Advances in Wireless Communications and Networks
2016; 2(1): 1-10
http://www.sciencepublishinggroup.com/j/awcn
doi: 10.11648/j.awcn.20160201.11

Use of RFID Technology as a Reporting Mechanism in Vehicle Tracking System

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To cite this article:
Mamudu Hamidu. Use of RFID Technology as a Reporting Mechanism in Vehicle Tracking System. *Advances in Wireless Communications and Networks*. Vol. 2, No. 1, 2016, pp. 1-10. doi: 10.11648/j.awcn.20160201.11

Received: September 4, 2016; **Accepted**: November 4, 2016; **Published**: December 5, 2016

Abstract: The integrated vehicle tracking research has been on the rise as both public and private sectors use the facilities in acquiring real time management information to enhance their business processes. This is predominantly used for monitoring and tracking but may not be able to report incidents. The research proposed a design to effectively communicate from the vehicle any incident which may happen on the highway. In order to achieve this, the design involved the combined wireless technology using Radio Frequency Identification (RFID), Global System for mobile Communication (GSM), and Global Position Satellite (GPS). The design is based on the use of RFID as a communication tool from the driver of a vehicle to a local database server. This design is termed Transport High-way Integrated Security System (THISS) will bridge the gap in the combined wireless technology by providing access to the driver with a key tagged RFID to help transmit prioritized signal via an in-the-vehicle unit to send the real time location of an incident. The main priorities are the three main incidents that are frequent on the high-way such as; robbery, accident and mechanical faults. When these occurrences happen, there’s usually difficulty in placing direct mobile communications for help or assistance.

Keywords: RFID, GPS, GSM/GPRS, Vehicle Tracking System, Flow Chart, Sequences Diagram, Unified Modeling Language (UML)

1. Introduction

This research introduces RFID based High-Way Transport Security System is a technology based on wireless communication. This falls under the vehicle location and tracking system. Different proposed tracking systems have being made by researchers. Many have being meant to solve problems of monitoring for companies. The acquisition of vehicle’s location can be done through Vehicle Tracking and Ticketing (VTT) at a specified time interval [14]. The information is transmitted to Tracking server using GSM/GPRS modem on GSM network by using SMS or using direct TCP/IP connection with Tracking server through GPRS. Tracking server also has GSM/GPRS modem that receives vehicle location information via GSM network and stores this information in database. This information is available to authorized users of the system via website over the internet.

Another research considered the introduction of a tracking system by the applying RFID and GPS in a combined study by implementing a Fisher Boat tracking System [22]. This was to introduce the GPS tracking system on land to the travelling boat on sea. The system worked very well at sea, because there are no obstacles that weakening signals from the satellites to GPS device. But the unlucky side is no sea cell-towers to aid communication. There are more Commercial satellites Communication Services on marine there are many ships and its tracking system is mandatory communications to base station [15], [16].

Research in the design of accurate vehicle location system using RFID had been proposed to implement the integration of RFID, GPS, GPRS and LANDMARC technologies in achieving accuracy in different complex environment [3]. This is simply to improve the precise vehicle location and get the mechanical information of vehicle status by the technology of wireless communication.

The rise of cargo shipment in the transport industry has become global and needed effective monitoring to help identify cargos moving from one country to another. In another view of the transportation security system, the use of RFID and GPS for Cargo Transport System where an RFID reader and GPS tracker wirelessly connects with databases to serve as testing grounds in the implementation of boarder security measures [4]. This is to help prevent future terrorist attacks and help in ensuring that the goods and products are not compromised while in transit. The system will also reduce the labor work of security check to its minimum. United States border security has become a major concern in the recent past. In order to enhance border security, a system must be put in place to allow the tracking of shipments from origin to destination. US Department of Homeland Security requests proposals of cargo transportation security tools for US Customs and Border Protection (CBP). Zhang (2013) research was initially for US Department of Homeland Security to check cargo identification at the US borders by Customs and Border Protection (CBP) in an Automated Commercial Environment (ACE).

This RFID based tracking system is called the Transport High-way Security System (THIS). The design looks at how the setup of the transportation monitoring on Ghana high-way operates. To provide effective means of communicating incidence in real time. The vehicles on the high-ways have increased in recent years. Identifying problem on the high-way cannot be dependable on the traditional system. There is a need to consider how the transport in the Ghanaian environment can be automated to help solve problems on the high-ways. This RFID based Transport High-Way Security System will inform where your vehicle is and where it has been and how long it has been. The system uses geographic position and time information from the Global Positioning Satellites. The system has an "On-Board Module" which resides in the vehicle to be tracked and a "Base Station" database that monitors data from the various vehicles. The On-Board module consists of GPs receiver, a GSM modem and an RFID module all embedded on a single architecture.

1.1. Problem Statement

This RFID based high-way transport security system is a design intended to address mainly the incidences on the high-way with poor communication as a main factor. Again, there is a localization problem which this research addresses; that is how to achieve accurate location or position of vehicle reporting incidence from the high-way. The GPS receiver receives coordinates which has high noise giving high error margin. This design is to come out with the best means of reducing the noise level in the GPS coordinates.

The automation of this tracking system will solve the delay in responds to high-way incidences. The driver is now given the privilege to report incidence rather than the normal monitoring of drivers from a remote area.

The current system of eye-witness view information is limited. On the high-way most incidence occurring takes a long time before they reach the appropriate quarters. This are frequently been distorted. Therefore this THIS sees to it that reports are based on real-time to show the exact location of an affected vehicle.

In most vehicles plying the high-way, the main means of security management is by mobile phone communication. This mostly does not yield any results, because whenever there is an attack on a vehicle, it is impossible to communicate. With this THISS a signal priority is given to the driver to communicate without any means of attacking persons knowing.

The above phenomenon has shown that research into automated transport security management is an important factor in the reduction of high-way incidences. There so much inconsistencies in reporting of high-way incidences. This THISS was initiated to aid in the contribution of existing knowledge. It is for easy communication from the high-ways at any particular instance in real-time. This research will help in the important in the transport sector to minimize incidence on the high-way.

1.2. Types of Incidence on the Highways

The major type of incidences and occurrences which happens on the highway includes vehicle accidents, highway robbery and mechanical faults. The following are some of the negative impact to economy.

1.2.1. Vehicle Accident

In 2010, the road crashes recoded in Ghana was 11,506 resulting in about 1,986 fatalities. Out of this, about 5,713 were seriously injured and 9.205 slightly injured [18]. The socio-economic cost of this is estimated at 1.6 percent of Ghana's Gross Domestic Product (GDP). According to the National Road Safety Commission (NRSC) annual report (2010), about 43% of the GDP of the country is spent on lost output, about 28% on Human cost and 5% on medical. This gives a matter for concern. Therefore this research seeks to use an RFID controlled vehicle tracking system to help monitor and effectively report incidences and occurrences on the highway. This will help serve as a check and control the rate of cost on road accidents.

1.2.2. Highway Robbery

Highway robbery in the transport sectors in many countries has led to the loss of valuable lives and properties. From anecdote source have something led to crashes of vehicles leading to various degrees of injuries. Armed robbers sometimes track vehicles on the highways to rob people with their valuables while some hijack vehicles and drive to nearby bushes to unleash terror on helpless victims. In other instances, tires, stones, woods, trees and pretended helpless people are used as a road blockade in other to stop vehicles for robbery. These acts have being the result of the absence of adequate security on highways in many countries has left the highways unsafe. The rate of crime in public transportation system in Nigeria is on the increase [19].

Therefore in other alienate these mishaps; this research will seek to implore the vehicle tracking and reporting model to address the highway robbery problems. This research will solve by means of the wireless communication technology to send signal on prioritize basis to the already stationed highway patrol teams for rapid response.

1.2.3. Mechanical Problem

According to the US Department of Transport (2015), statistical investigations were conducted on the critical reason for vehicle crashes on the highway.

The critical reason, which is the last event in the crash causal chain, was assigned to the driver in 94 percent of the crashes. About 2 percent of the crashes, the critical reason was assigned to a vehicle component's failure or degradation, and in 2 percent of crashes, it was attributed to the environment (slick roads, weather, etc.). In the mechanical related critical reason out of a total of 44,000 vehicles, about 35% were tires/wheels related. In about 22% of the critical reason were brakes related. Steering/suspension/transmission/engine related to about 3%. In the same vein, about 40% crashes of mechanical critical reason accounted for unknown vehicle related problems. Therefore for researchers to be able solve this problem associated with mechanical related crashes which may arise as result of the inability for a driver to report a mechanical incident. This may have accounted for drivers to hasten-up to a closer destination for assistance. There-by leading to certain bad decisions from the driver. However this case of US is no more different from Ghana and elsewhere in the globe [20].

Therefore this research will seek to use RFID in reporting such mechanical problems other appropriate stakeholders. The assumption is that, this research will help drivers to report any mechanical problem without panic for the transport station to aid in highway vehicle maintenance. The assumed result will be that the proposed model will help in the reduction of down time to maintenance and avoid hardship to various public transport passengers and eliminate the terror they go through.

2. System Composition

Vehicle tracking systems are a design technology which is mainly for the purpose of monitoring, identification and locating of vehicles. In tracking system, the means of its development uses different technologies in achieving a set goal. This goals may include; theft prevention, cross border identification, and checks for cargo transportation. The technologies which are frequently used are as follows:

- Global Position System (GPS)
- Radio Frequency Identification (RFID)
- Global Mobile Communication System (GSM)
- Differential Global Position System (DGPS)

Framework of Vehicle Tracking System

According to Ning et al (2013), vehicle tracking system has an architecture which consists os four main layer. These layers always interact with one another for effective communication. The vehicle tracking system is also a platform is shown in figure 1 consisting of the following layers:

- Physical layer
- Device layer
- Data transmission layer and
- Application layer

2.1. Physical Layer

This physical layer mainly uses a passive RFID tags. The vehicle has a controller which transmits electromagnetic signals to tags and saves information of position from the tags. The RFID tags are position at the sides of the road at a position for enough visibility.

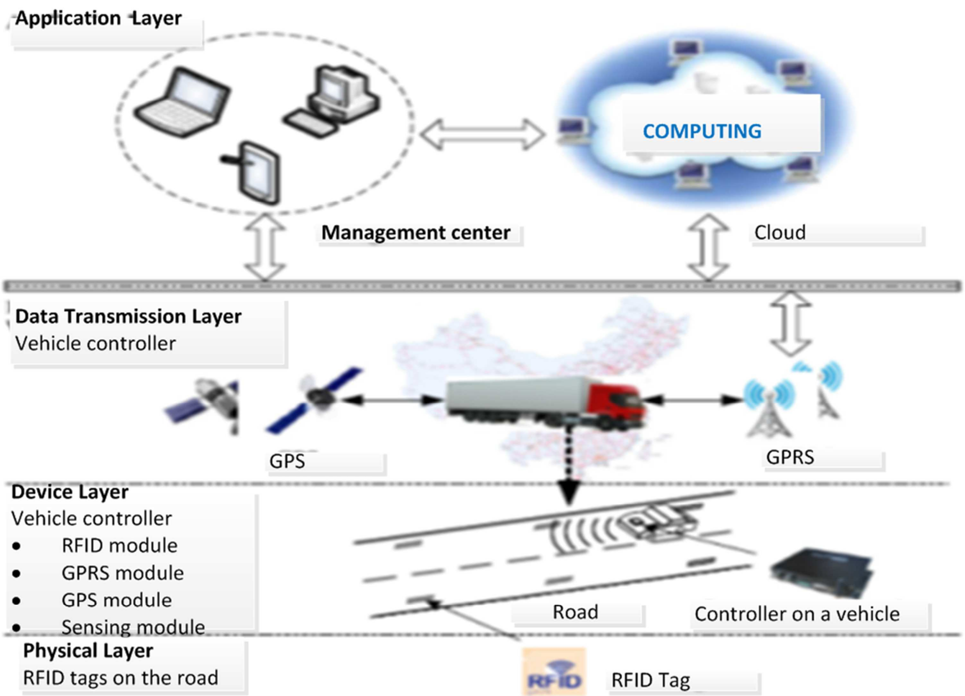

Figure 1. *Architecture of framework [3].*

2.2. Device Layer

The device layer is the vehicle controller which contains RFID module, a GSM/GPRS module, a GPS module and a sensing module. This is the main p of the vehicle tracking system which is used to pick data of all locations and then transfer. The work of this device layer is to collect; identification information, the GPS received data, and the status of the vehicle. These collected information is then stored and transmitted to a management centre through a GSM/GPRS means

2.3. Data Transmission Layer

The main function of this layer is transmitting all information received by the device layer to a remote management centre. This transmission is done through the GSM/GPRS network. There is also a transmission from the RFID tags at a rate of 256 kbps [3]

2.4. Application Layer

The application layer is the main remote controlling part of the entire layers. This provides the monitoring and remote management of the vehicles. This consists of the management centre and the cloud. The application layer processes all information which includes position, status of the vehicle in real-time events. This gives the system administrator the various means of determining the vehicle state.

3. Architectural Design of the in-the-Vehicle Unit

The most important part in how the in-the-vehicle unit communicates to the database server to help report to the authorized persons for necessary action. This consist of micro controller, RFID, GPS receiver, max232 uses RS-232 protocol for serial communication between the modems and the microcontroller, LCD, power supply, crystal for oscillation and a multiplex (MUX) which are all demonstrated in figure 2.

A serial driver IC is used for converting TTL voltage levels to RS-232 voltage levels [1]. When the system is initiated through with the RFID tag, request is sent by the number at the modem, the system automatically sends a return reply to that mobile indicating the position of the vehicle in terms of latitude and longitude.

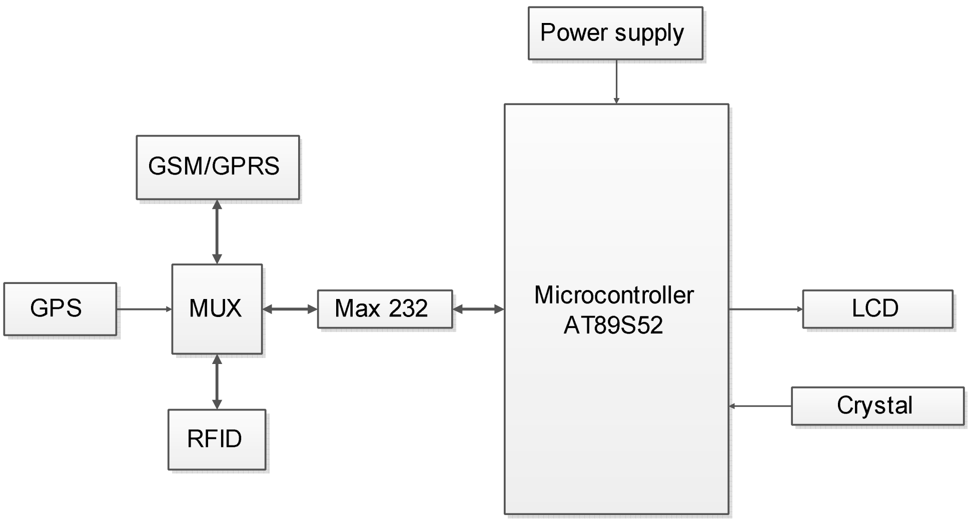

Figure 2. *The in-the vehicle unit.*

3.1. RFID Module

Radio-frequency identification (RFID) uses radio-frequency magnetic fields to transfer data. This data can travel up to hundreds of meters, which is different from the bar codes [10]. The RFID tags in the THISS is attached to the driver’s key-holder in the vehicle together with its reader embedded on the in-the vehicle unit. The RFID tag needs to be read and tracked by the RFID reader, the location of the vehicle will be known. Its methods of tracking is by means a passive in nature and the tracking data can be read from a networked device only when the driver tag is read by the RFID reader on the vehicle based on the number of reads within a time t, seconds each signifying prioritization.

3.2. Constituents of the RFID in the Vehicle Tracking System (VTS)

The RFID has two main components which are the RFID tags and the RFID readers.

3.2.1. RFID Tag

The tags are attached to devices that need to be tracked but this research; the tags are controlled by the driver who uses it when there is any incidence on the high-way. This is programmed with the on-board vehicle unit which has the RFID reader. The transponder includes a changeable or writable memory, and means" responsive to the transmitted interrogation signal for processing the signal and for selectively writing data into or reading data out from the memory. The RFID tag is a transponder then transmits an answerback signal from the data read-out from its internal memory, which signal may be interpreted at the base station. In the preferred inventive embodiment, the transponder generates its own operating power from the transmitted interrogation signal, such that the transponder apparatus is self-contained [9]. It communicates through three main priorities based on the kind of incidence occurring at a high probability. These three priorities are as follows:

- Robbery incidence
- Occurrence of accident
- Vehicle's mechanical problem

Each of these priorities follows a command online to the authorized persons for immediate RFID systems use different frequencies ranging from low to microwave range. RFID tags will establish communication with its reader, it will detect item instantaneously and relay it to a network [6], [5]. Top notch retail shops, employed this technology to smooth functioning of their operation [23].

Low frequencies like 30-500 KHz for short-range applications (usually less than two meters), Ultra High frequencies like 860-960 MHz, and Microwave frequencies like 2.4v-2.5GHz for longer transmission range (usually more than 27 meters) are mainly used for RFID based application [26]. Various simulation models on RFID viz. simulation platform of RFID operating in UHF region; realization & optimization of simulated UHF RFID; behavioral modeling and simulation of RFID antennas; realization & simulation of the hardware for RFID system and its performance study etc. are studied and developed to save the search time for the technologists involved in the fabrication of devices or designing a system [5].

The Ultra High Frequency (860-960MHz) mode used by the RFID system achieves higher communication ranges, higher data rates and smaller antenna sizes [11], [10], [13], [12].

Hence this research work deals with the use of UHF Passive tags of the RFID system. There is a try to develop a RFID system using MATLAB and study its performance in the frequency range of 860-960 MHz [24].

3.2.2. Radio Frequency Identification (RFID) Reader

The RFID readers can be grouped based on the tag-reader combination. The passive reader active tag (PRAT) is a system with a passive reader that reads signals from active tags. These tags can transmit data up to thousands of feet [9]. The active reader active tag system consists of an active tag that continuously transmits signals which are read by active readers. The RFID reader contains an radio frequency (RF) transceiver module (transmitter and receiver), a signal processor and controller unit, a coupling element (antenna), and a serial data interface (MUX 232) [21] to the on-board vehicle unit as shown in figure 2 in section 3. Therefore the reader is use in this technology to read information/signals from the RFID tag.

3.3. AT89S52 Microcontroller

AT89S52 is a low-power, high-performance CMOS 8-bit microcontroller with 8K bytes of in-system programmable Flash memory. This microprocessor is the central coordinating device on the on-board vehicle unit which allows signal routing with assigned algorithms [25]. The AT89S52 provides the following standard features: 8K bytes of Flash, 256 bytes of RAM, 32 I/O lines, Watchdog timer, two data pointers, three 16-bit timer/counters, a six-vector two-level interrupt architecture, a full duplex serial port, on-chip oscillator, and clock circuitry.

4. Design Methodology

This study describes the various methodologies used in the research work. The method used is predominantly an exploratory approach. However the technique use in build and developing the ideas is based on Unified Modelling Language (UML) a model platform. The UML approach uses block diagrams, sequence diagrams and use of flow chart in explaining the working process of this RFID vehicle tracking system. Figure 3 is the overall methodology used in modelling the idea.

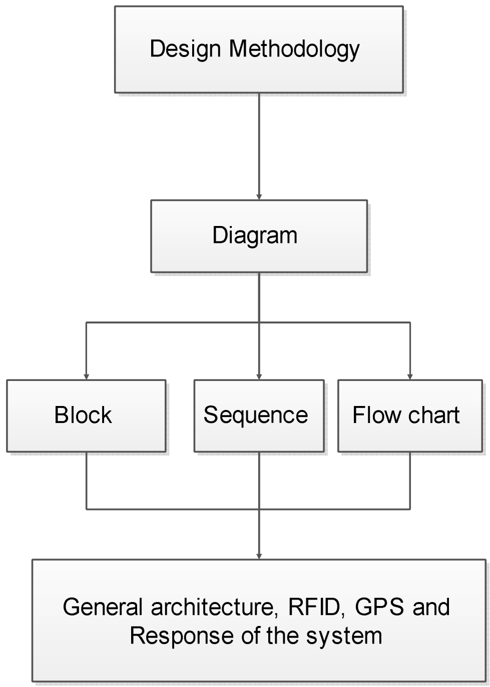

Figure 3. *RFID controlled VTS methodology.*

This research represents the general architecture, RFID, GPS and the system response with diagrams. The use of block, sequence and flow charts gives the design idea of its operation.

5. General Architecture Platform

The idea in this research is to solve the incidence problems on the High-way after a long ply and constant occurrence of robbery, accident and mechanical problems. This needed an intuitive innovation to curb this menace from continually happening. This has cost the nation a lot of productive resources both tangible and intangible. This research looks at a design termed the combined tracking technology, which has being in existence in many advanced countries to help solve identified problem at various levels. This design also looked at the textual design from various lead researches in their effort to solve crime, authorizations, manufacturing processes, transportation and many other fields.

The diagram in figure 4 shows the overall architecture of the design idea in this research.

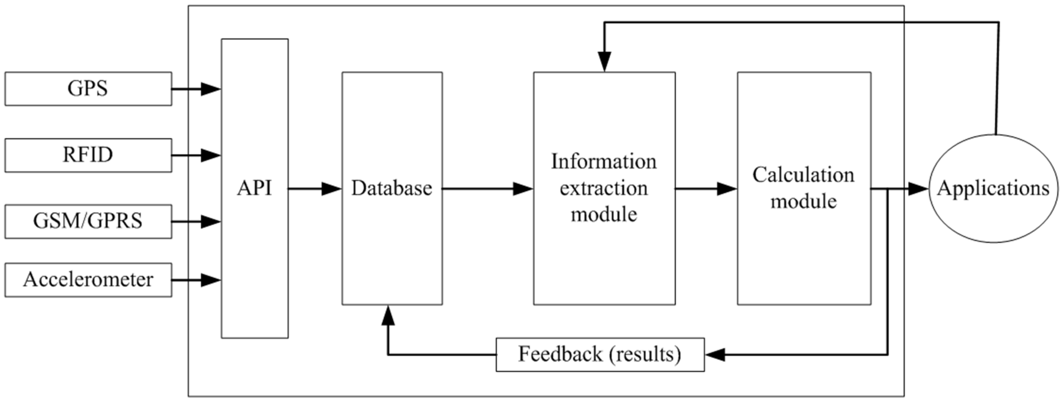

Figure 4. *The general architecture of RFID based High-way Security System.*

The in-the vehicle unit design consist of basically an accelerometer, a database server, and application interfaces. In this design there is a combined wireless technology employed which includes; RFID, GPS, and GSM/GPRS. Accelerometers can be used to measure vehicle acceleration. Accelerometers can be used to measure vibration on cars, machines, buildings, process control systems and safety installations [17]. They can also be used to measure seismic activity, inclination, machine vibration, dynamic distance and speed with or without the influence of gravity. It measures acceleration not by calculating how speed changes over time but by measuring *force*.

From Newton's second law of motion relates force, mass, and acceleration through this very simple equation:

$$Force\ (F) = mass(m) x\ acceleration(a)$$

$$\therefore a = \frac{F}{m}$$

In other words, acceleration is the amount of force we need to move each unit of mass. Based on this theory, the accelerometer will be able to measure the speed of the vehicle and its' position by the use of position-velocity-acceleration (PVA) model.

6. Discussions of the Operational Principle of the RFID Controlled Vehicle Tracking System (VTS)

6.1. GPS Data Decoding

G.P.S receiver continuously sends data and the microcontroller receives the data whenever it requires. The data sent by the GPS is a string of characters which should be decoded to the standard format [2], [8]. This is done by the program which we implement in the controller.

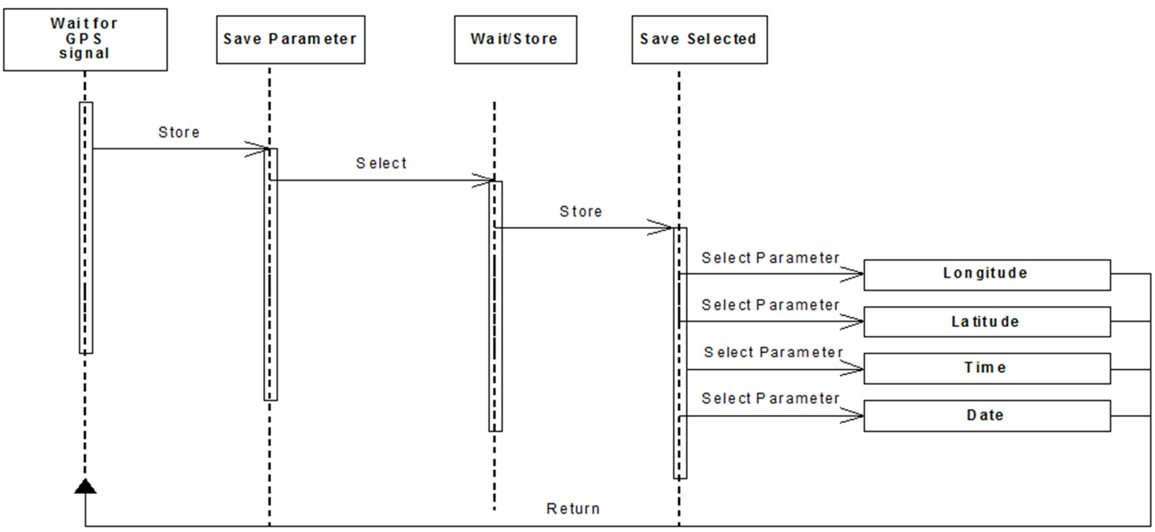

Figure 5. *Sequence diagram of GPS recordings.*

The figure 5 above shows the sequential process of how the GPS waits for signals from the satellites and a trigger from the RFID to communicate position of real time incidence occurrence.

6.2. Working Operational Flow of the RFID

The RFID tags of the THISS system is a read-only, and contains a serial number this is fed in the local database of the THISS for referencing. However, the read/write tags are also necessary; the specific driver information can be stored by the local tracking station. This information is stored on a non-volatile memory; this will help the retrieval of information even when the system is turned off.

The RFID reader on the in-the-vehicle unit sends an encoded signal to the drivers tag. This is the initial signal contains specific information to recognize the driver's tag, on receiving this signal, it response via radio frequency (RF) transmitter. The sent signal by the driver's tag has a specific identification code which is link to the database to recognize the driver's information and that of the vehicle. If both codes match, the exact location of the vehicle can be known based on the actual priority of incidence occurring on the high-way. There are time limit set by the system to notify the real time event of incidence, a continuous signal is sent on the THISS system at a predetermined frequency. The signals will have to reach the database server, and later transmitted to the authorized system.

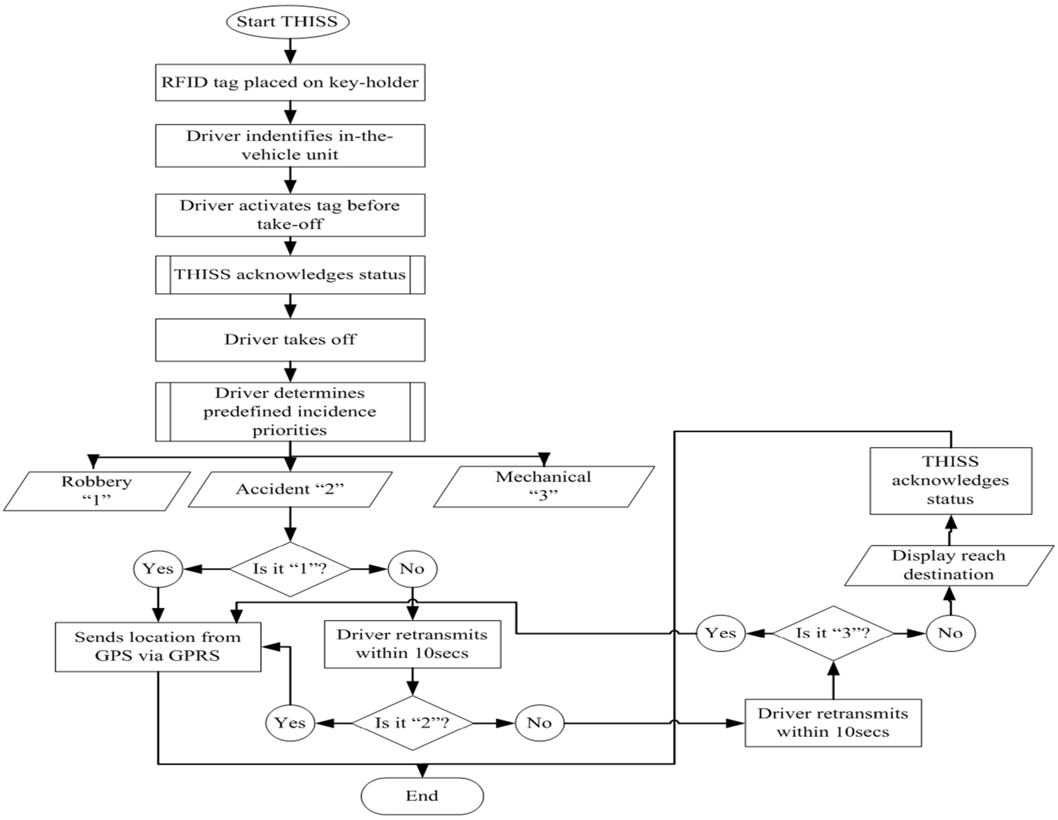

Figure 6. *The flow process of the RFID as a main communication tool.*

The flow diagram of the RFID system shows the actual operation of the communication of how the THISS will operate on the high-way.

The RFID the main communication of all the system, each vehicle is activated on the network if the vehicle is set to take-off to allow the acknowledgement of the status. Even though the vehicle location can be known at any given time, but the driver is solely responsible for the reporting of all incidences which may happen on the high-way.

6.3. How Incident Are Reported by the RFID Tag Activation

The priorities in this research are considered to be only the three most occurring incidences and occurrences on the high-ways which based on the quantitative survey from literature as described in the problem statement section. These incidences are prioritized as; robbery "1", accident "2", and mechanical problem "3".

6.3.1. Reporting of Priority "1"

In the analysis of priority "1", vehicle plying on the high-way at any particular time can experience an attack. Before an attack happens, the driver there is a high probability of he/she will have an idea of the presence of these armed robbers. Therefore this system has the capability of reporting through the means of RFID first signal priority "1" which is robbery to a database station.

The driver has to transmit the first signal ("1") via his tag and robbery attack signal is sent on to the network. This will show the exact location via coordinates at a particular radius. By this means, the nearest patrol team or authorized security force will response swiftly to prevent the incident from happening. This priority stays confirmed after ten seconds $(t > 10secs)$.. However, if the driver retransmits a signal from the RFID tag within the ten seconds $(t < 10secs)$ then the next priority is activated and transmitted on the THISS system.

6.3.2. Reporting of Priority "2"

This priority is to report road accident or an unnecessary speeding on the high-way where its difficulty to report such incidences. This can be done by the driver in the accident vehicle or most importantly by any passing vehicle. This reporting is done in a time constraint of within ten seconds from the reporting time of priority "1". However, high impact sensor can also compliment the reporting of this priority if it is a serious accident. On the other hand, if it a less impact accident, driver should be able to report within the next ten seconds after priority "1" $(0 \leq t \leq 10secs)$. After this period, if there is no third signal sent by the driver, the system will report.

6.3.3. Reporting of Priority "3"

This is the reporting of mechanical problem which is the third most occurring incident on the high-way. The on-board vehicle unit will report the incidence of mechanical problem if and only if the driver transmit three separate signal within 20 seconds $(10 \leq t \leq 20secs)$ after the priority "1". This will help transport operators to be able to send new vehicle to convey stranded passengers and drivers on the high-way and also mechanics to repair major faults.

6.3.4. Destination Notification

This is to notify the THISS system that the vehicle has reached its destination to allow the on-board vehicle unit to go off. This also allows the acknowledgement of the tracking station of vehicle's arrival at its' destination with coordinates taken for event analysis.

The fig below is the sequence process of how the driver uses his tag to communicate the real time event to the database server.

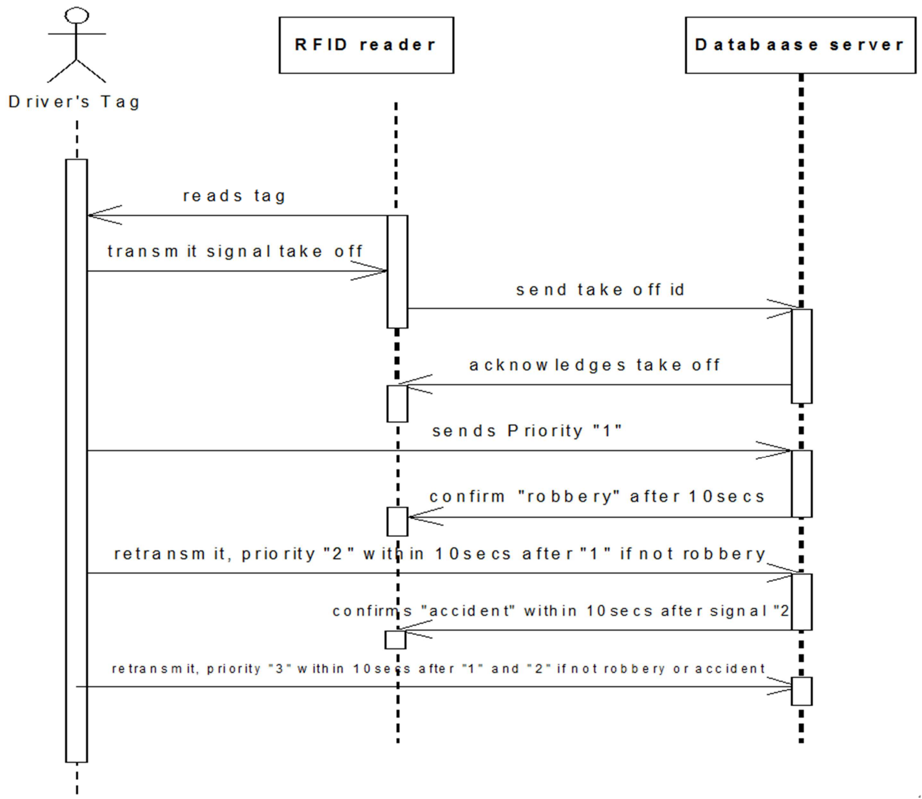

Figure 7. *The sequence diagram of communication from the driver to the server.*

The micro controller chosen is AT 89S52, which serves as the central command control of all this RFID based system components namely; the GPS, RFID, and the GSM/GPRS modules on the in-the-vehicle unit. It process includes when to use the system, which components to be used and at what time they should interact with each other. It is a programmable part of the system where all units have to access their commands. The micro controller has the privilege to update all units status of hoe each should response that is required to implement the in-the-vehicle unit.

6.3.5. Response of the RFID Based Vehicle Tracking System

The response of the system is the legitimate to the flow of how the in-the-vehicle unit communicates to the local data server. This will aid authorize persons to take the appropriate action to forestall any of the three main priorities on the high-way. In figure 8 shows a simple response of the Transport High-way Integrated Security System (THISS).

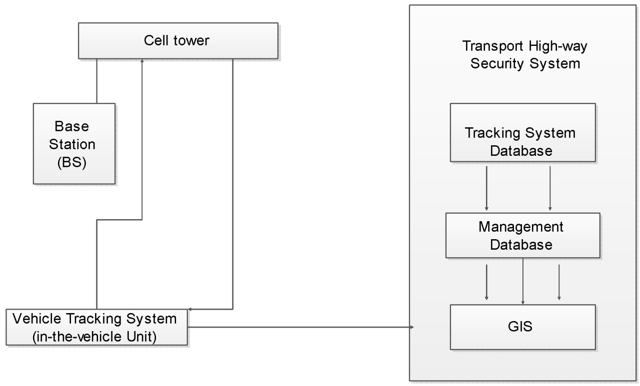

Figure 8. *The response diagram of the THISS.*

Management phase (database): the management phase contains functions of organizing driver's information, received data from the Base station (BS)/Subscriber station (SSs) (tracking data) and GIS data (check-points).

6.3.6. The Flow Diagram for the GPS System of the in-the-Vehicle Unit

Special radio signals from the satellites are received by the GPS receiver, which further carries out mathematical calculations on them.

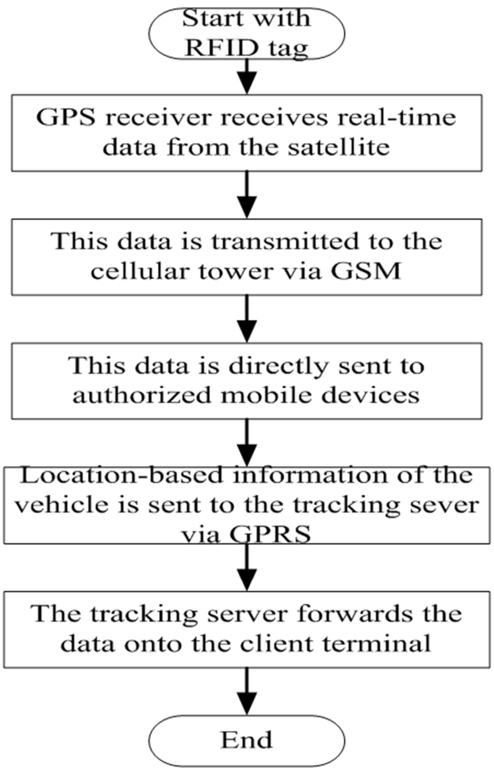

Figure 9. *The direct flow chart of GPS localization of vehicle.*

For calculating the exact position, the GPS receiver should know:

- Distance of the tracked device from each of the satellite.
- Rough location of the device to be tracked.

As mentioned earlier, GPS receivers calculate the distance from the satellite on the basis of the time taken for the radio waves to travel. To know this exact time, the clocks of the satellites and the GPS receiver should be synchronized. Satellites use an atomic clock while receivers use a quartz clock. The quartz clock continuously resets itself [7]. The receiver looks at all the incoming signals, and selects the current time signal for location calculations. All the other signals are aligned at a single point in space, by using this time value as a reference. The receiver itself resets its clock to the atomic clock value. Once this time value is known, and the satellites are aligned, spheres are drawn around these satellites based on the calculated distances that intersect at a particular point. As the receiver continuously resets its clock according to the atomic clock of the satellites, these distances are accurate, and the intersecting point will give the exact location of the device.

7. Conclusion

A better communication system suited for effective reporting of incidences and occurrences on the highway is proposed. The solution is wireless means of using RFID technology combined with GPS, GSM and a database server is defined in a general architecture. Therefore with the increasing population plying the highway means more incidences and occurrences are bound to happen. Therefore this proposed technology will help reduce the menace. The three major incidence claims thousands of lives, loss of properties, waste of time in incurring more cost, and reduction in the rich human resource base of the country every year. The responses are done by knowing the exact location on the high-way. Due to the complex nature of this design, some future studies are to implement and simulate the system to show how the RFID will response to communication of the priorities.

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