PUBLIC TRANSPORT MANAGEMENT SYSTEM: A PROTOTYPE PSV TRACKING AND MANAGEMENT SYSTEM FOR NAIROBI CITY

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Abstract
Vehicle location based services and tracking system available in Nairobi city mainly focus on private car owners, fleet management for various organization and cargo tracking. On the other hand, public service vehicles (PSV) have not attracted much attention of the car tracking companies. Public transport in Nairobi city is generally characterized by a lot of chaos; these ranges from poor management of the vehicles, traffic congestion, reckless driving and unreliable service provision. PSV owners have been victims of rogue operators who do not submit their full revenues thus greatly reducing their profit margins thus escalating their business running costs. The main objective of the project was to develop a customized location based service that caters for the needs of the public transport sector in Nairobi city. The project demonstrates development of a prototype open source solution for management of public transport in Nairobi. The solution uses GPS, web GIS and GPRS technologies for real time transmission of coordinates from the tracking device to the central database server and finally rendering on the web page. The development process of the system entailed the analysis of existing systems in the city, system design and development, evaluation and implementation. OpenGTS (Open GPS Tracking System) platform for tracking was adopted and customised to the needs of public transport in Nairobi.The research provides a cheap solution for effective management of public service vehicles by preventing vehicle misuse. The final solution comprises of a web based application, android application and customized query interface. The web based application provides graphical visualization and the customized queries while the android application used by the vehicle operator to update non spatial the database.

Key words: Tracking, GIS,PSV,OpenGTS and android

1.0 Introduction

Vehicle location based services and tracking system available in Nairobi city mainly focus on private car owners, fleet management for various organization and cargo tracking for instance G4S fleet management and Auto Track company. Public transport vehicles (PSV) have received little attention of the car tracking companies. This can be attributed to the chaotic nature of public transport mode in the city and high initial cost of investment in an efficient public transport management system. However, with the reduction of the cost of the GPS tracking devices, development of web GIS technologies and mobile GIS; an affordable solution for management of public transport can be realized.

The main objective of the project was to develop a customized location based service (LBS) that would cater for the needs of the public transport sector in Nairobi city. The project used GIS open source application both in desktop computers and android mobile devices to present a solution for improved management of public transport in Nairobi. The ubiquitous nature of internet in the city through cell phone network and mobile GIS provides a great platform for management of public transport with minimal supervision.

Recent developments in geospatial technology have led to emergence of Global Positioning System (GPS)-enabled cell phones and mobile devices which have promoted growth of location- based services (Daisuke *et al.,*2010). Daisuke et al also explains that integration of GPS with Geographic Information Systems (GIS) is efficient for logistics, fleet management emergency medical services, rescue, and relief work.

Daisuke et al, 2010 further explains that accessing LBS calls for the use of customized devices or cell phones with their own closed proprietary protocols or closed source code. The devices cannot be modified and can be only used for their particular purposes. Therefore, it is difficult to develop or tailor LBS that could meet a wide variety of application scenarios and users' needs. However the android platform provides a standard coding environment for various mobile devices. This can be effectively be harnessed to provide LBS to the mass android market and address the management problems encountered in the transport industry.

The existing transport system in Nairobi been greatly influenced by population pressure and urban structure (KIPPRA, 2006). The profile of urbanization in the city is mainly affected by geographical, historical and contemporary factors. Inadequate urban planning is also a challenge that is indirectly affecting transport in the city. Most of the current challenges in urban road transport in Nairobi City can be attributed to the high population growth rate, high energy costs, poor utilization of infrastructure facilities, low vehicle capacities, location of high density residential areas and lack of organized public transport (KIPPRA, 2006).

Public transport in Nairobi city can generally be said to be characterized by a lot of chaos; these range from poor management of the vehicles, traffic congestion, reckless driving and unreliable service provision. Public service vehicle owners have been victims of rogue operators who do not submit their full revenues thus greatly reducing the profit margins with high business running costs. The main concerns of the vehicle owners is the lack of clear policies governing and the many agencies controlling the sector ranging from the police, the Transport Licensing Board , the Nairobi City Council and the cartel that man various terminals. Corruption is also another issue that business men in the public in the city especially with the police.

1.1 Tracking Technology Overview

In the market today, there are various navigation solutions of different forms. The tracking systems either operate in client-server or as standalone desktop mode, (Mantoro T., 2012). Majority of the client-server systems are designed to provide tracking only. The client-server system is cheaper while a standalone solution will give better performance in terms of time of response. It's convenient to upgrade geo-information in a client-server environment. The upgrade can be done at the server end. In a standalone solution, geo information needs to be upgraded in each instance of the application making the process costly especially if the many people need to be served.

Daisuke Y. *et al,* (2010) explains that tracking service providers keep the location information in their own database. Users access this information, sometimes over international telecommunication infrastructure, and pay per access. He further states that, SMS (Short Message Service) available in mobile networks is another mode of information transfer available in such systems. In these systems, the user organization has limited flexibility and has to bear a relatively higher cost. There are many "open" applications that have been developed to support LBS. One of the solutions for Web- based GPS tracking management system is the OpenGTS("Open GPS Tracking System").OpenGTS is the first available open source project designed specifically to provide web-based GPS tracking services for a "fleet" of vehicles It provides Web-based mapping, report services, authentication, and other useful functions, (Frantz C., Mariusz N. and Martin K. 2012).

2.0 Methodology

2.1 Overall Approach of the Project

The project explores the viability of using open source software and Android operating system to manage public transport in Nairobi city. The overall approach of the project was as shown in Figure 1 below. Problem definition reviewed the general challenges of transport and the specific huddles facing PSV sector in the city. After this the research objectives and questions were developed followed by literature review where related research was reviewed. In research design an interview questionnaire was designed followed by focus group discussions for data collection. The system addressing the challenges realized from the data collection was developed and the resulting system discussed.

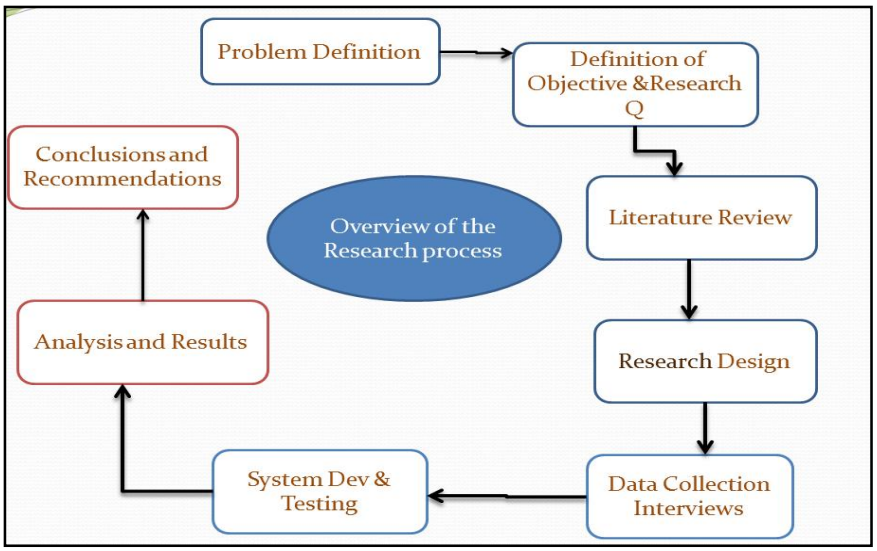

Figure 1: Overall Approach of the project

2.2 Overview of the System Development Process

The system development process was classified into four broad stages as shown in Figure 2 below. The first stage of the project was the inception phase that involved consultation and discussion with various stake holders to get information on how existing public transport services were being managed in the city. These shed light on the prevalent challenges of public transport in Nairobi. The discussion also provided an assessment various needs of public service vehicle in the city. An inquiry was also made to determine the current intelligent management systems available in the city and how open source tools have been used. The companies that were consulted include City Hoppa, Kenya Bus Service, Double MM and Matatu Owners Association.

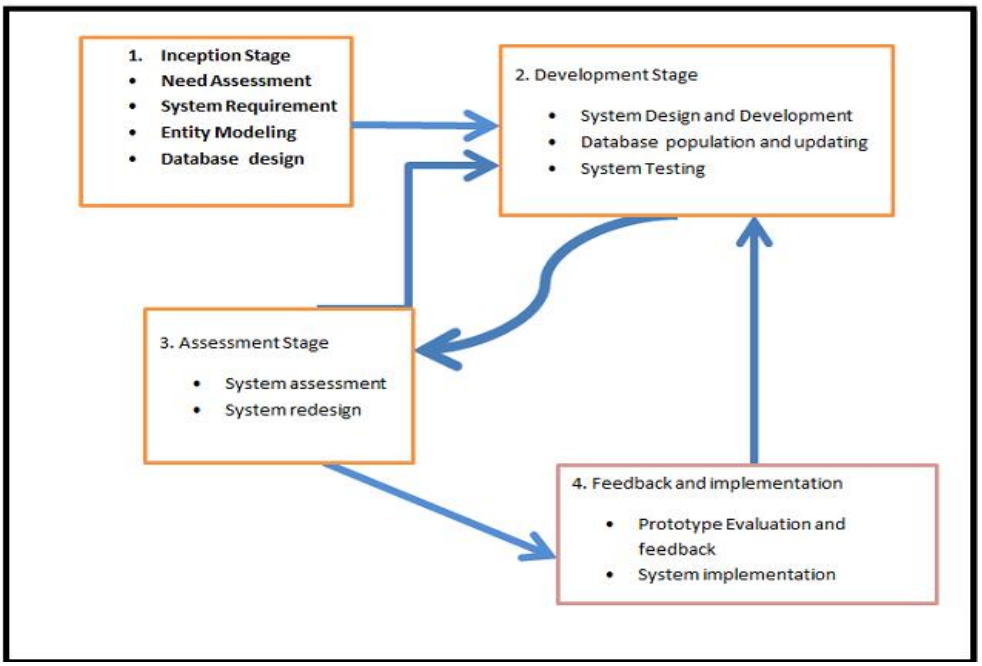

Figure 2: Overview of the system development process

The second stage was the development stage which commenced with developing a comprehensive system design detailing all the required components of the system. The main programming and scripting languages that was used are; Java, JavaScript and HTML both on the server and client sides of the system to modify the

OpenGTS source code and XML. All the key tasks of setting up the web server, GIS map server and database server were carried out at this stage. The web based application for tracking was developed in this stage using Java in the Eclipse Integrated Development Environment based OpenGTS platform. Eclipse IDE also provides plugins that link up with android software development kit (SDK). This enabled java programing with android libraries. The android SDK was used in development of the mobile component of the system. An application that draws coordinates from GPS was also developed and installed in an android phone for prototype type testing of the system. MySQL database was also created populated with the base map elements required for the tracking system. Some of these elements are road, administrative boundaries bus stops and other locations relevant to public service vehicle like petrol stations.

The last phase was the assessments stage. It entailed testing of the system that had been developed using actual tracking data sent to the database to evaluate its performance. The data was transmitted from the tracking device (GPS enabled phone) in a PSV. The weakness and problems of the system were determined and preceding stages repeated.

3.0 Results

A working open source solution able to track public transport within the City was developed. The system enhances management of PSV by linking the non-spatial data with the tracking data resulting in a better system for management of public transport. It is composed of three elements namely, the web interface, an android application running on a mobile phone and server side application for database management.

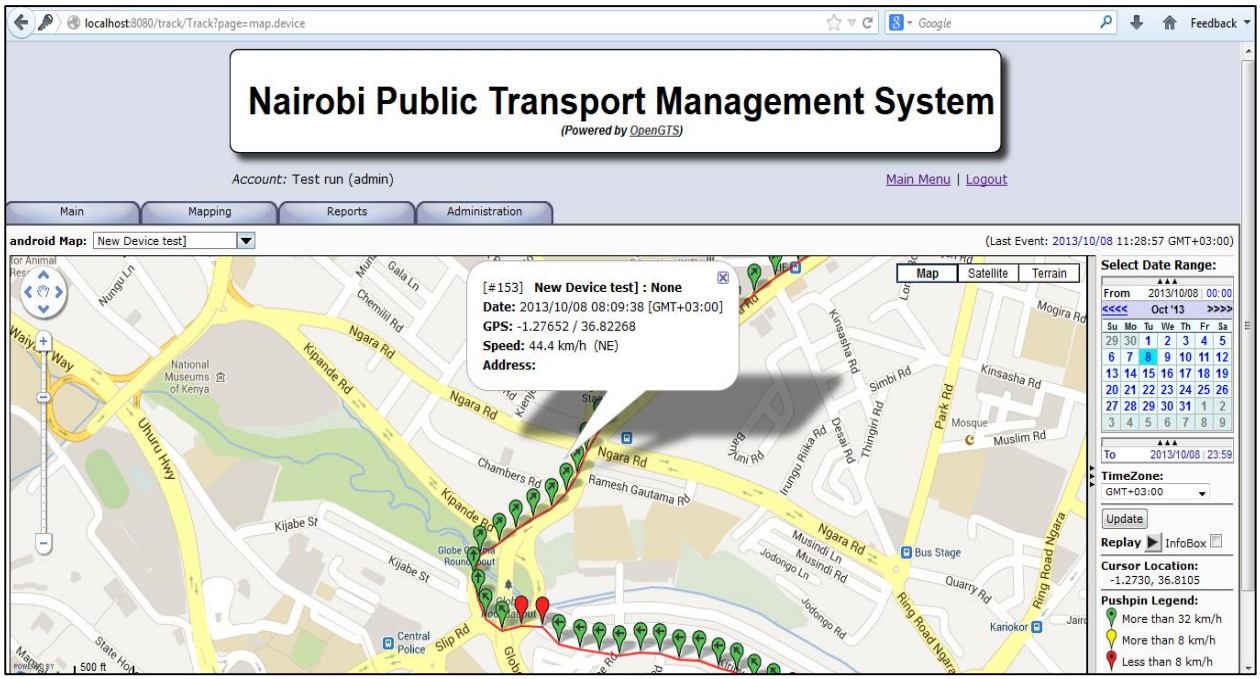

Figure 3: Map view of the Transport Management System

The web interface (Figure 3) is accessible using standard browsers where users can log into the system to view the vehicles they are tracking and retrieve the summary details of a given vehicle. The android application (Figure 4) installed in the vehicle operator's device can be used to provide non spatial data to the central database. The non-spatial data entailed total amount of cash income in a day, expenses incurred, collected fares per trip, reports on any incident and conditions on the road. In the managers side the application was used for viewing location of the vehicles and summary of daily activities.

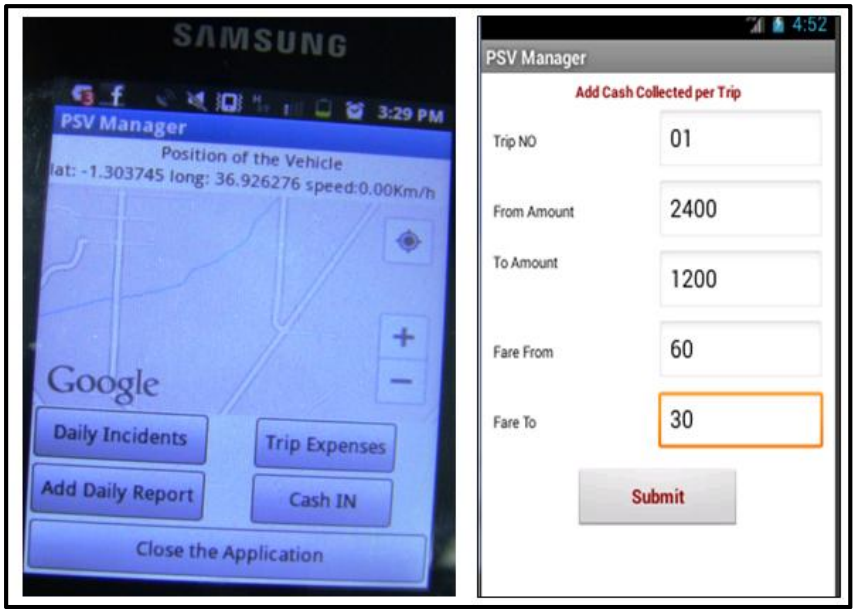

Figure 4: PSV Manager running on Samsung android phone

4.0 Conclusion

The developed System can determine the number of trips made daily by keeping count of the number of track logs made in a given route by a specific vehicle. This will go a long way in evaluation of the overall performance of the vehicle hence assisting in the management in decision making and planning. The solution has the capabilities of real time tracking, vehicle usage monitoring on designated routes and provision of daily summary report of vehicle activities. The software component of the system consists of Java based application for android devices and web based user developed by customization of OpenGTS.

Many of the transportation studies in the Nairobi city broadly focus on transportation planning and policy framework with limited focus on public transport. Therefore there is great need for further research in PSV as mode of public transport with emphasis on how emerging technologies can be used to addresssome of the problems in the sector. As realized from the needs assessment of public transport clear guidelines on enforcement of public transport regulation in the *Matatu* industry needs to be formulated and implemented. One of the challenges encountered during the development and implementation of the project was that MySQL database does not have spatial data types like lines, points and polygons. To improve spatial analysis and interoperability with other GIS software of the system there is need to use spatially enabled database. The OpenGTS platform heavily relies on use of the command prompt or scripts which are not user friendly hence the need for improved graphic user interface especially in configuration and customization of the software.
Further work is still required to improve the analysis capabilities of the system using the tracking data collected. One of such analysis would be network analysis to help vehicle operators choose the least cost routes at any time of the day depending on the prevailing road conditions.

Acknowledgement

The authors wish to thank the Jomo Kenyatta University of Agriculture and Technology for providing resources to support this research work. We also appreciate Matatu Owners Association, City Hoppa Bus Company Limited, Kenya Bus and Double MM Bus companies for their cooperation during the needs assessment and evaluation phases of the research.

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