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Using Radio Frequency Identification to Develop an Algorithm for Tracking Vehicles

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Author's contribution

The sole author designed, analyzed and interpreted and prepared the manuscript.

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ABSTRACT

One of the major problems facing law enforcement agents in developing nations is their inability to apprehend road traffic violators without physically stopping them to demand for relevant particulars. Some of these particulars when presented may either be fake, expired or genuine but there is no way the law enforcement agent can confirm the genuineness of the particulars without delaying the driver. Several methods are being used to track a moving object and access relevant information about the object but each of these methods has their pre requirements for implementation and limitations.

In road transportation, most of the methods and technologies being used are either manually operated or not fast enough to generate accurate and immediate information of vehicles that are being tracked. In this paper, relevant works were clearly reviewed to identify the requirements, shortcomings and limitations of tracking vehicles. The database of road transportation using relational database model is proposed. Examination of the practicability of applying automatic identification technology generally and Radio Frequency Identification (RFID) technology in particular to identify vehicles plying the various in road transportation is carried out. The

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requirements of the system were clearly stated and two algorithms; system and RFID were proposed to enable the computer and the technology communicates effectively and efficiently with each other in order to track any moving vehicle and transfer a unique identification of the vehicle to the computer for further information. The system was tested using sampled data and the result was successful.

Keywords: RFID; reader; algorithm; transportation; ITS; transponders.

1. INTRODUCTION

Transportation can be briefly defined as the movement of people and or goods from one place to another through a means. The means may be walking on land, vehicle on road, train on the rail and plane in the air or ship on the sea. The concern of this paper is the movement of vehicles on roads which is henceforth referred to as road transportation. Road transportation therefore is the conveyance of people and or goods on road from one place to another by a particular mode. Road transportation is characterized by its multimodal system, which may be by walking, cycling and driving.

The means of transportation generally, which could be vehicle, plane or ship can either be regulated or unregulated. In a regulated transportation, the modes of transportation are owned and operated based on government policies, rules and regulation that are formulated and made to be in operations from time to time which are also complemented by international policies, rules and regulations that are enforceable worldwide. Furthermore in a regulated means of transportation, the means of transportation are in most cases owned and managed by fleet operators, which may be government, corporation or any other legal entities. In addition to government rules and international regulations governing the operation of such means of transportation where applicable, their owners also set their own internal rules and regulations in order to ensure the safety and reliability of their vehicles.

Road transportation is the cheapest and most affordable means of transportation that is capable of penetrating every nook and corner of an area. Because of its wide acceptability, cheapness and affordability, it is exposed to various degrees of dangers which people and governments are aware of but sometimes pay little or no attention to curb. Just as road transportation is witnessing frequency in its patronage that is facilitated by rehabilitation of roads, construction of new ones and introduction of new vehicles, there are advances in the fields of computing and communication which can be applied to road transportation to improve its activities and reduce the dangers associated with its usage.

There are some noticeable features of other systems of transportation; air and water that make them safer and secured than road transportation and one of them is that they have their peculiar methodology of exchanging information from the point of departure till they reach their final destination. Furthermore, it is impossible to see planes and ships in the air or on the sea without valid papers i.e. they cannot be piloted or roared without valid documents. However, this is not impossible in road transportation; it is either the vehicles do not have valid papers or the driver is not licensed to drive. Despite the fact that information is common to the activities of the three means of transportation, it is given more attention and recognition in other means of transportation than road transportation. Therefore, these have been major deficiencies in road transportation which have not been given due consideration in order to make the system safer, more efficient, effective and reliable. Since there are techniques by which other systems of transportation can exchange information, it is therefore desirable to develop such technique for road transportation.

As it is common in all transactions, information is needed to be processed and exchanged through a technique and the most modern technique of processing and disseminating information is automatic, also called electronic technique. When we talk of this technique, what readily comes to mind are computer and communication facilities. These two components of automatic technique of data processing have witnessed some changes and advancement in recent time to the extent that they are now being used in virtually all spheres of human endeavors. Among these changes are the reduction in the size of computer, increase

in the processing and storage capabilities of computer, advances in wireless networking technology and the exponential development of semiconductor technology that have introduced a new paradigm of computing, called personal mobile computing or ubiquitous computing. This development offers a lot of opportunities that can be applied to the mobility feature of road transportation.

1.1 Objective

The primary objective of this paper is to design a tracking algorithm for road transportation for easy identification of traffic offenders. In addition to this, other objectives are.

- Provide a means of identifying vehicle plying the road and operational delays in road transportation.
- Integrate Information and Communication Technology into road transportation

The development of the system consist of determination of tracking method, development of the algorithm.

2. INTELLIGENT TRANSPORT SYSTEM (ITS)

Many factors are responsible for the rapid increase in the use of road transportation worldwide and among these factors according to [1] are construction and rehabilitation of roads, increased welfare packages, establishment of more industries, creation of employment opportunities and transformation of rural areas. The implication of this is that these factors have combined together to make possession of a mode of road transportation a necessity to every household. The growth in motorization brought about the need for a system that will assist in navigation, ease congestion, make road transportation safe, reliable; all of which calls for a means by which violators of traffic rules and regulation can be caught and arrested with ease. All these needs and other critical factors have combined together to open a new sector in road transportation called Intelligent Transport System. The system encompasses all systems, equipment, devices etc. developed or designed for use on the road. In the period from 1992 to around 1995 the ITS sector was known as Intelligent Vehicle Highway Systems (IVHS). At that time, it was recognized that all forms of transport could benefit from the application of Information and Communications Technologies (ICT) but however the term ICT had not yet been described in popular vernacular.

Intelligent Transportation Systems vary in technological design and application. ITS ranges from basic transport management systems such as car navigation, traffic light control systems, container management system, variable message signs or speed cameras to monitoring applications such as security CCTV systems. It also include advanced applications that incorporate live data and feedback from a number of other sources, such as Parking Guidance and Information System (PG&IS), weather information and bridge devising system. Additionally, predictive techniques are being developed, to allow advanced modelling and comparison with historical baseline data. Some of the constituent technologies typically designed and implemented in ITS are subsequently described in seriatim hereafter.

Among the early developments in ITS is [2]. In this work, the design and implementation of a road safety relational database was presented. The work was conceived to address the problems associated with proliferation of the sources of data collection in road transport system. These problems are data:

Incompatibility,
Incorrectness
Inconsistency
Redundancy:

This in turn leads to inaccurate and conflicting statistics generated and published by different research groups. In order to solve these problems, the study proposed a relational database to support road safety system and it was implemented using RAPPORT relational Data Base Management System on VAX11-750computer. The study provided a distributed database of road transport from which statistics relating to road safety can be generated and analysed.

One major problem confronting the law enforcement agents in discharging their duties and responsibilities outside their base is the issue of communications. [3] was motivated by the lack of effective and efficient medium by which law enforcement agents can communicate with each other (person to person), the need to integrate the then evolving

technology of Internet with Police activities and the need to introduce sanity to our roads to develop a vehicle-based system for reporting and maintaining records of road transportation offenders and other offences, which he called National Police Command and control system. The primary objective of the system was to develop a means by which crimes committed along the road can be reported immediately to the Police and by Police to the stations. The system centered on the use of vehicle based communication system for reporting, detecting and preventing crimes generally. The system involved communication between the Police patrol vehicles and their headquarters through web based system. However, the system was too expensive to maintain and it was restricted to areas where there is internet connectivity.

A standalone and non in-vehicle built system to aid navigation developed by [4] addressed some of the problems affecting road transportation. In this work, Automatic Road Transportation System with Radar Guidance and Precision Navigation to aid navigation was developed. This system was developed because of the need to have a system that will make navigation easier, ease road congestion and eliminate breaking of traffic rules and regulation in road transportation. The paper identified the scientific requirements for the design of a scientifically based system of navigation that emphasized the need of in-vehicle equipment to aid communication in road transportation. The use of in-vehicle equipment such as distance monitoring radar, obstacle avoidance radar etc. that had been previously proposed by [5] was meant to assist drivers in communicating with their base station and provide additional safety for users of road transportation but could not be achieved due to the level of technology then. The main contribution of this work was the deployment of radar guidance and precision navigation to road transportation. The shortcoming of this study is the fact that in case of an accident the decision is left for the driver to decide whether he should have noted at which instant to override the automatic or whether it was justified for him to trust it. In order to overcome this shortcoming, a fully automatic road transportation system which does not need human interaction, maybe except for an emergency brake button, and can therefore provide numerous benefits like unmanned automatic transportation of goods, driverless vehicle movement to parking facilities, etc. was proposed in [6]. Based on careful analysis of this system, it is evident that the following limitations are associated with it:

- It is capable to providing guidance to cooperative road users, that is, the drivers but it is not an efficient and effective system to identify road violators and uncooperative road users among the numerous users.
- Furthermore, the system is an approach to removing the breaking of traffic rules but it does not provide any assistance to law enforcement agent where the rules are broken.
- It does not allow access to its information.
- Relevant information are pre-determined, fixed and cannot be processed for decision making.

Another system developed for use in road transportation could be found in [7]. In this work, Specific Time Alert (STA) system was proposed. STA is useful for tracking vehicles in road transportation. The primary objective of the system was to provide the means by which stolen vehicles could be traced and tracked. In this system, the GPS provides independent positioning and timing information to the system by capturing, analyzing and distributing such information along with other complementary data for tracking vehicles. The usefulness and relevance of the systems had been clearly identified and stated in [8-10]. These systems and other similar ones had assisted the law enforcement agents and corporate organizations to track missing and stolen vehicles. Despite the wide acceptability, efficiency and usage of this system, it was later discovered that:

1. It was impossible to retrieve all necessary information relating to any given vehicle from the system
2. It is only a tracking device
3. Information cannot be uploaded or downloaded from the system
4. Though it is useful to the law enforcement agents in the recovery of stolen vehicles, it cannot assist them in the detection and prevention of road traffic offences.

Other deficiencies and unsuitability features of this type of system could also be found in [11]. In view of these deficiencies, it is imperative to look for efficient, effective and relevant system that is capable of meeting the diverse needs of the law enforcement agents, vehicle owners and clients.

2.1 Automatic Identification

A vehicle can either be in stationary position or on motion A vehicle in a stationary position requires little or no stress of tracking since all data relating to it can be easily got but when it is in the other position i.e. on motion, there is the need to devise a means by which its unique identification will serve as a trail for getting the full identity This is where the need for a technology that can efficiently track it becomes imperative. The vehicle under consideration is an object; therefore an object tracking, by definition, is to track an object (or multiple objects) over a sequence of images. The image that is of utmost importance to this paper is the vehicle plate number. Object tracking, in general, is a challenging problem because it is difficult to track an object. Among the difficulties associated with tracking an object in motion include abrupt object motion, changing appearance patterns of the object and the scene, non-rigid object structures, object-to-object and object-to-scene occlusions, and camera motion. Generally, tracking involves identification which may be manual or automatic. The manual mode of identification does not require any stress since the object(s) to be tracked is (are) stationary. Automatic identification, or auto-ID for short, is the broad term given to a host of technologies that are used to help machines identify objects. Auto identification is often coupled with automatic data capture. That is, it is a means to identify items; capture information about them and through communication devices gets the data into a computer electronically. The aim of most auto-ID systems is to increase efficiency, reduce data entry errors and maintain data integrity. There is a host of technologies that fall under the auto-ID umbrella. These include bar codes, smart cards, voice recognition, some biometric technologies (retinal scans, for instance), optical character recognition (OCR) and Radio Frequency Identification (RFID).

An important step in the implementation of the auto-ID is the development of appropriate algorithm to recognize it. Generally, there are three broad types of algorithms. The three broad types are:

a. point tracking,
b. kernel tracking
c. silhouette tracking.

Various algorithms had been developed to automate traffic data collection and one of these is [12] that adopted a method known as a macroscopic data collection through image processing to track movement of many vehicles and pedestrians. This paper describes how to obtain variables from video taking and simple image processing that can represent the movement of pedestrians and its variables. The objective of the tracking algorithm is to match the points between slices by giving an object number to each point in each slice. Two points are matched if and only if the two points represent one object. Since each point in each slice denote a location at a time, the distance between two match points in two consecutive slices can also represent the speed of that object. Matrix Ds is a binary matrix that represents the distance between point *i* in slice *s* and point *j* in slice *s +1* and the distance can be found by using equation 2.1 as stated in the study

$$D^5(ij)=\{1\leftrightarrow dij \leq T \quad (2.1)$$
$$\{0\leftrightarrow dij > T \quad (2.1.1)$$

Where,

T is the threshold between objects in a slice.
dij = Distance between points i in slice s and j in slice.

Therefore if q is number of points in slice s and

r is number of points in slice s ▪1, then Ds is matrix q by r.

Other algorithms for pedestrian or vehicle that have been developed to trace the movement of one or two pedestrians based on sign pattern could be found in [13] and feature detection by [14]. The main objective of all these was the development of an algorithm for developing the technology deployed in tracing pedestrian and vehicle movements.

2.2 System Design

The algorithms for tracking vehicles involve two components; the software and the hardware. The first component centres on the design of the database and the second component involves the identification and design of the hardware. The software design primarily focuses on the database design of road transportation and it was carried out by following the steps enumerated below:

a. Identification of a suitable database model; in this design, relational database

model was used because of its relative advantages
b. Identification of constraints on the operational data
c. Design

i. Identification and classification of files and attributes
ii Classification of transactions that can be carried out on the database
iii Design of data entry forms
iv Creation of the database
v Documentation of the database.

2.3 Automatic Identification Technique

Two techniques are popularly used under automatic identification and these are Radio Frequency Identification (RFID) and automatic number plate recognition. This paper is concerned with the former.

2.3.1 Radio frequency identification

One unique feature of a vehicle is the registration number; consequently, the vehicle plate number shall be an object of tracking to get full information about the vehicle. One of the most convenient ways to track a vehicle registration number is to use one of the automatic identification techniques. The most appropriate technology is Radio Frequency Identification (RFID). Radio frequency identification is a generic term for technologies that use radio waves to automatically identify people or objects. There are several methods of identification, but the most common is to store a serial number that identifies a person or object, and perhaps other information, on a microchip that is attached to an antenna (the chip and the antenna together are called an RFID transponder or an RFID tag). The antenna enables the chip to transmit the identification information to a reader. The reader converts the radio waves reflected back from the RFID tag into digital information that can then be passed on to computers that can make use of it. RFID can be used to track different types of items, materials, objects and equipment. It can also be used to trigger equipment down oil wells. The most common applications are payment systems; toll collection systems for instance, access control and asset tracking.

Just as a radio is tuned in to different frequencies to hear different channels, RFID tags and readers have to be tuned to the same frequency to communicate. RFID systems use many different frequencies, but generally the most common are low-frequency (around 125 KHz), high-frequency (13.56 MHz) and ultra-high-frequency or UHF (860-960 MHz). Microwave (2.45 GHz) is also used in some applications. Radio waves behave differently at different frequencies, so the right frequency must be chosen for the right application. The distance from which a tag; be it passive or active can be read is called its read range. Read range depends on a number of factors, including the frequency of the radio waves used for tag-reader communication, the size of the tag antenna, the power output of the reader, and whether the tags have a battery to broadcast a signal or gather energy from a reader and merely reflect a weak signal back to the reader. Battery-powered tags typically have a read range of 300 feet (100 meters). High-frequency tags, which are often used in smart cards, have a read range of three feet or less. UHF tags-the kind used on pallets and cases of goods in the supply chain-have a read range of 20 to 30 feet under ideal conditions. If the tags are attached to products with water or metal, the read range can be significantly less. If the size of the UHF antenna is reduced, that will also dramatically reduce the read range. Increasing the power output could increase the range, but most governments restrict the output of readers so that they don't interfere with other RF devices, such as cordless phones.

Other requirement for the use of RFID technology is a computer system.

There are different configurations of computer but the most ideal configuration for RFID must have the following capabilities and features:

The system must be multimedia ready. In other words it must have the capability to transmit and accept data that are in text, picture, animated images, sound and video.

The system must have a speed of at least 500MHz, with 256 MB RAM and 40 GB Hard drive space for data storage.

3. RFID TECHNOLOGY

Radio frequency identification is a generic term for technologies that use radio waves to automatically identify people or objects. RFID is widely applied in various spheres and business. It is fast gaining in road into transportation

system generally and road transportation in particular. In transportation, RFID has provided the means to automate significant aspects of transportation in the past two decades. Every day, RFID allows transportation movements for millions of people to be simplified, allowing greater speed and efficiency, enhancing the capacity of our transportation network, and reducing wasted time and pollution. There are several methods of identification, but the most common is the one that uses a reader and transponder also called tag. Basically, RFID is made up of two components and these are the reader and transponder.

3.1 Reader

The reader sends out electromagnetic waves to store a serial number that identifies a particular person or object, and perhaps other information, on a microchip that is attached to an antenna (the chip and the antenna together are called an RFID transponder or an RFID tag). The antenna enables the chip to transmit the identification information to a reader. The reader converts the radio waves reflected back from the RFID tag into digital information that can then be passed on to computers that can make use of it.

RFID tags and readers have been designed for many frequency bands

- Low frequency: 66/132 kHz;
- High frequency: 13.56 MHz;
- Very high frequency: 49 MHz;
- Ultra-high frequency: 315, 433, 902 to 904, 909.75 to 921.75 MHz, or 2.45 GHz; and
- Microwave frequency: 5.8 GHz (Europe-backscatter), 5.9 GHz (US-OFDM).

Frequency selections are made by designers based on regulatory limits for products, available components, data bandwidth, latency, and the number of readers/speed performance at the site.

The security is enhanced by programming and locking to prevent changing, while others use authentication of the tag or reader to ensure higher levels of security.

3.2 Transponders

No battery, or a long battery life measured in years, for simple aftermarket devices installed by the vehicle driver/owner.

Secure ID number storage and readout, with some systems having factory.

Additional memory in the transponder for scratchpad read-write memory as the transponder passes by readers.

Consequently, two algorithms were developed for its efficiency; the system algorithm and the RFID algorithm.

3.3 System Algorithm

The system algorithm is the algorithm that shows the procedures for the implementation of the system. It shows the step-by-step design and implementation of the system. The system algorithm is as shown below:

An RFID tag is attached to a vehicle
An RFID reader reads the information stored in the tag
The reader is attached to the PC through the serial port
Information from the reader is stored in MySQL Database
A GSM is used to access the information stored in the Database through E mail Server
A laptop can also be used to browse the information stored in the database using HTTP protocol.

3.4 RFID Algorithm

The RFID algorithm is a representation of the working of the RFID. It is as shown below:

Identify the port to which the reader is attached to the PC
Open and class the ownership of the port
Resolve port ownership contention between multiple Java applications.
Create an output stream associated with the port
Write the stream of data to the port
Register an event listener to the port
Specify an event type: notify on data available
The event type calls the interface method serial event
Within the serial Event method, the RFID tag data is read. When the tag is in the reader's field, it transmits via serial port to read data in the computer system.

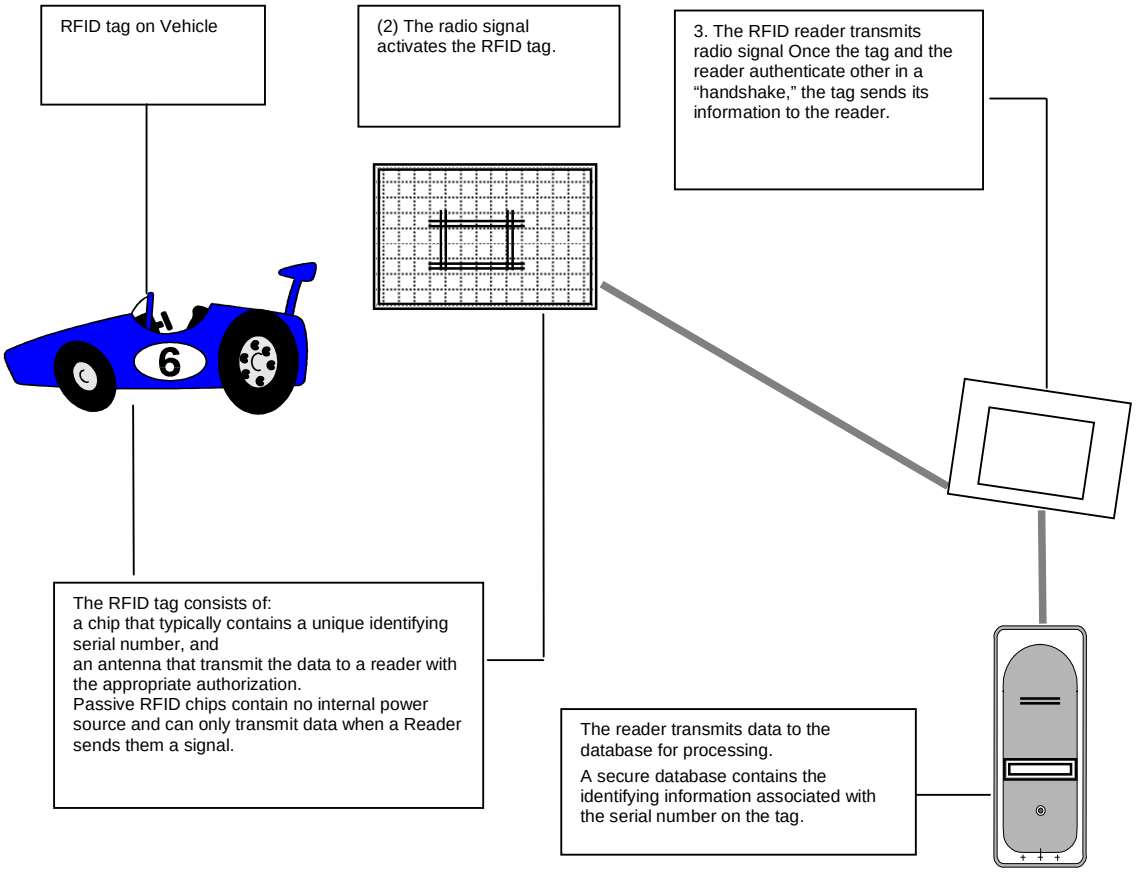

Fig. 1. How RFID works

4. IMPLEMENTATION

The implementation of this system requires that a database of all vehicles had been developed and installed in a multimedia ready computer that has also been appropriately configured. The system has one database called roadtransportdb and it makes use of ten database tables vehicles_table, vehicle owner_table, driver_table, Driver license_table, Journey_table, passengers_table, Route _table, load_table, Accident_table and traffic offence_table, which help to manage information about vehicles, drivers, insurance, passengers, goods, traffic offence, driver's license,owners, journey and route and useful in the apprehension of offending vehicles that passed by the system. Forms were used by the user to access the database. Two sets of form for each record were designed. The first set were designed using Microsoft Access and were meant to be used for the back up activities while the second set were designed using Visual Studio. Net and were used mainly to carry out necessary transactions on the database at the front engine.

RFID card reader and the computer were interconnected. The RFID tag was attached to the plate number of vehicle(s) being tracked. The reader will automatically recognise the vehicle immediately it passes by the reader and the vehicle registration number is automatically passed to the computer. The vehicle number can thereafter be used to generate further information about the vehicle. The diagrammatic representation of the implementation is as shown in Fig. 2.

Practical demonstration of the system was carried out and the system was able to provide details of all offending vehicles that passed by it.

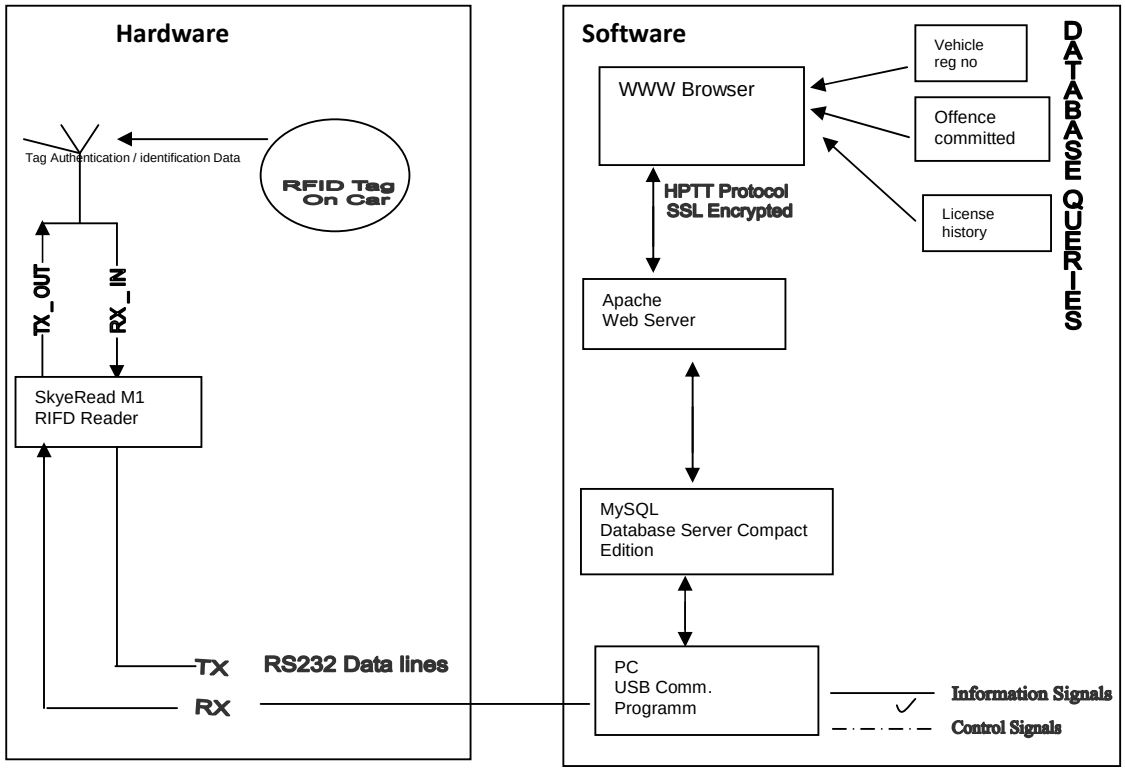

Fig. 2. Graphical view of the implementation using RFID

5. CONCLUSION

RFID is a reliable technology for tracking of objects. This technology can be deployed to track vehicles in road transportation by attaching the tag to the vehicle plate. The reader is required to be connected to a multimedia ready computer as a peripheral device. The vehicle will be automatically tracked any time it passes by the reader and relevant information relating to the vehicle can be further retrieved from the database in the computer. Two algorithms are needed in or order to achieve this and the algorithms are the system and RFID algorithms which have been presented in this study.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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