MOBILE PHONE –BASED PARKING SYSTEM

Karari Ephantus Kinyanjui[1] and Andrew Mwaura Kahonge[2]

[1] Department of Computer Science, Dedan Kimathi University of Technology
efantus.kinyanjui@dkut.ac.ke
[2] School of Computing and Informatics, University of Nairobi
andrew.mwaura@uonbi.ac.ke

ABSTRACT

Traffic flow, allocation and availability of parking space within the streets of Nairobi is a major concern to every motorist. The availability of the mobile phone and its increased affordability has led to its adoption as the main gadget and technology for contemporary communication in most developing countries. Furthermore, the convenience it offers to users and its cost effectiveness has made it the technology driver not just in developing world but also in the developed countries. One area where its application has born fruits in some countries is in mobile parking. By use of mobile communication, cities in countries such as Singapore and Germany have experienced increased efficiency in traffic management and parking fees collection. The technology also depends on banking models used in these countries; a fact that makes it necessary for any similar solution been developed elsewhere to consider the local system environment.

KEYWORDS

Parking, Mobile, Sensor, Camera, Fee, Council

1. BACKGROUND

Traffic congestion is a major problem especially in big cities like Nairobi. Sometimes traffic within the city grids to a halt, which is more often the case when it rains and police officers go for shelter leaving the traffic uncontrolled. In many occasions when this happens, it takes time before smooth traffic flow is re-established.

In a normal day, the congestion may be caused by several factors including the absence of information on available parking spaces. As a result drivers spend time driving along the streets in search of parking space. This means that a significant number of vehicles are on the streets hoping to locate a parking space which increases the number of cars on the streets unnecessarily and contributes towards the congestion not to mention the pollution caused by their exhaust fumes and the noise emanating from their engines.

Once a driver finds a parking space and parks the vehicle, he may spend some time looking for a city council parking attendant in order to pay the parking fees. Sometimes, the time spent looking for the attendant is significant and most drivers dread leaving their cars before they pay the parking fee due to the consequences which include having your vehicle locked or even towed which in turn attracts heavy penalties.

In some cases, drivers collude with parking attendants so that they forfeit the receipt but pay an amount less than the actual parking fee to the attendant. This has the effect of reducing the

revenue derived from the parking fee and denying the city council the all important cash needed to implement its budget.

Assignment of supervisors to man a region with a number of attendants is aimed at reducing fraud hence increasing revenue. However, the supervisors themselves have been colluding with the attendants in many cases to let drivers' park vehicles at a lesser fee but which they pocket and do not deliver to the city council. The net effect could be a bigger loss since the council has to cater for wages of both the attendants and supervisors.

To eliminate or significantly reduce corruption the project provides an alternative means of payment of the parking fees that do not require cash to exchange hands.

To reduce the time spent on locating parking slots; this project provides a way of accessing parking slots information –specifically their availability- remotely on request. It also shows the possibility of variable message signs and light emitting diodes (LED) displays being used for providing such information.

The project also provides for automatic generation of reports on revenue collected from parking fees, which would in turn provide a basis for faster decision making.

2. OBJECTIVES OF THE PROJECT

The Objective of the project was to exploit existing mobile computing technology and infrastructure in the development of a system that illustrates how management of parking spaces in a city can be automated.

The overall aim of was to design, develop and test a mobile phone-based parking system. In order to achieve this overall objective the following was carried out:

1. Investigation on the suitability of sensor technology in monitoring parking spaces on the streets of Nairobi.
2. Investigation on the suitability of the use of mobile phones in finding information on available parking space.
3. Investigation on the suitability of using mobile money transfer services in payment of parking fees.
4. Designing and implementing a prototype system that manages parking spaces on the streets of Nairobi. The system makes use of mobile phones, sensors and Mobile phones money transfer services.
5. Providing of information on revenue collected to the management.

3. PROJECT'S SCOPE

The product in this project is a System for mobile phone-based parking system for the city of Nairobi. The software is intended for use by drivers and City Council of Nairobi parking officers. The drivers can use it to get information on available parking spaces in a given street and to pay for the parking fees while City Council of Nairobi's officers will use it for accounting and parking management purposes.

The project focused on three main functions:

1. Providing information on available parking spaces
2. Enabling payment of parking fees using the mobile phones money transfer services

3. Providing information on fees collected for accounting purposes

The software product is flexible enough to accommodate future changes in technology and requirements. It is developed using open source tools hence no license needs to be paid to a third party.

4. ASSUMPTIONS

The assumptions made during the implementation and deployment stages of this project are:

1. All parking lots are coded. This made it possible to separately identify each parking slot and have a slot as a unique (primary) key in the database.
2. The city by-laws allow use of mobile phone money transfer services in payment of their bills and fees.
3. All users are subscribers to the same MPSP. This assumption is purely as a result of cost associated with getting common number.

5. LITERATURE REVIEW

A mobile phone–based parking system requires the support of other modules for them to have optimal performance. These modules may include a sensor to provide updates on the traffic situation on the streets and in the parking spaces. Variable message signs could also be used in providing feedback to drivers and other users.

This section provides insight into the use of mobile phone-based systems elsewhere in the world as well as the sensor technologies used.

Through the introduction of E-payment of parking recently in the city of Nairobi, this system will work hand in hand with mobile phone-based parking system. After identifying the parking niche, the driver or the owner of the car will just require to register his name and plate number of the car to the E-payment parking system. Once the driver has paid for the parking, there will be no need to go round looking for a council parking attendant thus saving time.

The E-payment parking will also reduce to a great amount the corruption that exists with parking attendants in the city. Each payment will lead to production of a receipt in form of a message. This will increase the amount collected as revenue by the government.

5.1 Mobile-Based parking systems

There are several examples of application of mobile phone-based parking systems especially in developed countries. Below is a citation:

5.1.1 Berlin

Application of mobile parking system in Berlin Germany aimed at creating demand dependent pricing schemes in the future.

In 2004 only a large number of on-street parking machines were in use and allowed for payment of parking fees in Berlin. A mobile parking system designed by Mobile Parking GmbH focused on implementation and demonstration of a system using innovative cellular phone technologies. Drivers as well as enforcement agents used mobile phones for the service. A service centre

registered automatically the parking duration times of the users and charged them in accordance to the time they have parked. City officials received all the anonymous statistical data of parking transactions that have occurred within their jurisdiction. The parking proceeds collected with this new system were "virtual", i.e. instead of coins collected from parking meters; the proceeds arrived once a month by bank transfer.

The flexibility, efficiency and the acceptance of the mobile parking system were demonstrated and evaluated under real world day-to-day conditions. By 2005 more than 6,800 users were registered. Approximately 600 mobile parking transactions per day were executed.

This mobile parking system developed mobile parking Gmbh has one major similarity with the mobile phone-based parking system (MPPS) that is the subject of this project.

The technology exploits cellular (mobile phone technology) just like MPPS. It does not completely eliminate the need for enforcement agent. This is in order to take care of those who default on payment. The same case happens with MPPS. Whereas the attendants (those who receive cash and issue receipts) may be eliminated, the enforcers (those who lock and at times tow the defaulting vehicles) must be there to deal with defaulters.

GMbh also provides flexibility by charging based on the time the parking is used. MPPS also provides for the same.

However two major differences can be cited:

Payment in the case of Gmbh system is virtual. The money is only fully realized with bank transfers at the end of the month. In the case of MPPS mobile cash transfer services are used to pay and that money will is realized from a mobile money transfer services provider rather than from a bank. The time when the money is realized depends on the internal policy of the city council.

The second difference is based on the requirements. For Mobile parking Gmbh users must have credit a card. Although the use of credit card has picked in Kenya and in fact ATM cards are being used as debit cards, there are still several Kenyans who have no access to banking services and many others who do not have credit cards. A solution to be applied in Kenya would therefore not be effective if it is based on the credit. MPPS requires the user to have a mobile phone which is more prevalent in Kenya than a credit card.

5.2 Sensors for Mobile Based Parking Systems

Sensors form an important component of automated parking systems. The literature below provides insight into the various sensor technologies. It also provides the basis for support of a locally developed solution.

5.2.1 Vehicle Detection and Surveillance Technologies

A survey of technologies used in vehicle detection requested by Federal Highway Administration s (FHWA) Intelligent Transportation Systems Joint in the USA and conducted by Mexico state university reveals a number of facts some of which are listed below.

1. There are technologies that are cheap at cost but expensive to install since they require trenches and tunnels to be dug across the roads and along the pavements.

2. Some technologies may be affected by weather patterns and as a result report erroneous data.
3. Some technologies cannot detect stationary vehicles
4. Cameras without infra red capability cannot function at night
5. Some sensors have a wide coverage whereas others have limited (small area) coverage.

The table below provides detailed information about sensor technologies and is adapted from Mexico state university report to FAHW:

Table 1: Sensor Technologies

Technology	Strengths	Weaknesses
Inductive Loop	• Flexible design to satisfy large variety of applications. • Mature, well understood technology. • Provides basic traffic parameters • (e.g., volume, presence, occupancy, • speed, headway, and gap). • High frequency excitation models provide classification data.	• Installation requires pavement cut. • Decreases pavement life. • Installation and maintenance require lane closure. • Wire loops subject to stresses of traffic and temperature. • Multiple detectors usually required to instrument a location.
Magnetometer (Two-axis fluxgate magnetometer)	• Less susceptible than loops to stresses of traffic. • Some models transmit data over wireless RF link.	• Installation requires pavement cut. • Decreases pavement life. • Installation and maintenance require lane closure. • Some models have small detection zones.
Magnetic (Induction or search coil magnetometer)	• Can be used where loops are not feasible (e.g., bridge decks). • Some models installed under roadway without need for pavement cuts. • Less susceptible than loops to stresses of traffic.	• Installation requires pavement cut or tunneling under roadway. • Cannot detect stopped vehicles.
Microwave Radar	• Generally insensitive to inclement weather. • Direct measurement of speed. • Multiple lane operation available.	• Antenna beamwidth and transmitted waveform must be suitable for the application. • Doppler sensors cannot detect stopped vehicles.
Infrared	• Active sensor transmits multiple beams for accurate measurement of vehicle position, speed, and class. • Multizone passive sensors measure speed. • Multiple lane operation available.	• Operation of active sensor may be affected by fog when visibility is less than »20 ft or blowing snow is present. • Passive sensor may have reduced sensitivity to vehicles in its field of view in rain and fog.
Ultrasonic	• Multiple lane operation available.	• Some environmental conditions such as temperature change and extreme air turbulence can affect performance. Temperature compensation is built into some models. • Large pulse repetition periods may degrade occupancy measurement on freeways with vehicles traveling at moderate to high speeds.

The table below shows the cost implications of each type of sensor and is adapted from Mexico University report to FHWA:

Table 2: Cost of a sensor

Sensor type	**Cost in US Dollars(2001)**	
Magnetic (induction or search coil)	385 to 2000	
Inductive loop	500 t0 800	
Ultra Sonic	600 to 1900	
Microwave radar	700 to 3300	
Infrared	Passive 700 to 1200	Active 6500 to 1400
Magnetometer (Two axis fluxgate)	1100 to 6300	
Acoustic array	3100 to 8100	
Video Image Processor	5000 to 26000	

The above technologies are in one way or another not efficient enough for the MPPS system. However, the tropical weather conditions and especially Nairobi's temperate climate allows for application of infra red cameras given that they would not require pavements to be cut and that snow which is the main hindrance in Seattle is not present in Nairobi. Further, the infrared technology can be used even at night. This requirement supersedes Nairobi's current requirement since parking lots demand is highest during the day and at night the city council doesn't even charge for the parking.

To provide for scalability and flexibility, the infrared detectors would be one of the best cameras to implement the system. MPPS can apply them but due to cost and for purposes of demonstrating the project, a simple web camera was used.

5.3 SMS gateway

SMS gateway is a device fitted with software which enables it to allow transmission or receipt of SMS messages with or without the use of a mobile phone. When messages are received via this gateway they may be transmitted to another media including websites or even written to a database. In some cases automatic replies may be issued or even bulk SMS sent depending on purpose of the overall system. The SMS gateway software is also referred to as SMS server.
Several SMS gateway software as well as hardware exists today. In fact; some laptops in the market are fitted with generic hardware for an SMS gateway and all the user has to do is buy the Subscriber Identity Module (SIM) card and install it to enjoy the gateway's services. Today's (2010) Kenyan market provides Global Systems for Mobiles (GSM) modems as the hardware for SMS gateways.

However; for extra functionalities, the gateway will need the support of SMS server software. This is not freely available in the market for many reasons; one of which is that different people will need the server software for use in different ways. The server must be customized to the requirements of every organization.

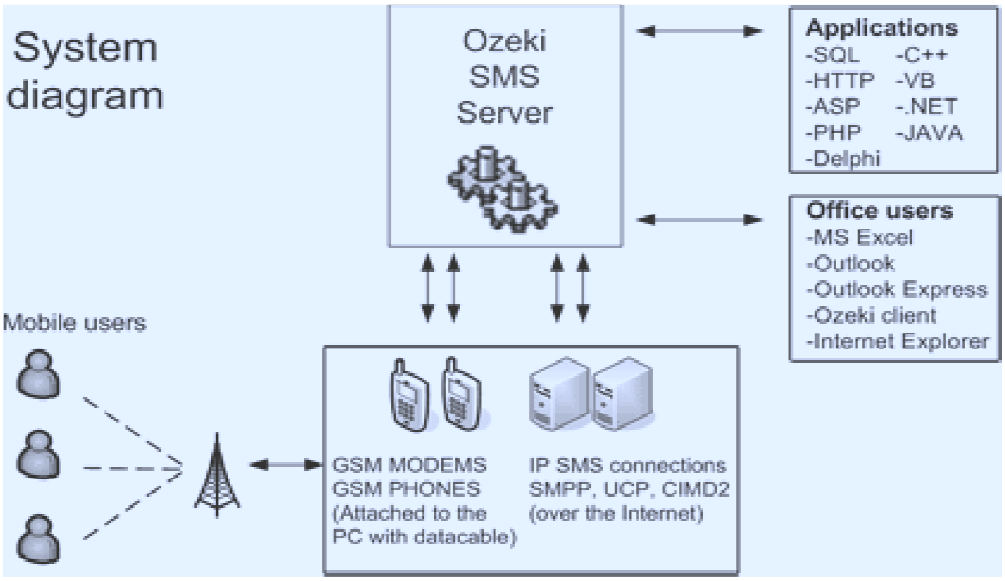
5.3.1 Ozeki SMS Server

This is an SMS gateway system created by Ozeki Informatics Ltd. The company was established in year 2000 by Hungarian private investors and is based in Budapest, Hungary

The company provides high edge SMS servers to business organizations and software houses for use in their systems or in the case of software houses for use in developing systems.

One of their widely used servers is Ozeki SMS server version 6.0. It is a powerful and flexible SMS Gateway application that enables you and your applications to send/receive SMS messages to mobile devices with your computer. It has an easy to use user interface, and an excellent internal architecture. The application can use a GSM mobile phone attached to the PC with a phone-to-PC data cable or IP SMS technology to transmit and receive the messages. Ozeki Message Server works on Microsoft Windows XP, 2000, 2003 operating systems.
Its architecture is shown below:

Figure 1:Ozeki Gateway



Due to its advanced nature and with its several advantages as discussed above the Ozeki SMS server is one of the best to use. However, for purposes of demonstrating MPPS I have used an alternative to avoid the USD 800 cost that I would otherwise incur to acquire it and which would not pass the economic feasibility test.

5.3.2 MIT AITI SMS Server

Massachusetts Institute of technology-MIT- Africa Internet Technology Initiative (AITI) was first envisioned by Paul Njoroge while attending the 1998 MIT Leadership summer program after his sophomore year at MIT.

Developed by the MIT the AITI SMS server is a java based framework available free of charge to programmers who then complete the development by creating a server module and a corresponding application.

The server spawns a thread each time it receives a message; processes the message and gives an appropriate reply. It could also be modified to be push only-that is; be a send only server. Its architecture depends on what the programmer wants to do with it because he/she receives only a framework and then completes the code to fit the user requirements.

This was the most appropriate to use in the MPPS project compared to Ozeki for the following reasons:

1. It is a java based technology, which is the MPPS developer's favorite language
2. It is free of charge implying that no direct cost other than development time would be incurred.
3. Because it would be developed for MPPS future maintenance cost would be minimized and there would be no cost associated with customization as it would be the case for Ozeki.

5.4 Camera software

Most of the camera software's in the market are not generic and experience incompatibility problems that sometimes could be very annoying to the user.

6. SYSTEM ANALYSIS AND DESIGN

6.1 Overview

The Structured Systems Analysis and Design Method (SSADM) was used as the development methodology for this project.

SSADM is a waterfall based method used in the analysis and design of information systems. It was developed by the Central Computer and Telecommunications Agency (CCTA) in United Kingdom.

This project used the techniques of SSADM in analysis and design of the system.

6.2 Research methodology

With respect to requirements analysis, the following methods were used in fact finding:

6.2.1 Observation

The work environment was observed and provided details on the interaction between the parking attendants and the drivers. This provided an understanding of the flow of data in the system.

The benefits derived from using this method were:

1. Advantages
2. The Facts/data obtained can be relied on
3. It was easy to verify facts
4. We obtained some data on the physical environment
5. The method was relatively inexpensive

6.2.2 Document review

I studied the documents used in the current system. This provided an understanding of how the system stores data and the kind of data it stores. The greatest benefit derived from here is that the facts obtained are very reliable especially given that the documents were those currently in use.

6.3 The Analysis

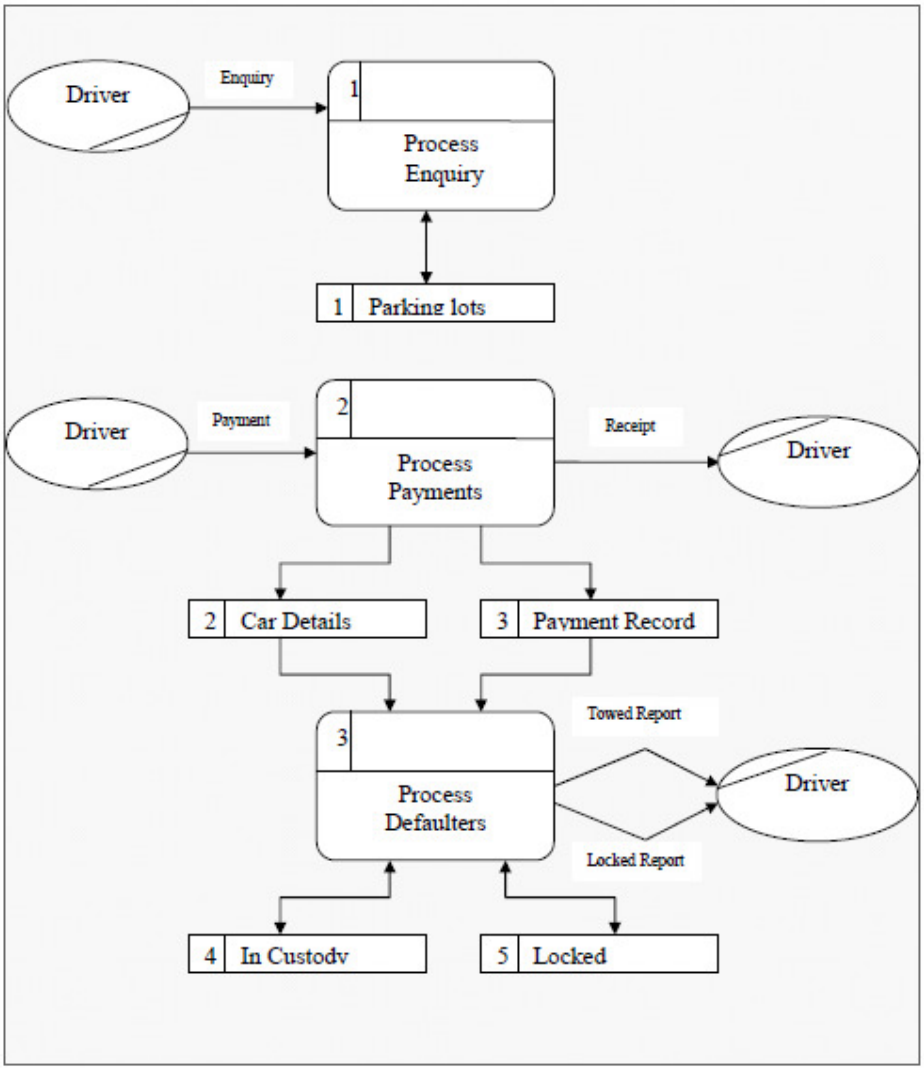
This stage employs data flow modeling in analyzing the current system. It involves identifying, modeling and documenting how data moves around the parking system.

In it; processes - which are activities that transform data from one form to another-, data stores-which are the holding areas for data-, external entities –which send data into the parking system (PS) or receive data from the PS, and data flows-which identify the route by which data flows-are examined. The end results of this technique are the Data Flow Diagrams (DFDs) shown below:

6.3.1 Process Analysis

6.3.1.1 Current System DFD

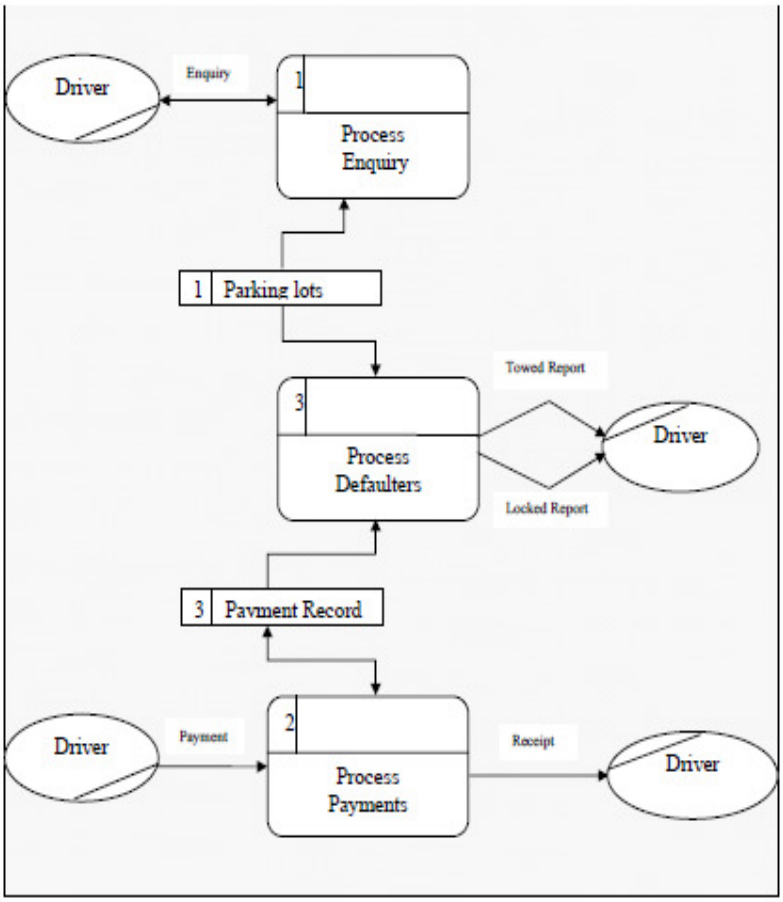
Figure 2: Current System Level 1



6.3.1.2 New system DFD

One of the major differences between the current and the new system captured by the DFD is the ability of a parking lot to sense and report a defaulter.

Figure 3:New System level 1



6.3.2 Data Analysis

This process involved identifying, modeling and documenting the data requirements of the mobile parking system.

The data was separated into entities- things about which a business needs to record information- and relationships-the associations between the entities. This was archived by use of normalization. The end result of which was the entity relationship diagram-ERD shown below.

The system needs to hold data about cars and the street where the car is parked

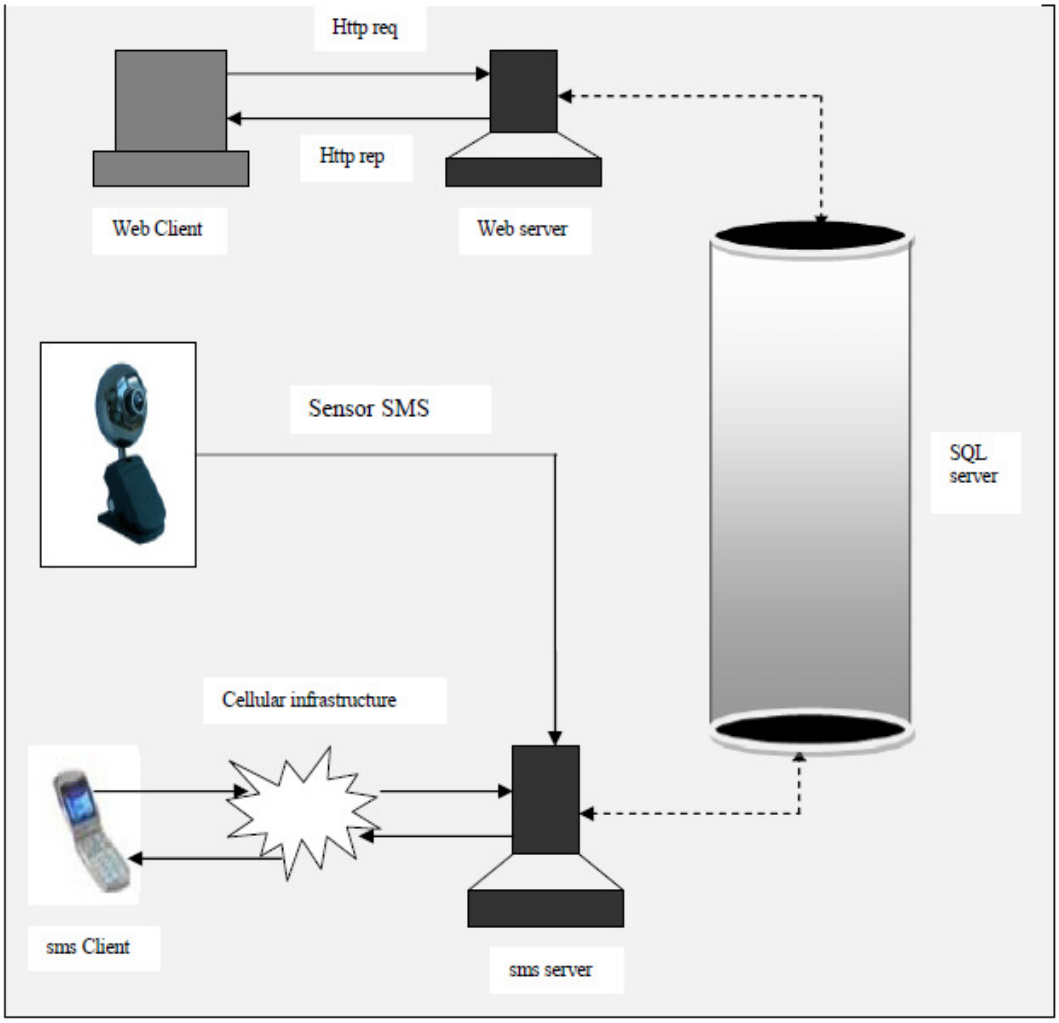
Car
Registration number
Parking amount
Status {towed, clamped, paid}
Initial time
Expiry time

Parking lot
Street name
Street code
Lot code
Number of lots
Used lots
Available lots

6.3.3 Physical design

The system can be split into three modules; the client side, the server side and the database or SQL server. Each part is captured in the diagram below and is well explained thereafter.

Figure 4: System Architecture

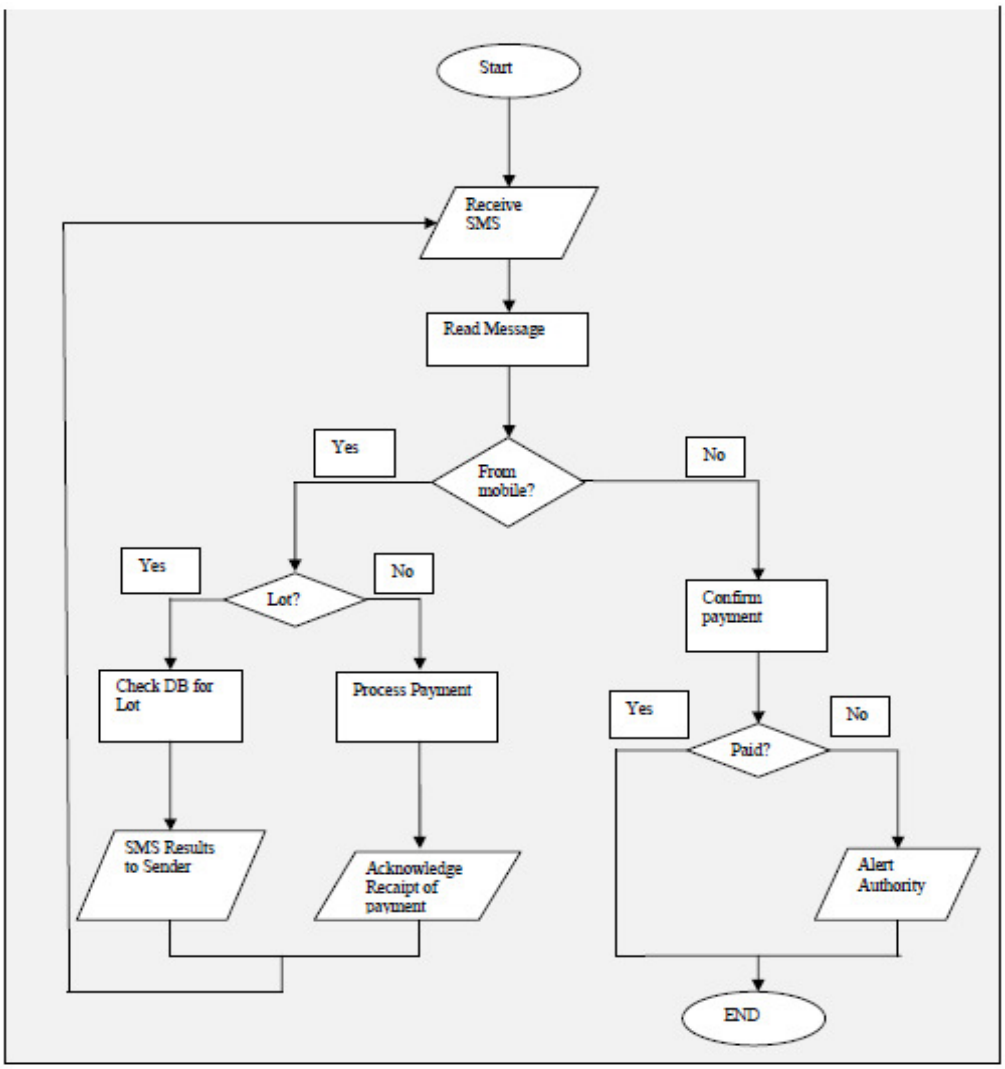


6.3.4 Flow of Program Logic

6.3.4.1 SMS server

Below is a graphical representation of the flow of control within the SMS server.

Figure 5: Flow Chart



7. System Construction and Testing

7.1 Web Module implementation

The client side of web interface is implemented using HTML and javascript whereas the server side uses PHP.

Html is used to define web pages that are displayed on the client side and to determine the format by which web content is displayed.

JavaScript is used on the client side to implement:

1. Form validation by ensuring fields in the log-in forms are all entered with the correct data

2. Use of cookies enhance user friendliness by preventing redundant data entry
3. Use of event handlers to enhance user interactivity with the system
4. Modification of HTML elements to provide for easier reference to window objects via HTML buttons.
5.

PHP is used to write server side scripts. These scripts execute on the server side but their results are displayed on the client side. PHP provides the following:

1. Connection to the database
2. Creation of cookies to enhance user friendliness
3. Generation of dynamic pages

7.2 Mobile module implementation

Mobile client rides on existing provision and requires no coding or modification to work.
Server side modules were created using java language and are based on SMS server framework provided by MIT AITI.

Connection and manipulation of the data base is achieved using MySQL Java Database Connectivity Driver (mysql.JDBC) and SQL data manipulation language (DML).

The main driver of the SMS server is the Main class. The main method in this class defines an inbound SMS handler that waits for incoming messages.

A new thread is spawned every time a new SMS is received. The application therefore remains lightweight and conserves the system resources by ensuring that each request is handled by a particular thread and not a separate process altogether.

7.3 Sensor Module implementation

The sensor module is supported by two applications that use java. One is on the client side and the other on the server side of the deployment architecture but both exploit the SMS server architecture.

The first sensor application is an executable java file which runs when the sensor through Yawcam detects a vehicle being parked or a vehicle leaving the parking. It sends an SMS to the server side which triggers a search through the database and an update of the database.
The second sensor module is responsible for receiving the sensors SMS and carrying out the search within the database as well as updating it.

8. CONCLUSION

The System has provided proof that the deployment of sensor based client server mobile parking system is possible and can largely ease the problems of a city's parking system.

The system deployment constraints include cost especially hardware cost and non- existence of by-laws to govern such a level of automation.

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10. AUTHORS

Name: Ephantus Kinyanjui Karari
Mobile: +254 721 374 616
Interest: Web and Mobile computing
Occupation: Assistant Lecturer & PhD Student; School of Computer Science, DKUT (www.dkut.ac.ke), Nyeri, Kenya

Name: Andrew Mwaura Kahonge
Mobile: +254 728 774 482
Interest: Web, Distributed Computing, Hand held computing devices
Occupation: Lecturer, School of Computing and Informatics, University of Nairobi, Kenya