft. This device cannot capture faces of thief/thieves to aid their apprehension or faces of accident victims to indicate the severity of the impact. In addition, by introducing more accurate GPS unit the system could be made more robust.

Hlaing et al. (2019), developed a system of tracking vehicle using Arduino UNO that control the GPS receiver and the GSM module. The longitude and latitude coordinate of vehicle as generated by GSM and GPS provides information indicating the

location of vehicle as an output but only the data from National Marine Electronics Association NMEA is readable and displayed on LCD.

The methodology includes; block diagram design, system circuit design, program development and flow chart for system operation description. The hardware major components involve microcontroller, GPS receiver, GSM modem and LCD. The microcontroller is serially interfaced to the GSM modem and GPS receiver. The GPS receiver provides the vehicle's position in the form of latitude and longitude, the GSM modem is then used to send these data on request. The microcontroller oversees these processes. Figure 4 illustrates the implementation of the GPS and GSM based vehicle tracking system.

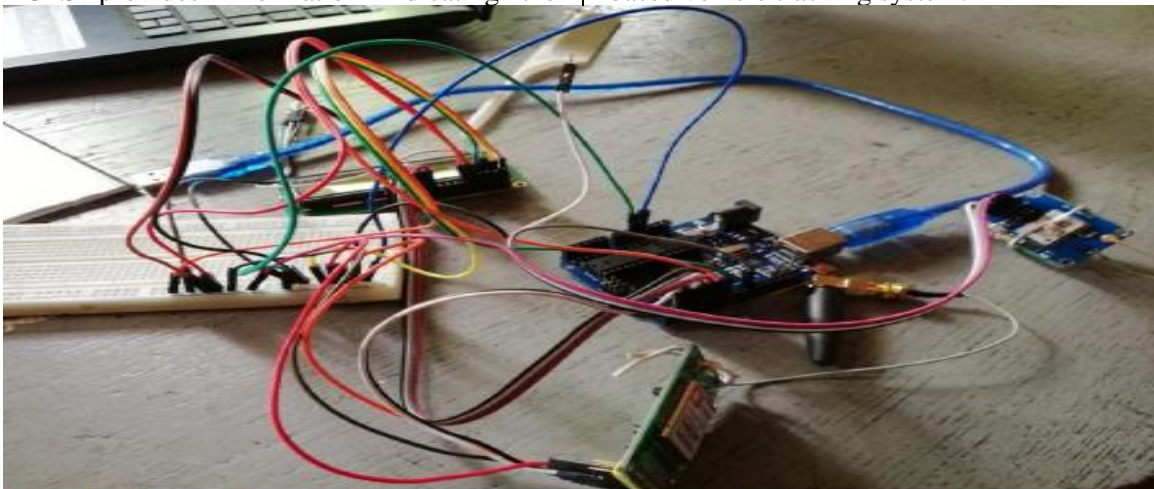


Figure 4: GPS And GSM Based Vehicle Tracking System Design And Implementation (Source: Hlaing and Naing, 2019).

The paper then concludes that the designed vehicle tracker system which is simple and cost effective, is working optimally, and could be upgraded without necessarily rebuilding from the scratch. The system is limited to vehicle tracking.

The fourth paper discussed is a work done by Maduka et al (2020), they developed a microcontroller-based tricycle tracker system using GPS and GSM modules. The aim of the work is to design and implement a tracking system that monitors the operation of tricycles to ascertain its daily operation and levy payment, to prevent levy evaders and thereby increase revenue generation for the government. The work is almost the same with the previous discussed papers, but here it is purposely for tracking daily operation of tricycle (keke) in order to generate income to the government by preventing intent levy evaders, this was achieved using triangulation method. The most important component that differentiate this system and others is triangulation method which is usually used in cellular communications to track the

geographical position of a mobile target. To evaluate the distance (d) travelled by a tricycle within a geofenced environment of length (l), this formular is applied.

$$d = l \frac{\sin \alpha \times \sin \beta}{\sin(\alpha + \beta)} \dots \dots \dots (i)$$

Applying the coordinates of existing communication masts owned by network providers on the Google satellite, the distances separating three (3) masts can be calculated. The tracked target embedded with tracker device is detected using Region of Interest (RoT) with three masts by aid of GPS information. The detected RoT by the masts is applied by approximated radio maps algorithms, to evaluate the various distances, the values a server sum to triangulate the precise location of the tricycle (Ashkenazi and Ben-Moshe, 2005). These processes were achieved using a set of coded instructions run in the IoT device. Figure 3 depicts the triangulation process.

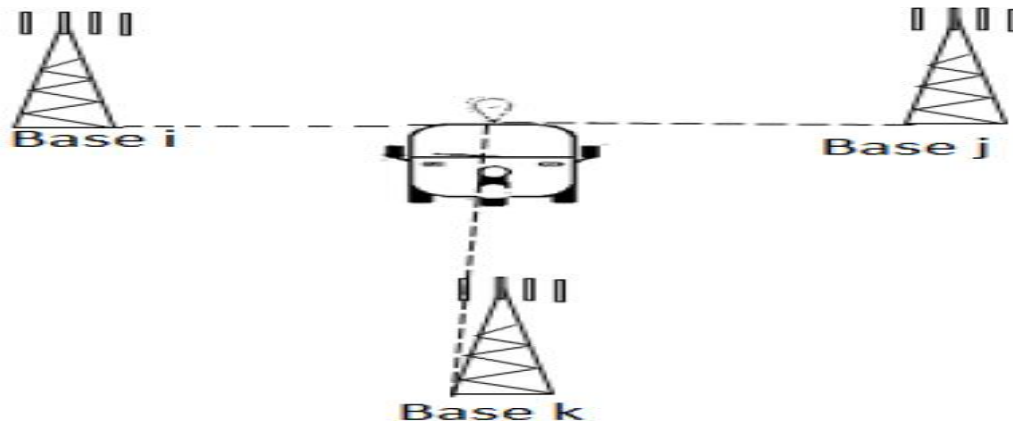


Figure 5: Triangulation Location Of Tricycle (Source: Maduka et al, 2020)

The methodology adopted include the design of a tracker circuit and development of an android application that runs on a smart phone. The tracker device embedded in the tricycle consists of a microcontroller (M2), NPN transistor (Q5), GSM/GPS module (G2), relay (RL1) and other components. The microcontroller is the brain of the overall system, such that it assess and processes all incoming and outgoing information, where the GSM/GPS is a transceiver that receives and send data. The tracker circuit is as shown in Figure 4.

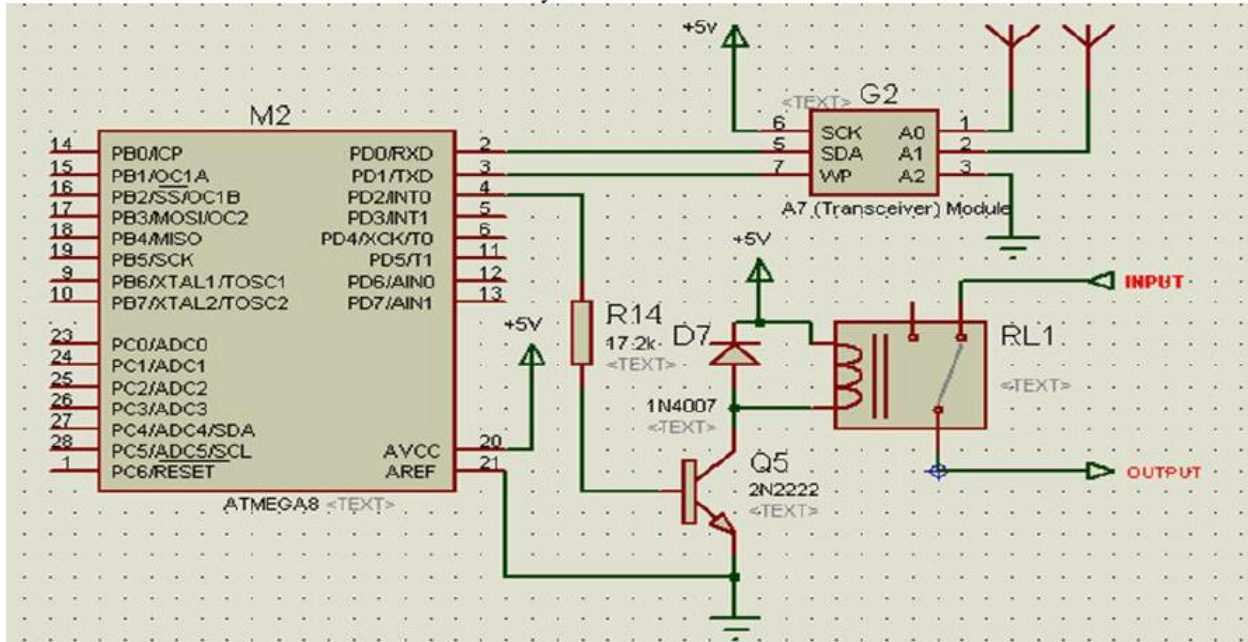


Figure 6: Tricycle tracker circuit diagram (Source: Maduka et al, 2020)

The microcontroller is programmed to transmit signal to the relay through the NPN transistor to turn off the engine of a tricycle that has covered the required distance to pay the day's operational levy and is yet to do so. This entire process is controlled using the developed application installed in an android smart phone.

The paper then concludes that the designed microcontroller-based tracker device is implemented, and will help in minimizing revenue leakages intrinsic in the process of revenue collection, thereby increasing Government revenue generation. Programmed application developed in this work can only run in an android smart phone. This work can be extended to include enrollment of private vehicle operators for yearly vehicle registration and papers renewals to reduce high cost of maintenance and manual record system. It can also be widened to integrate and merge miniaturized cameras, speed regulation sensors, crime detectors and other applicable devices to help check, monitor, control and reduce to minimum other pending fraud and crime.

3.0 INFERENCES

Having done an in-depth literature survey of four (4) papers, one can have an overview of what each system can do, each's limitation, and what more

needed to be done. The fact that technology is growing rapidly is an advantage to maximize to make life more easier and worth living by building optimal systems.

4.0 CONCLUSION AND FUTURE SCOPE

This paper has succeeded in analyzing some recent microcontroller, GSM and GPS based vehicle tracker systems and to predict their applicability in real-time. Therefore, it is recommended to researchers to take this review as a base path to improve the systems discussed for better performance, efficacy, cost affordability and system miniaturization.

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