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Development of an On-Line Spatial Road Offence Monitoring System

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ABSTRACT

Road transport system is the most important means of transportation in Nigeria and indeed in many developing countries. Traffic offences are the major causes of road congestion and accidents on Nigerian roads. Unfortunately, hundreds of innocent souls are lost due to the accidents brought about by traffic offences and violations on the highways. Presently, FRSC officers depend on the paper-based means of monitoring road offence throughout the country. Nigeria presently lacks a centralized system which aids the collection, storage and retrieval of road offences nor an electronic means of studying the pattern of the distribution of road offences by offenders. This paper presents an Online-Spatial road monitoring system which allows field marshals on the road to capture information using their mobile devices which is stored in a spatial database system accessible by other FRSC Officers via a web browser. In order to develop the system, informal interviews were conducted with FRSC, design was done using relevant unified modeling language (UML) tools, system was implemented using web-based technologies like PHP, Hypertext Markup Language (HTML), Structured Query Language (SQL), Cascading Styling Sheets (CSS). The system comprises of a mobile application server, web application server, Web GIS server and a Spatial Database offered by Google's Map API – a free real time mapping system. In conclusion, this system will allow information stored by the field officer to be accessible by other FRSC officials in the office which can include: offence name and location, road offender information and offences committed, activities performed by FRSC staffs etc. The study concluded that the deployment of an online spatial road monitoring system will aid easy capture of road offences either as texts or geometrical objects (maps) in a real time manner.

Keywords: Spatial, FRSC, Monitoring System, Road offense, Transport System

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1. INTRODUCTION

Road transport system is the most important means of transportation in Nigeria and indeed in many developing countries (Ofoegbu, 2013). This is because roads are the major connecting links of states, towns, cities and villages. It has equally been estimated that road transportation represents about 85% of passenger and haulage activities in Nigeria (Ofoegbu, 2013). Nigeria has the largest road network in West Africa and second largest road network south of the Sahara with an estimated road length of 193200 kilometers (Ofoegbu, 2013). The Nigerian road network comprises Federal roads, State roads and Local Government roads. According to Ofoegbu (2013) the United Nations announced in its 2011 road and safety survey that Nigeria ranked as the second worst in the World in road accidents in 191 out of 192 countries surveyed.

In 2007, Nigeria recorded 162 deaths per 100,000 persons. By the same report, the Nigerian Federal Road Safety Corp said in 2007, 4944 persons died in9114 reported accidents with 17,390 injured. Oluwasanmi (1993) reported that between 1960 and 1993, 18,000 persons died in road transport accidents in Nigeria. Indeed the Nigerian Road Safety Corps reported that in 2009 there were 7737 reported road accidents involving 2252 vehicles resulting in 1056 deaths. Traffic offences are major causes of road congestion on Nigerian roads. Unfortunately, hundreds of innocent souls are also lost due to the accidents brought about by traffic offences and violations on the highways. Regrettably, despite many innocent souls being lost daily through road traffic management failures, the impact is not recognized by successive federal and the state governments to initiate wide ranging policies that could reduce the trend in Nigeria.

Traffic education entails the conscious training of all road users which includes: drivers of motorcycles and motor vehicles alike towards proper and lawful behavior on public highways. Oni (2000) stated that this should involve knowledge of road traffic laws and the Highway Code, comprehension of road signs and traffic signals, knowledge of one's responsibility while driving, respect for other road users (pedestrians and motorists alike), respect for traffic control officers and their directives. Rules and regulations are paramount in all aspects of life that range from the way one wishes to live to how others should accommodate one's life style.

All human beings need to enjoy their rights to access and use public infrastructure but it should never be allowed to happen at the detriment of the lives of others. In the traditional systems used in monitoring road offences, a notice of offence sheet is issued to the offender and necessary information is collected with the fine of the respective offence fined based on the charge points – the more serious the offence the higher the points hence, the higher the fine charged. A particular is confiscated in order to ensure that the road offender pays the fine in order to retrieve the confiscated material which may be a valid identity card or passport whichever the case may be. In most cases, the offenders usually get away with not paying the fines simply because they do not come back for the confiscated document and identifying them on the road at a later time usually becomes a problem. A system which stores information on road offences and offenders can be used to retrieve information on a suspected road offender with timely response stating the status of the offender which helps improve the management of road offences on Nigerian road thereby, reducing the likelihood of accidents which lead to untimely deaths due to the negligence of some irresponsible road users.

Geographic Information Systems (GIS) are computer-based systems that enable users to collect, store and process, analyze and present spatial data (Onuigbo et al, 2013). GIS provides an electronic representation of information, called spatial data, about the Earth's natural and man-made features. A GIS reference these real-world spatial data elements to a coordinate system and these features can be separated into different layers. The layers are representation of different categories of data for the ease of analysis and visualization. For example, layers can represent the different roads that exist in Nigeria like federal and state roads/highways, location of different traffic offences, the different types of traffic offence etc. A GIS also stores attribute data which is descriptive information placed in a database separate from the graphics but linked thereby allowing both to be synchronized together hence, attributes can be used to describe and manipulate different data entries in the spatial database (Akomolafe et al, 2009). Therefore, a GIS can combine geographic and other types of data to generate maps and reports, enabling users to collect, manage and interpret location-based information in a planned and systematic way. Such technology may be accessed via the use of Global Positioning Systems (GPS) which is available in most mobile devices available today especially in cell-phones and smartphones, this is referred to as Mobile Geographic Information System (mobile GIS).

Mobile Geographical Information System (Mobile GIS) is a Geographical Information System based on mobile computing and mobile Internet (Li et al, 2002). It is not a conventional GIS modified to operate on a smaller computer, but an extension of Web GIS to mobile Internet including wireless Internet/Intranet and mobile communication network. But architectures of On-line Spatial are unsuitable for Mobile GIS, because of several bottlenecks such as the low-bandwidth of wireless network, the diversity of mobile devices, limited processing power and screen display limitation of mobile devices and the diversity of mobile system platform (Wei et al, 2002).WAP-based Mobile GIS can be described as mobile users can perform the almost same functionality as of On-line Spatial but in a mobile environment at any time, any place and without the limitation of operating system and wired link.

The trend in cell phone development and usage in the world and in Nigeria today is breath-taking. Mobile phones have drifted considerably from the big, large-antennae, unattractive GSM phones to trendy, beautifully carved multimedia phones, and now to the amazing world of multi-function, intelligent smartphones (Falaki, 2002).A smartphone is a high-end mobile phone that combines the functions of a personal digital assistant (PDA) and a mobile phone. Smartphones recently add features of PDA such as portable media players, cameras with high-resolution touchscreens, web browsers that can access, and properly display, standard web pages rather than just mobile-optimized sites, GPS navigation, Wi-Fi and mobile broadband access. The key features of smartphones include: web access, mobile application, an operating system, messaging facilities, touch screen/QWERTY keyboard. This paper is focused on the development of a Mobile GIS-based road offence monitoring system for the officials/managers of the Federal Road Safety Commission (FRSC) in Nigeria which will aid the storage and retrieval of relevant information on road offences alongside with visualized information which gives a better understanding of the information in a geographical context, thereby enhancing the decision making process.

2. RELATED WORKS

2.1 Road Offence Monitoring Systems

Road offence monitoring is the continuous process of keeping tabs on the development of the roads and the users of such roads. It involves the observance of all activities taking place on the roads with the aim of reducing disturbances on the road like; traffic congestions, road accidents, indiscipline on the part of road users and also punitive measures taken to ensure that law and order is maintained by all users of the road. A number of technologies has become available for the purpose of monitoring road traffic and offences on the roads, a few are addressed as follows:

a. **Intelligent Traffic Systems (ITS)** utilize ICTs to manage driving, traffic, transportation and all factors that are important in one way or the other to transport safety, design and education (Figure 2.2). ITS systems could be in-vehicle systems, or external infrastructure support. Interfacing road infrastructure hardware with in-vehicle warning and control systems is another road safety groundbreaking technology.
b. **Point to point communications (PPC)**enables Road safety officials to use high-speed radio systems to communicate between multiple locations and for vehicle-to-vehicle driver communications. Radio frequency (RF) channels, allocated by the telecoms regulatory body (the Nigeria Communications Commission NCC, in Nigeria's case) are meant to be used to communicate from one location to the other among mobile road users.
c. **Wireless networks (Wifi and WiMAX):** Hand-held, portable electronic devices leverage existing cellular and private wireless networks to provide a one-touch access to traffic data, weather condition reports, transport news, etc. The efficiency of the systems builds on the currency of their data which updates in real-time and fully accessible from web applications within contemporary smartphones, blackberries, android, iPad and other handheld electronic devices. Widely-used wireless standards include the Wireless Fidelity (Wifi) and Worldwide Interoperability for Microwave Access (WiMAX) with varying supporting features (802.11b,g and 802.16e respectively).

d. **Web-based road safety portals** which are expressed as websites are the single most important component of the internet which has given the internet its flare, glamour, fame and global relevance. The web represents the huge volume of resources, multimedia content and data bank which are limitlessly accessible using client browsers, and other web applications through networking technologies. Road safety web portals enable the continuous publication of interactive resources which can equip stakeholders with vital statistics concerning the true nature of traffic conditions, accident spots, nearby health institutions, and real-time distress calls. For effective road safety operations, the use of internet technologies provides an online data interactivity for the sharing of vital statistics among stakeholders in absolute real-time.
e. **Automated Emergency Call System (eCall)**: In alliance with reputable mobile network providers, the eCall is a communication system that designates a unique telephone number (often toll-free) exclusively for reporting emergencies and distress conditions. eCall can also be integrated into web-based road safety portals to give it wider access beyond the bounds of the cellular network's coverage area.
f. **IP-based CCTV and surveillance cameras:**Traffic Closed Circuit TV (CCTV) systems integrated together with surveillance cameras are video-based vehicle/motion detection systems used for remote surveillance of traffic situations to track offenders, to build usable traffic data and to provide an archive for future road transport enhancements (Figure 2.3).
   Specifically the use of Internet Protocol (IP) based CCTV systems and surveillance cameras introduces a lot of interactivity in the remote manipulation of the cameras, and also eases the task of searching for specific reference scenes. Under special investigative cases, the versatility of IP surveillance cameras enables them to replay specific traffic offences highlighting scenes of interest. This helps to enforce road safety compliance, curb recklessness, and also to improve the efficiency of road traffic personnel in apprehending offenders.
g. **Speed monitors:** Strategically positioned along highways, speed sensors are two-way electronic communication devices that estimate the relative speed of road vehicles, and compares it with the stipulated speed limits. In advanced implementations, any speed over-shoot beyond the stated limit triggers a zoom-in from the nearest camera and the vehicle is instantly traced while video capture/recording is automatically activated. A signal is also instantaneously relayed to a nearby patrol team and such a vehicle can be followed and the driver quickly apprehended. A very beneficial refinement to the applicability of speed monitors is the automated accumulation of points by such drivers which could add up to lead to a license withdrawal
h. **Car navigation systems (Driver support systems):** These are a range of intelligent systems that warn the driver based on information received from a central database or other environmental interpretations of what may appear to be adverse condition that may lead to a crisis if no precautionary measures are taken. Such warnings may include bad weather, obstructed lanes, speed limits, slippery lane, etc.

2.2 Road offence monitoring globally

Concerning the applications used for reporting traffic offences on the roads, Peytchev et al (2001) proposed asupervisory traffic decision support system that connects with real-time traffic control system which serves the Nottingham city. They based their design on Distributed computers Memory Environment DIME where real-time traffic data are send in a fast manner to a centrally control database. They introduced a decision support system that reports results acquired in the process of building the prototype. The system also used a variety of approaches such as Short Message Service (SMS), Wireless Application Protocol (WAP) and TCP/IP connection and is design in such a way that the GIS subsystem and the telecommunication subsystem can transmit on-line passenger data to mobile devices. Inmon (2003) noted that in United States of America, the Model State Traffic Records System (MTRS) was developed to integrate information now stored in different forms and systems through the state, to integrate operations of various agencies and to reduce duplication of effort by different entities. MTRS also aids in comprehensive planning and evaluation.

Highway safety problems are isolated by applying accident and UTC data supported by roadway environment, driver, and vehicle background information to:

a. location analysis techniques to identify hazardous locations;
b. standard statistical analysis techniques to identify patterns that indicate possible problem areas and details of the MTRS data base are summarized.

The Traffic Records System Inventory is provided as a service to the public and in particular those within the highway safety community. It represents the best available information about each of the traffic safety data systems within each state and territory. The information contained in the Traffic Records Systems Inventory drawn from a database containing basic information about the traffic records systems within each state and contact information for each state system. States are encouraged to update theirpages at least annually. According to Bala et al (2012) a Wireless Access Protocol (WAP) capability in transmitting traffic offences in Malaysia was developed. The system was developed to correct issues relating to the collection of fines relating to traffic offences which has always been a problem due to the improper checks and balance system that is put in place especially in curbing traffic offences committed by Singaporeans who are suspected of being major road violators. The system was developed to correct the deficiency of real-time processing capabilities that are lacking in the existing Automated Vehicle Scanning System (AVSS). The study involved the development of a prototype application that integrates the Mobile and Web application that transmits data to the road traffic agency and updates in a real time thereby minimizing the loss of revenue and equipping law enforcement agents with the required tool necessary to apprehend traffic offenders.

2.3 Road offence monitoring in Africa

In Uganda, the Traffic Case Records Information System (TCRIS) is used in the storage and retrieval of traffic cases in the traffic department of the Ugandan Police. The initial method used to manage traffic cases was manual; information collected daily is written on paper and stored in files for reference, thus making the captured cases susceptible to loss, easy accessby unauthorized people and destruction (Mubaraka et al, 2013).The system captures thedefaulters' bio data, traffic offence committed and the charge for the traffic offence. The TCRMS makes the use ofthe camera that captures the photo of the defaulter and the biometric gadget that captures the defaulter's thumb print for police reference. All these are centrally stored in the database but are sharable with migrations department, Bank of Uganda (BoU) and Uganda Revenue Authority (URA) which government departments work closely with police in regard to such offences. The system is thus user friendly in the way it inserts, retrievesand updates user information.

2.4 Road offence monitoring in Nigeria

Traffic control and management remains a challenge in densely populated cities and towns worldwide (Ogunsanya, 2004). Although, a number of developing and developed nations have made concerted efforts to reducing traffic congestion, Nigeria seems not to move in any direction. In spite of all the existing traffic laws and regulations to curb the increasing rate of traffic offences and violations on the Nigerian highways, thousands of motorists are apprehended daily and sanctioned for various traffic offences on the roads. Traffic offences are a major cause of road congestion on Nigerian roads and also the cause of the increasing number of accidents resulting in the loss of innocent lives on the roads (FRSC, 2012). The Federal Road Safety Corps is the lead and coordinating agency for road safety management in Nigeria. This status has conferred on the FRSC the responsibility of playing its role as the key driver of all road safety efforts in Nigeria. While this is essential for achieving the goal of the safe system approach, unfortunately it has become unattainable due to its current involvement in managing road safety at operational level, a position it shares with several other agencies also duly empowered to perform similar functions.While a shared road safety responsibility provides the benefits of coverage where cross-functional gaps exit, it portends the dangers of role- submergence and conflictwhich may arise out of competing interests.

It is disturbing to note that such conflicts currently characterize road safety activities in Nigeria. The Nigeria Police

Force is constitutionally empowered to act as the primary enforcement agency of all traffic laws and regulations of the Federal, State and Localgovernments in the country; this function it performs through its Motor Traffic Division. Thus like the FRSC, the Police carries out road patrols, vehicle checks, and prosecute traffic offenders (Sumaila, 2001). The Vehicle Inspection Officers (VIO) is constitutionally mandated to issue and renewLicences for all private and commercial vehicle drivers, and issue such permits as Hackney Carriages, Stage Carriages, and Goods Carriages (Ogunsanya, 2002). They also regulate fares and register new vehicles and keep a register of such in all states of the Federation. It is with this body that FRSC faces the greatest conflict especially in carrying out some of its important road safety activities. There are other Federal Ministries (e.g. Transport, Works), State Ministries e.g. Works and Transport; Transport Regulatory Authorities; Local Government Councils; and Trade Unions e.g. National Union of Road Transport Workers (NURTW) who are empowered to play either a persuasive, preventive or punitive safety roles in the country (FRSC, 2012).

2.5 Existing Road Monitoring System

A number of study has been made in the area of road monitoring systems but quite a few has emphasized the use of GIS systems in tackling the problem of road offence monitoring. Most of the related work are also limited to the hardware as the major source of data capture especially in traffic monitoring area. For a road offence monitoring system, such offenders have to be apprehended and the information about the offender is collected by interrogation and filled into a notice of offence sheet (FRSC, 2012). Peytchev (2001) proposed asupervisory traffic decision support system that connects with real-time traffic control system which serves the Nottingham city. The design was based on Distributed computers Memory Environment DIME where real-time traffic data are send in a fast manner to a centrally control database. Decision support system was introduced that reports results acquired in the process of building the prototype. The system also using variety of approaches such as Short Message Service (SMS), Wireless Application Protocol (WAP) and TCP/IP connection, is design in such a way that the GIS subsystem and the telecommunication subsystem can transmit on-line passenger data to mobile devices.

Akomolafe et al (2009) enhanced road monitoring and safety through the use of geospatial technology with the use of GIS and GPS technologies. The GIS tools were used to perform the five steps of data acquisition, manipulation, pre-processing, management and analysis using the GPS receiver to record the coordinates of the roads around parts of Nigeria. The coordinates which were collected as geodetic system were then converted to UTM system. GIS software was then used for geo-referencing the roads to the coordinates which is digitized in order to produce the object map. This system makes it possible for road traffic officials to store information on the exact location along the road where a road offender is arrested. Bala et al (2012) explored Wireless Access Protocol (WAP) capabilities in transmitting traffic offences in Malaysia. The system required the development of a prototype application that integrates the Mobile and Web application which transmits data to the road traffic agency and updates in a real time. The application minimizes the loss of revenue and equips the traffic law enforcement agent with a tool to apprehend offenders. It also gives the assurance that offences are easily reported even at the peak periods when other traffic detection devices will not stand the congestion.

Crnišanin et al (2013) proposed architecture for the integration of GIS and GPS for vehicle monitoring. The GPS serves as the data capture mechanism for information of vehicle position at the moment of observation, spatial database part for storing the information after some refinement process before it moves to the GIS subsystem. Using SQL expressions, spatial queries are able to determine spatial relationships (distance, adjacency, containment) and also to perform spatial operations (area, length, intersection, union, and buffer). Although, the implementation is simple and with low implementation cost, such systems that connects GPS and GIS technologies for vehicle monitoring system have a great future in the transportation building block for all future open source spatial projects.

3. METHODS

The prototype was developed from an already manual process of road offence monitoring by the FRSC in Nigeria. This prototype uses the Conceptual Data Model for road offence monitoring system described in the previous section. The model was designed for developing a road offence monitoring system useful in tracking road offences in the South-western part of Nigeria. The development was done using SQL, PHP, jQuery, JavaScript, XHTML.

4. PROTOTYPE IMPLEMENTATION OF THE ROAD OFFENCE MONITORING SYSTEM

The web-GIS based road offence monitoring system is developed with many existing technologies and industry standards that supports interoperability between the various hardware and software components of the system. These technologies and industry standards enable seamless communication between the various system components. This helps to achieve a fully integrated and automated system. The purpose of the implementation is to prepare and produce a system that can captures road offences from the roads across the south-west part of the country and help monitor the distribution of the offences committed in certain locations to reduce the frequency of their occurrences.

The system architecture was proposed for the web-GIS based road offence monitoring system. A user-friendly web browsing software that guides the user of the system is required. All operations conducted on the field data collection system employ a web-based interface. This interface format was chosen over a proprietary application because it allows inherent cross-platform compatibility and relatively simple page creation and modification. This interface also communicates effectively with mobile devices like GPRS/3G mobile phones, PDAs and smartphones.

4.1 System Architecture

System architecture provides the framework for an interoperable, standards-based, secure exchange of protocols, resources and devices for the functionality of a system (Muralidhar, 2009). The system architecture of the On-line Spatial road offence monitoring system is divided into four sections namely; the hardware, software, security and network architecture.

The hardware components of the proposed system uses n-tier architecture where n is any number greater than one. In this type of architecture, the application is hosted on a web server while the database was hosted on a database server residing on another server (in this case, the Google map server). The application can be accessed on a client work station via a Uniform Resource Locator (URL) that points to the application directory on the application server but for the field official a mobile application API was used to interface him from any location as long as there is internet.

In the proposed system, the structure of the system was exposed while some of the implementation was hid from the users. The system was developed following the use case scenarios as stated above in the Use case document. Web Application is preferred to other forms of applications in designing the road offence monitoring system for all other stationary FRSC officers located at the offices and a mobile application developed for the mobile Field marshal for data capture in this thesis because such applications are more accessible, the HTTP protocol used is a standard protocol that can run on many platforms, they have a lower maintenance and deployment cost as it uses the Internet's infrastructure to deliver its functionality (Ziemer, 2002).

Figure 4.1 describes the system architecture used in the design of the proposed road offence monitoring system. The user(s) of the road offence monitoring system such as the commanding officers, FRSC officials and administrators use the web browser as the interface to get access to the road offence monitoring system while the field marshal uses the mobile application to access system functionalities. Both techniques transmits the user's action to the web server, sending the requests using the HTTP protocol.

The web server determines if the request can be fulfilled directly, otherwise the Web GIS applications server must be invoked. The Web GIS applications server communicates with the GIS Web Server which in turn communicates with the Spatial Database Server to store information that is input by the system user. Also, if the user wants to query data from the database, the Web GIS applications server must be invoked and follow the same route of HTTP requests to get the output results.

Finally, the On-line Spatial applications server with the expected result set from the application server generates the web pages that are returned to the user. In a road offence monitoring system, there should be secure exchange of health data amongst party members i.e. commanding officers, FRSC officers, field marshals etc. There must be security in place during the design of the system. Data security relating to security and confidentiality of personally identifiable information, including personally identifiable road offence information must be maintained or collected to prevent inappropriate release to unauthorized users(Dept ofInformation Resources, 2012). Data and Information security for the proposed system is implemented both on the hardware and software components. On the Software, User Authentication and Authorization is mandatory before having access to the application system, this ensured that every authorized user of the system has a unique username and password that must be validated before logging into the system (Gluscevic, 2003). Also, data encryption is also implemented to hide the meaning and details of sensitive information from unauthorized personnel.

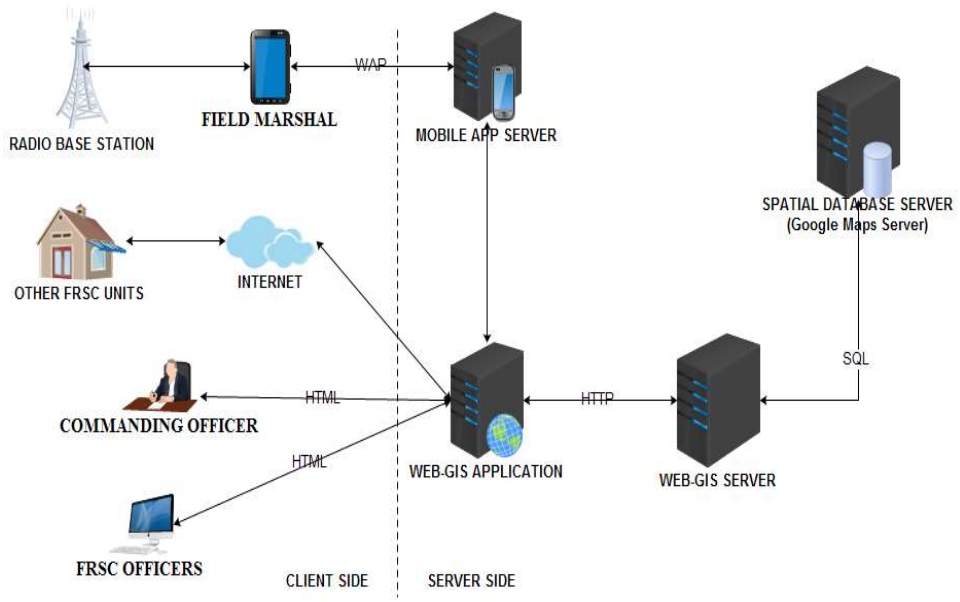

Figure 4.1: System Architecture of the Road Offence Monitoring System

4.2 Prototype of the Road Offence Monitoring System

The web-GIS based road offence monitoring system allows information relating to road traffic offences to be stored, accessed and modified. There are four essential parts of the web-GIS based road offence monitoring system that will be used during the implementation: a RDBMS (Relational Database management System), a WAMP server, a Common Object Request Broker Architecture(CORBA).

The database is developed based on a minimal physical schema derived from the logical schema of the Conceptual Disease Monitoring and Surveillance System Model (Furlani et al, 2009). The CORBA is used as the underlying communications infrastructure; allowing users to connect to the web based GIS HIV/AIDS surveillance system server and get information to and from the database.

Home page and Login Modules

Figure 4.1 gives a display of the home page for the web application portal when accessed by the FRSC officers located at the office. All users have to login with their username and passwords before they can be allowed to access information stored on the system. Figure 4.2 shows the login page for the system administrator before he/she can perform any tasks. This is because all the information that has been captured by the system through the field marshal remains confidential to members of the FRSC.

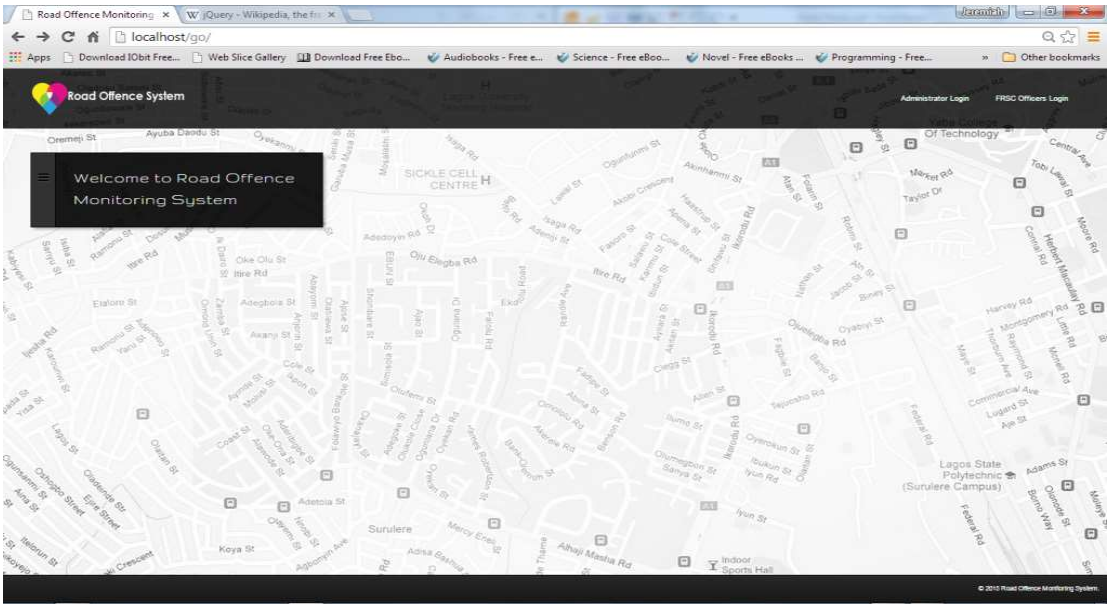

Figure 4.1: Home page of the road offence monitoring system

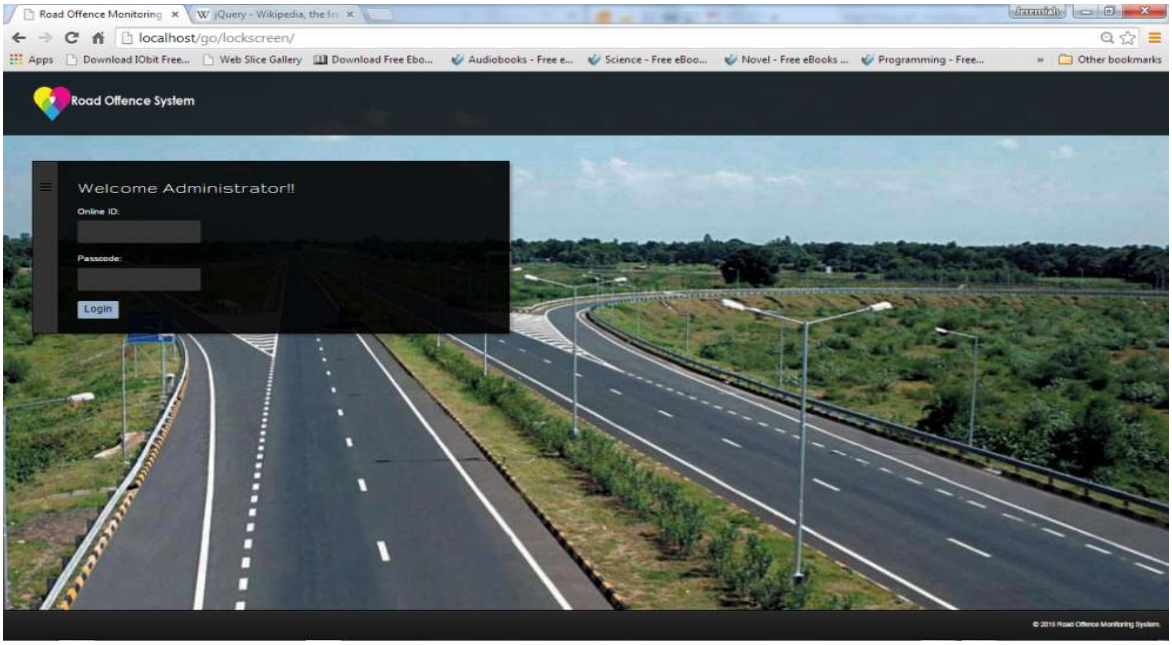

Figure 4.2: Login page for the administrator

Data capture module

The data capture model is the interface via which the information on road offence is being collected and stored on the road offence monitoring system. This information is captured with the use of the mobile device which is used by the field marshal upon which the mobile road offence monitoring system application is stored. As soon as the information is stored by the field marshal, the spatial database is updated in real time with information on the reported offence (Figure 4.3).

FRSC Officers' Registration Module

As earlier discussed, there is no way in which anybody can access the system without initially being registered by the system administrator. The FRSC officers' registration modules is very important for all users – no unregistered user can be able to access the system nor perform any kind of action on the system. The registration requires information like: the officer's name, sex, date of birth, rank, command, designation, data of appointment, phone number, address etc. (see Figure 4.4).

FRSC Officer Details Module

The FRSC details module allows super users like the administrator to view the profiles of all registered users of the system. The administrator from here can retrieve any information about all users as long as such information is made available in the system. Only the system administrator can access this kind of information, since it is only the system administrator who has the right to create profiles for all users (Figure 4.5).

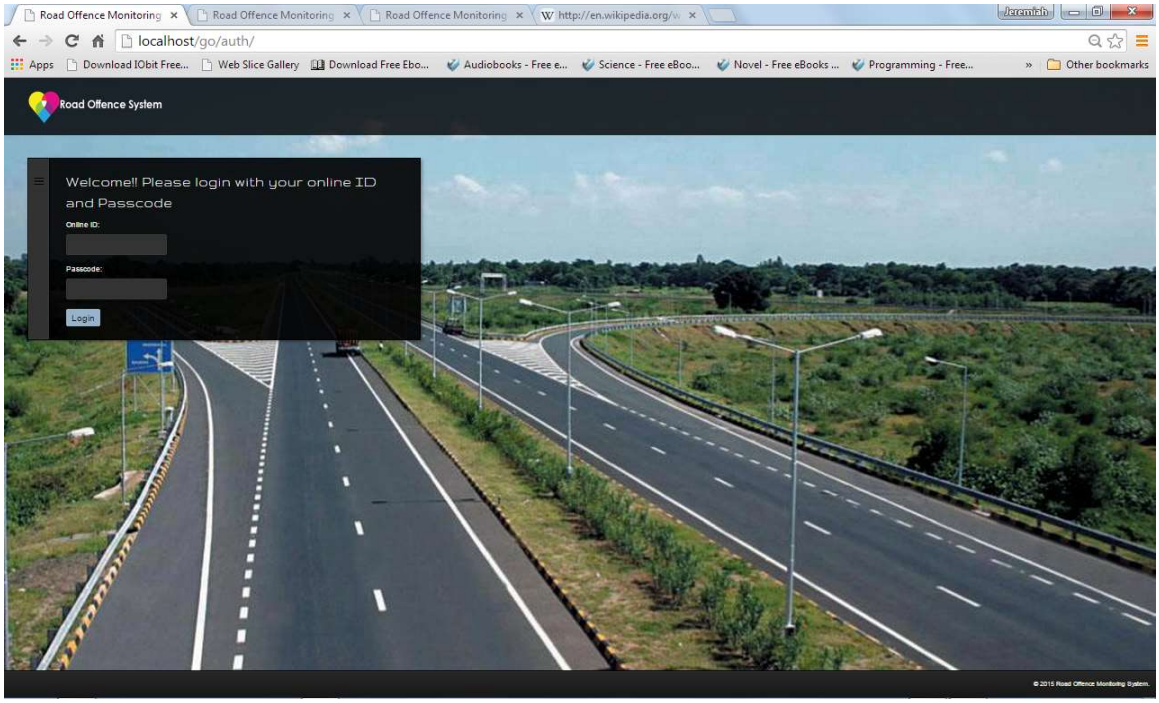

Figure 4.3: Data capture page used by the field marshal on the field

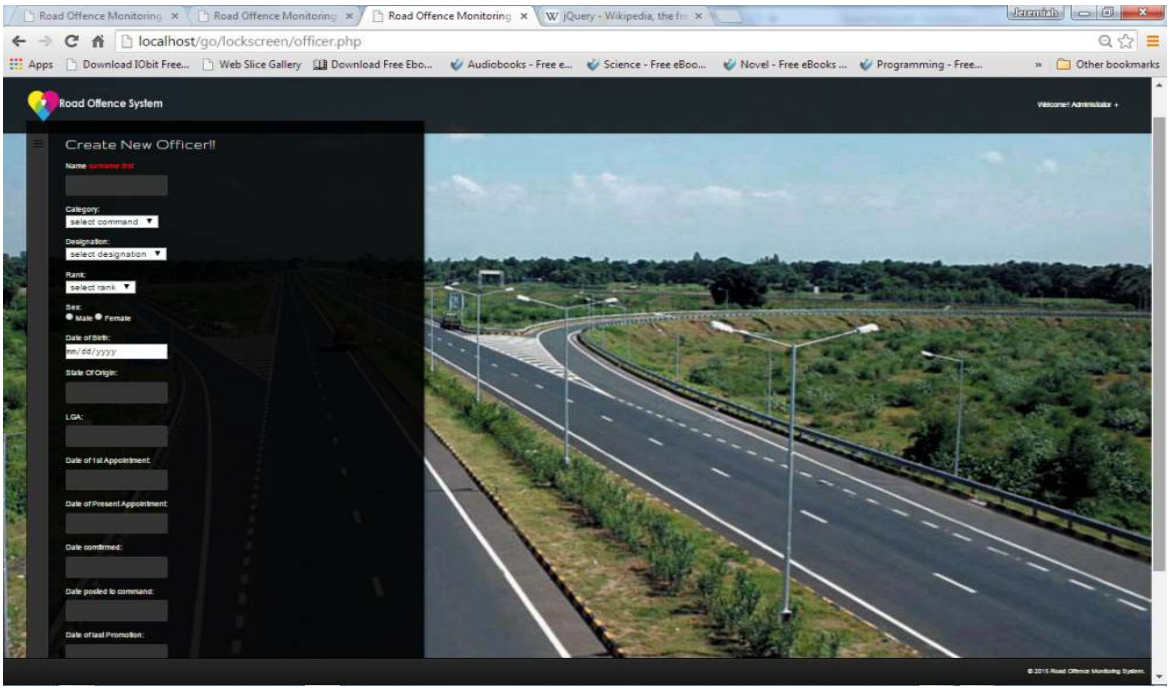

Figure 4.4: Register FRSC officer module

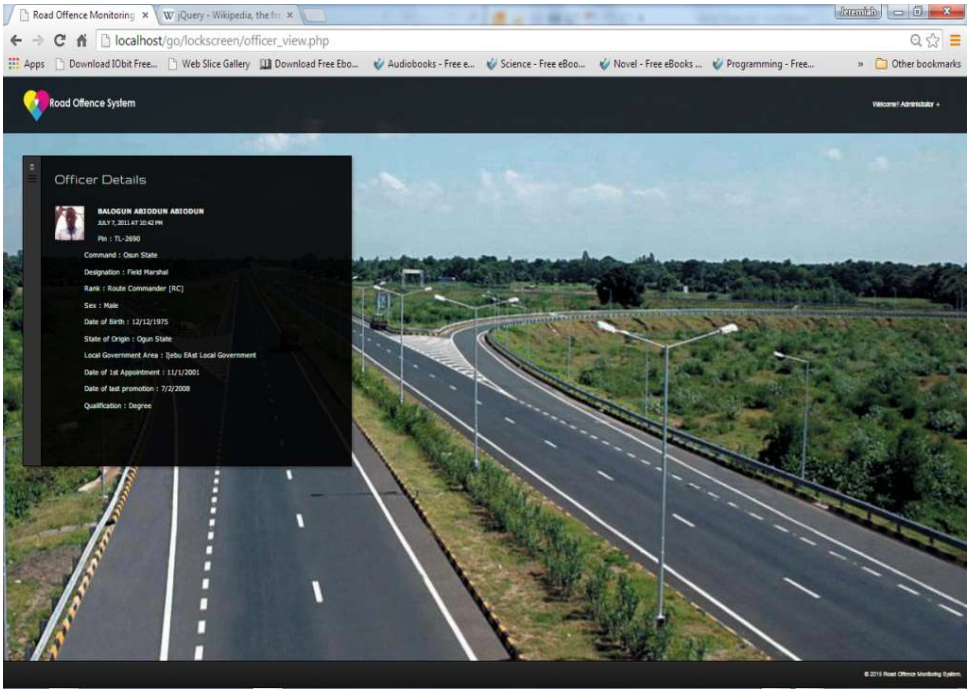

Figure 4.5: View FRSC officer's details module

Change password module

Whenever the system administrator creates a profile for all users, it is important that all users change their default password provided by the administrator. When the system administrator also accesses the system for the first, whatever username and password used in accessing the system becomes the default username and password which can also be changed to a preferred password if need be (Figure 4.6).

View Road offence module

All system users have the right to access any information needed on the road offence monitoring system, as long as it is that the person is a valid and registered user. FRSC officers, commanding officers and field marshals can view the reported road offence which is made available by the field marshal via the mobile application made available to him/her. Figure 4.7 gives a display of the geographic image while Figure 4.8 gives a representation of the map showing the location of the offence as a red marker on the map. The information on the left hand side of the window is a summary of the information relating to that particular road offence and the offender in question.

Pending Notifications module

The pending notifications page allows the FRSC officers to be notified the moment a new report has been made about a road offence. The notification can be accessed by all users of the system including all field officers, if the information was reported by other field marshals in a different unite under the sector. The notifications provide information on the offender and category of offence committed (Figure 4.9). The moment the pending notification is clicked, the system shows the view road offence module for the reported offence.

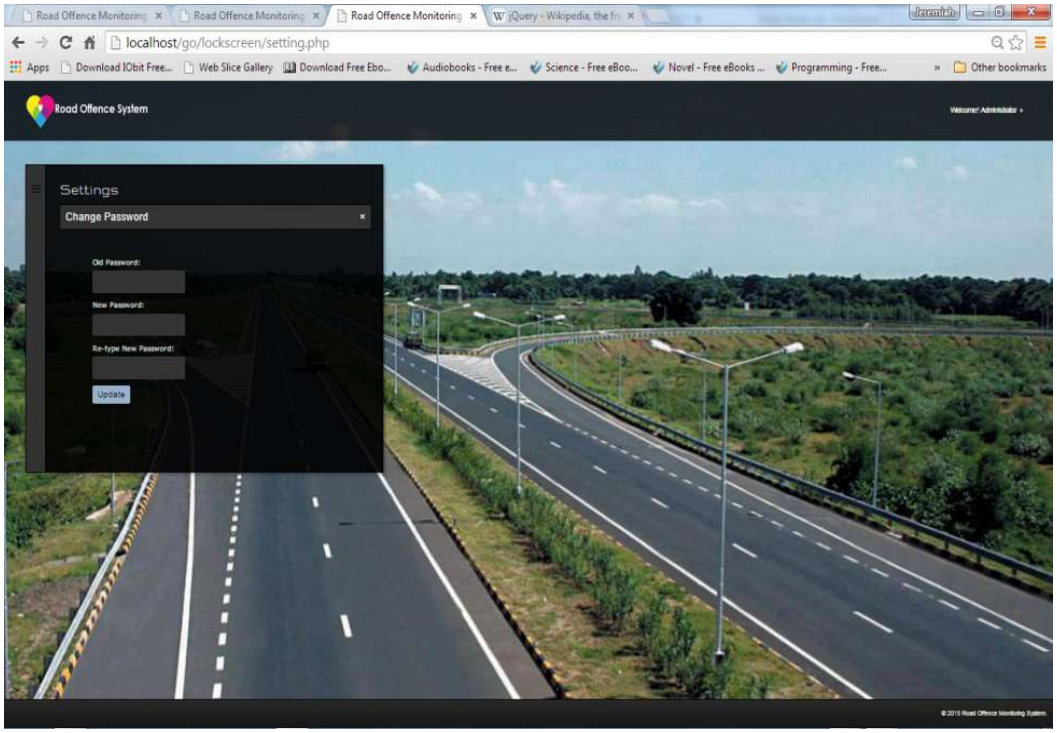

Figure 4.6: Change password module

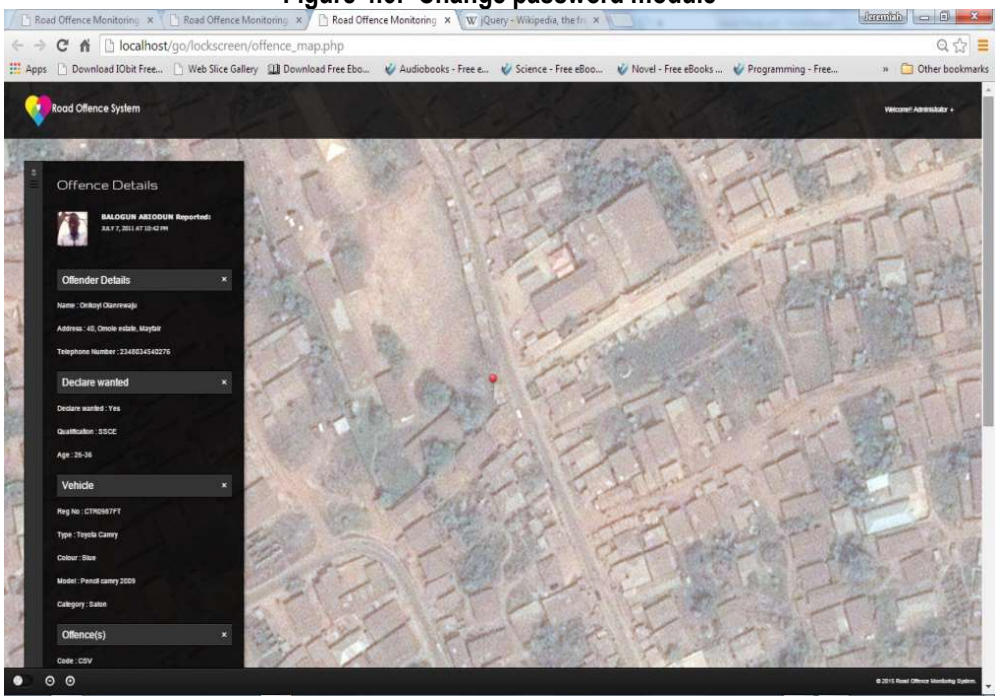

Figure 4.7: Satellite image of the location of a road offence

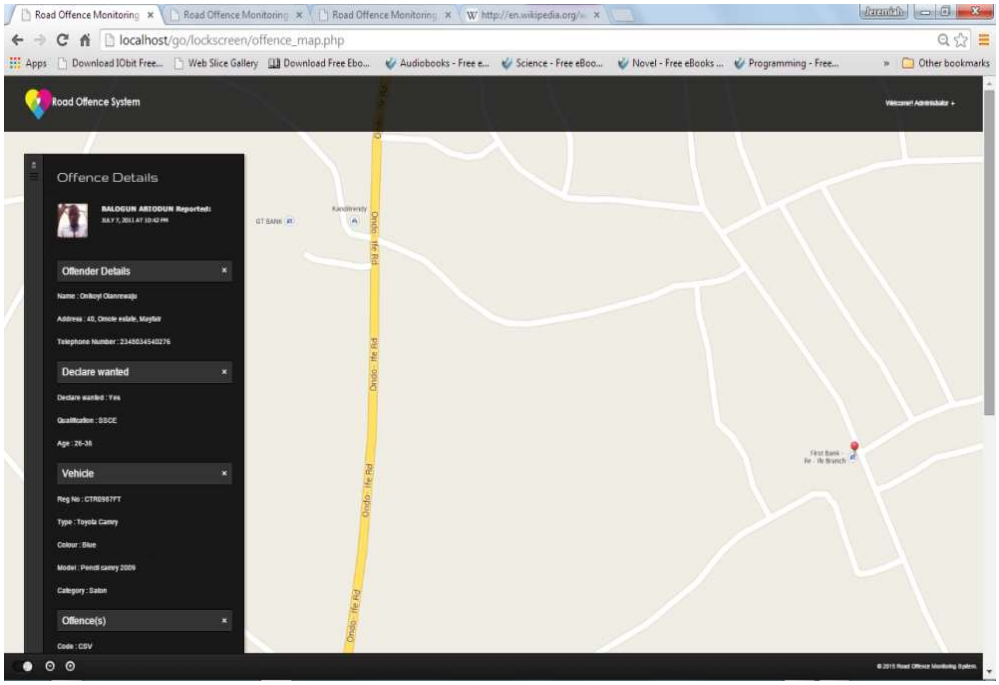

Figure 4.8: Map showing the location of a road offence

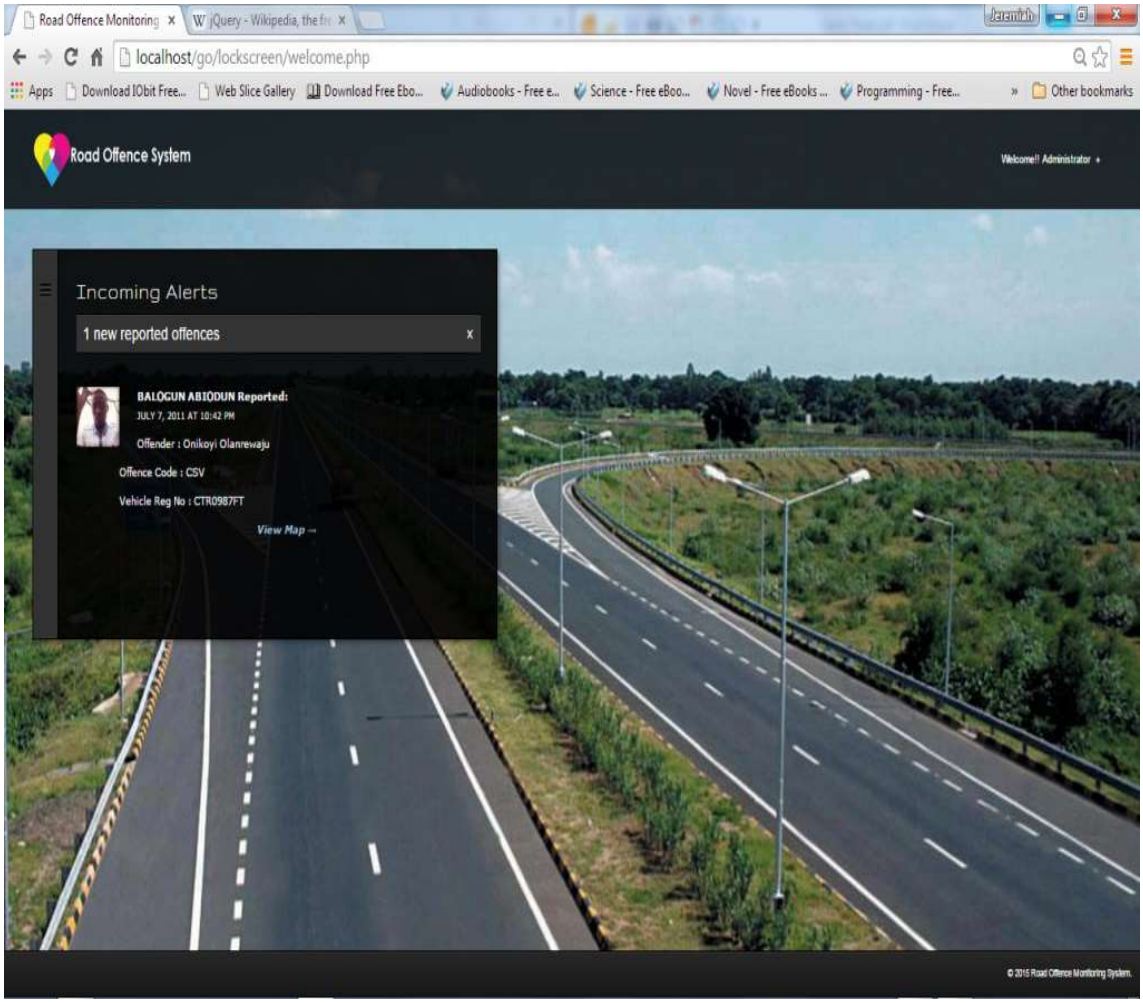

Figure 4.9: Pending notification of a road offence just reported

Data query module

The data query is that part of the system where all users can query the road offence monitoring system for all sort of information. For example, if an FRSC field Marshal encounters a road offender on the road who claims to be a first offender, the person's information can be retrieved if available using either his/her name, driver's license number or the vehicle license plate number. If such a person is not found on the database then such a person is a first offender and the FRSC is official is left to use his/her discretion in handling the case (Figure 4.10 and 4.11).

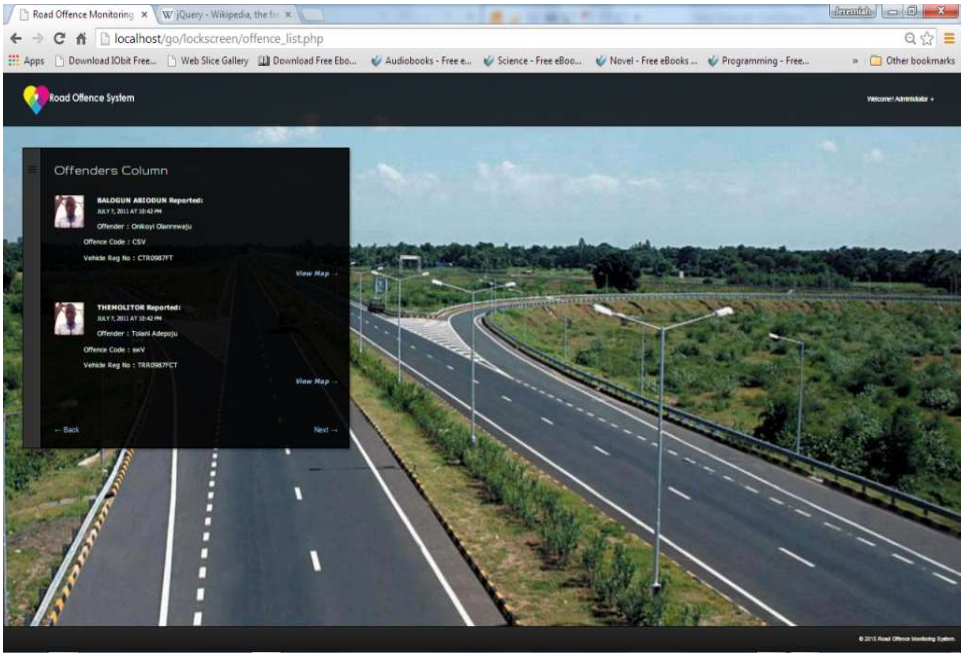

Figure 4.10: Query results for the road offence committed by an offender

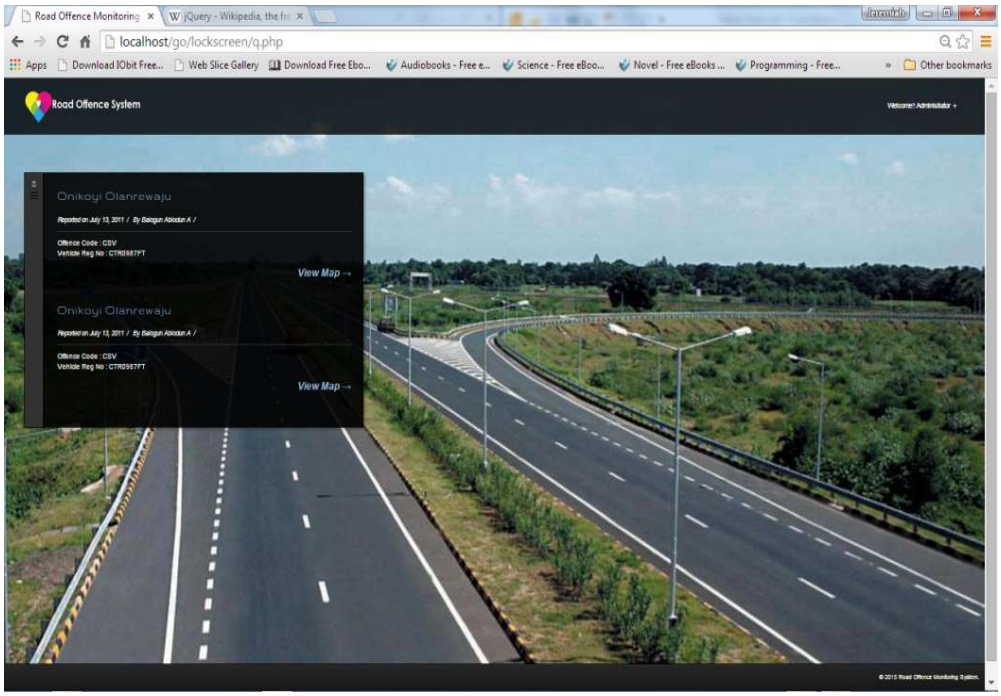

Figure 4.11: Offender query results for those that committed CSV

4.3 Discussion

The proposed road offence monitoring system was developed as discussed earlier to facilitate the easy storage and retrieval of road offence-related information which can be easily accessed by Officers of the FRSC who are registered to the system as authorized users. This system will also act as a means of providing effective and timely information concerning the state of road offences in Nigeria, given the information found therein. The system also allows users to query information from different locations in South-western Nigeria form the units all to the sector commands. This system will be very useful to Nigeria as a result of the kind of information that is stored in the system.

With the road offence monitoring system, road traffic managers and maintenance officers etc. will be able to access the information available in the system as long as they are registered. The information provided to these people may also be helpful in facilitating new policies that may help improve the state of Nigerian roads at large. In general, the road offence monitoring system can become a central repository to all road and traffic managers across Nigeria with all information relation to road traffic and road offence stored in one single portal where analysis can be made to identify the kind of relationship that exist among the data stored.

As a result, of the internet, the information available in the road offence monitoring system can be made accessible by other stakeholders of the Transportation sector which could help justify actions relevant and important to the development of the Transportation sector and also reduce the rate of road offences committed by Nigerians daily.

5. CONCLUSION

In conclusion, the On-line Spatial road offence monitoring system was developed using a mobile application for data capture and a web portal for data retrieval and processing by the users of the system. The web application is responsible for sending messages to and from the GIS server which in turn communicates with the Google Maps resource via its API so as to facilitate an optimized mapping interface. Google map was chosen due to the short development time needed to develop a spatial database from the scratch which may not be as optimized as Google's Map.

The development was done using SQL, PHP, jQuery, JavaScript, XHTML etc. al chosen for their simplicity, portability, interoperability and they are free and open source technologies. The system was designed and developed to capture road offence information such as offence type, offender name, offence location, prosecuting officer, time of arrest, offender's gender etc. the proposed system developed in this paper will provide a road offence database which will enhance the monitoring and surveillance of any disease in the Nation.

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