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Web Based Public Transport Management System: A Prototype PSV Tracking 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. In addition, public transport in Nairobi city is generally characterized by a lot of chaos; these range from poor management of the vehicles, traffic congestion, reckless driving and unreliable service provision. The main objective of the project discussed in this paper 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 customized 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.***

Keywords: Tracking, GIS, PSV, Open GTS and android**.**

1. Introduction

Vehicle location based services and tracking system available in Nairobi city in Kenya 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 this 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 [1]. Integration of GPS with Geographic Information Systems (GIS) is efficient for logistics, fleet management emergency medical services, rescue, and relief work [1]..

On the other hand, accessing LBS calls for the use of customized devices or cell phones with their own closed proprietary protocols or closed source code [1]. 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 programming environment for various mobile devices [2]. This can be effectively be harnessed to provide LBS to the mass android market and address the management problems encountered in the transport industry in Nairobi.

2. Problem Statement

Urban centers in Kenya have been expanding rapidly since independence in the 1960s. According to Ministry of Transport during the two inter-censual periods, the rate of growth of urban population increased from 8 % in 1980s to over 34 % in 2003 and is projected to reach over 50% by 2020 [4]. The population of Nairobi alone has reached about 3.2 million residents (2009) with a day time population of 4.5 million people [9]. Despite these developments growth in urban transport infrastructure and services has not been at par with this population increase. The Ministry of Transport further explains the problems of public transport in major cities and urban areas, especially Nairobi, Mombasa, Nakuru, Kisumu and Eldoret, to be inadequate supply of public transport vehicles (mostly buses and mini buses), a large number of cars and heavy goods vehicles, heavy traffic congestion during peak hours, and stiff competition for limited road space between pedestrians, cyclists and motorists [4]. Traffic congestion is envisaged by long queues of slow-moving vehicles and long waiting and travel times in

the large towns in the country. Poor physical planning has led to lack of parking space in town centers, especially in Nairobi [4].

The existing transport system in Nairobi has been greatly influenced by population pressure and urban structure [3]. 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 [3].

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 [4]. 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 [4]. Corruption is also another issue that business men in the public in the city especially with the police [4].

3. 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 [6]. 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 [6].

Tracking service providers keep the location information in their own database [1]. 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. [1].

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")[2]. 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, [2].

Android mobile operating system currently commands the largest share of the smart phone operating system in Kenya [8]. This makes it more accessible to many people in Nairobi and therefore suitable for development of this project. Android was developed by Google in collaboration with the Mobile Handset Alliance and released as an open source software platform [2]. It is increasingly being adopted by smartphone manufacturers. Beyond a Linux-based kernel and the device-specific hardware drivers, it offers a comprehensive software stack of libraries centered on the Dalvik Virtual Machine (DVM). Dalvik operates like the Java Virtual Machine (JVM) and provides its own runtime libraries [2]. Semantically related library functionality is controlled via so-called managers (e.g. Location Manager for all location-related functionality) where useful. At the top layer of functionality, applications access both the various managers and library functionality using Java syntax [2].

4. Methodology

4.1. 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.

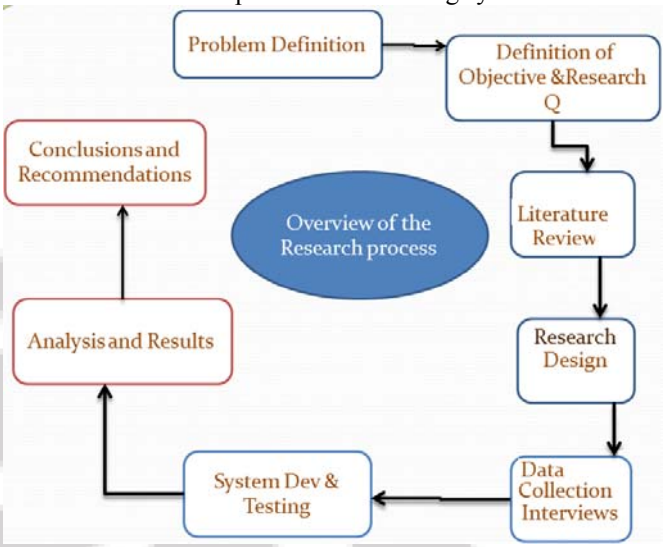

Figure 1: Overall Approach of the project

4.2. System Architecture

The overall system was envisaged to have three main components namely; the internet application, the server and the GPS tracking unit. There are two types of expected users of the system, the client side user consisting of the vehicle operators and owners and the server side administered by the support team. The client side was made of a web-based

application where users can track the movement of the vehicle and query the attribute data stored in the database relevant to the specific vehicle. An android application on the client side was also part of the system. The application allows the vehicle operator's to update the database and the managers to track using their mobile devices. Figure 2 shows the general overview of the system architecture.

The server side of the architecture consists of Apache Tomcat web server which is used in managing and displaying web content, the MySQL server for database management. The tracking component of the system mainly consist of the GPS based automatic vehicle location system that uses GPRS network to send geographic coordinates with time stamps to the central database server. However, in this project GPS enable android phone with an embedded tracking application was used in the place of the tracking device in the prototype developed.

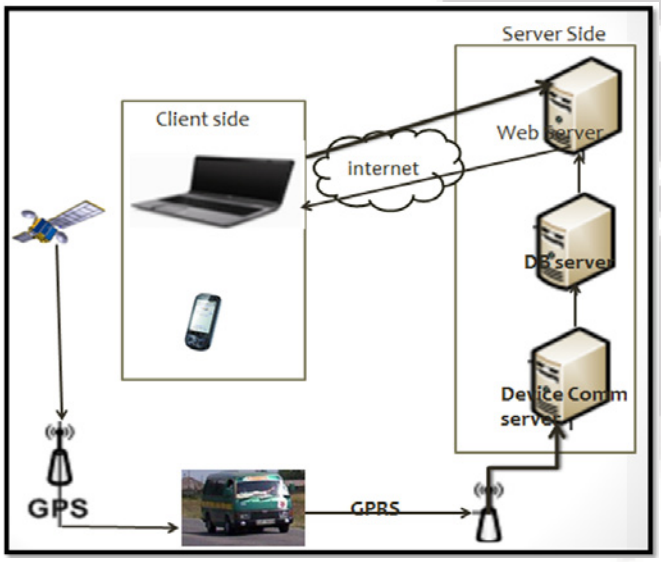

Figure 2: System Architecture

4.2. Overview of the system development process

The system development process was classified into four broad stages as shown in figure 3 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.

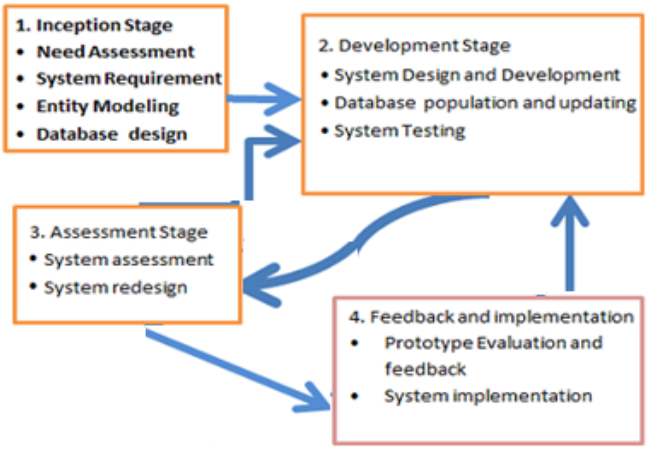

Figure 3: Overview of the system development process

The second stage was the development phase 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.

5. Results

5.1 Current Status

The public bus transport in the city was found to be 90% owned and controlled privately through Savings and Credit Societies (SACCO) franchise bus management companies. However the government through traffic police and city council enforces regulation and provides policy guideline. The responsibility of management daily operations of the vehicle was solely on the owner despite being registered in a SACCO or operated under the brand name of a bus company.

The normal workflow of the vehicles commenced early in the morning with the release of the vehicle. At this point some vehicles were fully fuelled while other cases gave the bus operators the liberty to fuel during the day. The driver and the conductor the take off to their designated route ferrying passengers to the city centre and back. Most of the vehicle operators work for the whole day and submit their revenue to the owner at the end of the day with the fuel tank full to capacity. All the transactions were only captured in form of receipts and hand filled forms to be later analysed by the vehicle proprietors. When unforeseen incidences occurred like accidents and arrests by police the owner was alerted so that he would decide on the course of remedy.

The business is mainly run based past experience and the general trends that heavily relay on how honest the vehicle operators are to their employers. Comparison of the provided revenue stream and the past trends provides the owners with a picture of the state of affairs in their business. In most cases this was done using manual booking from the filled forms to the ledger books which would be keyed into spread sheets. This is quite tedious and prone to human errors. The analysis of the existing state of affairs revealed the dire need of a semi-automated computerised system. This will not only increase efficiency in record keeping but also assist in analysis thereby improving the overall management process.

5.2 Developed System

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 4: Login view of the Transport Management System

Figure 5: Map view of the Transport Management System.

The web interface (figures 4 and 5) 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 6) 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.

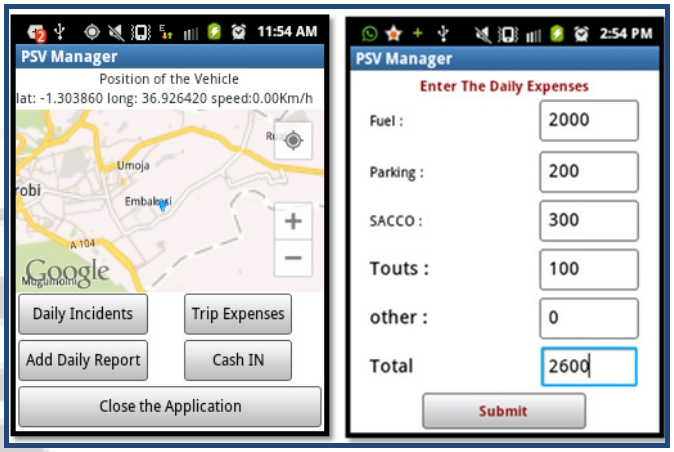

Figure 6: PSV Manager running on Samsung android phone

6. 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.

7. Recommendations

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 address some 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 industry should be 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 research 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. The future scope of this study should further entail development of an integrated system that displays analysis in the vehicle and controls its speed.

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