# GIS-Based Geodatabase For Multi-Criteria Decision Analysis In Location Based Service: An Application For Lagos State, Nigeria

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**Abstract:** Location Based Services intrinsically imply services rendered to mobile users with respect to their geographic locations. The main objective of this research is gaining an understanding of the concept of Location Based Services and the requirements necessary for the different technologies that underlie them. The most significant part of this project is developing a geodatabase for the design and implementation of Location Based Services for Lagos State, Nigeria. Due to the ability of Location Based Services to provide quick and easy access, and fast connection speed, the internet is the preferred platform for the location based service demonstrator. A platform is designed to query the Location Based Services. This platform contains the main functionalities of Location Based Services: search possibilities and map rendering with additional features such as the routing of roads, places, and points of interest. So far in the design and implementation of this work, a user friendly platform has been created that will avail the ordinary user the opportunity to be able to carry out basic GIS functionalities. Also, it can give assistance to the planning of daily routines. With this work, it has been demonstrated that GIS can be taken to a new level where we have an increased participation and under the driving of requirements and technology, Location Based Service will have much more wide spread application area. It is important we leverage on the potentials of low-cost web-based GIS applications like this for more stakeholder participation and effective governance.

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## 1. Introduction

Location- Based Services (LBS) means services provided to mobile users according to their geographic locations (Beaubrun et al, 2007). The modern definition of LBS presents them as a group of emerging telecommunication services that successfully and purposefully merge ubiquitous position determination, mobile data communications and position-related content, with a defined level of Quality of Service (QOS). LBS are services that are triggered by the current geographic location of the mobile user and his surroundings. LBS are generally information services accessible through mobile phones, Personal Digital Assistants (PDAs) or other mobile devices. LBS include emergency services, car, and personal navigation, point-of-interest search, track and trace, and many others. Positioning is one of the most important components of any LBS. Therefore information about features around the user can be given to him or her, and be changed as a function of where the user is. LBS assist people in their decision-making during the performance of tasks in space and time (Isabelle, 2003).

The main function of LBS is the possibility to retrieve information about the features in the proximity of a mobile user, utilising positioning techniques. The services will help people to navigate on daily errands, on work-related tasks and journeys as well as at leisure time hobbies. There are several application areas like mobile work, shopping and delivery, hobbies and sports, tourism and culture, public transport and safety. The guidance will be implemented on the basis of mobile multimedia and it should be available in both outdoor and indoor environments. The services will be based on generic technology like portable devices, wireless networks and location services. Many people are familiar with wireless Internet, but many don't realise the value and potential to make information services highly personalized. One of the best ways to personalise information services is to enable them to be location based. An example would be someone using their Wireless Application Protocol (WAP) based phone to search for a restaurant. The LBS application would interact with other location technology components to determine the user's location and provide a list of restaurants within a certain proximity to the mobile user. The dataset constructed incorporates points of interest within the state. The LBS will be demonstrated using Internet technology and different services such as information, location and routing be provided via an internet page.

### 1.1 The Study Area

The study area selected for this project is the whole of Lagos State (see Figure 1). Lagos State used to be the capital of Nigeria until 1991 when the capital was moved to Abuja. The State was created in May 1967. It is bounded in the North and East by Ogun State, the Atlantic Ocean in the South, and an international boundary with the Republic of Benin on the west. As a trading port, Lagos has a recorded history dating back to the Portuguese explorers of the 16th century. The State is composed of the old Federal Territory of Lagos, which remains the nation's financial hub and was the Federal Capital of Nigeria up to December 12, 1991, and the old Colony Province of the defunct Western Region of Nigeria, comprising Badagry, Ikeja, Ikorodu, and Epe Divisions. There were twenty (20) Local Government Areas (LGAs) in the State, but recently the government of Lagos State carved out 37 Local Development Areas (LCDAs) out of the original 20 Local government. This was done in order to make allow good governance and also to make development to spread all over the state.

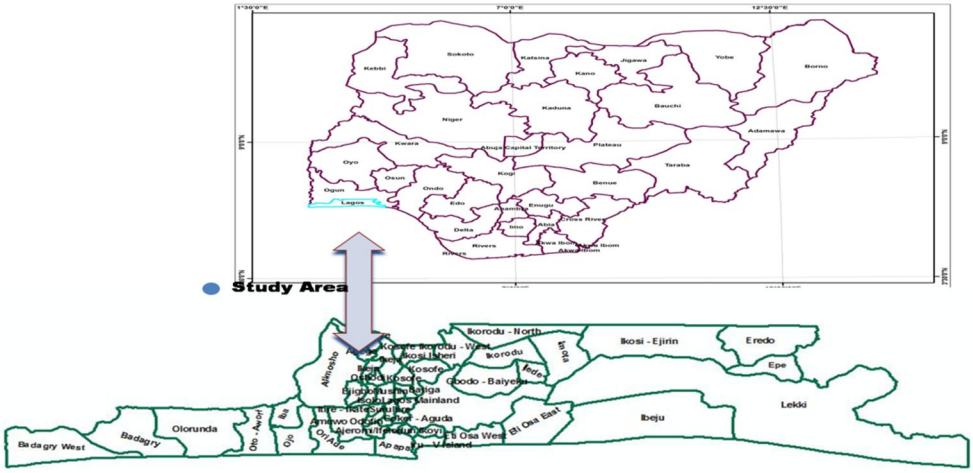


Figure 1. Lagos in relation to Nigeria

### 1.2 Aim and Objectives

#### 1.2.1 Aim

The main aim of this research is gaining an understanding of the concept of LBS and the requirements necessary for the different technologies that underlie them. The most significant part of the project is developing a geodatabase for the design and implementation of LBS for Lagos State.

#### 1.2.2 Objectives

The goals of this research include:

1. To develop a geographic datasets (geodatabase) of Lagos State. The various datasets include educational institutions, traffic facilities, police post, bus stops, churches, various economic, and social services etc.
2. The Geodatabase so developed will be use for:
(a) Searching nearest Point Of Interest (POI)
(b) Map rendering: This will be practically demonstrated through involving the various elements of design, programming and implementation.
3. A web platform will be developed for the implementation of these LBS. The retrieval way proposed for this LBS demonstrator is based on Internet technology. Therefore the different services such as information, proximity search, geo-locating and map rendering will be provided through a web page and it will be based on user define queries on the LBS system.
4. To draw maps showing major components of the urban environment such as banks, schools, hospitals, and commercial agglomerations within Lagos State and to model the spatial relationships among these components using GIS.

## 2. The Concept of Location Based Service

A location-based service is the capability to find the geographical location of the mobile device/user and then provide services based on this location information (see Figure 2). LBS provide information and data to the user based on geographical position. One of the best ways to personalize information services is to enable them to be location based. An example would be someone using their WAP based phone to search for a restaurant or bank. Thus we could say that LBS deliver geographic information between mobile and/or static users via the Internet and/or wireless network.

LBS include emergency services, car and personal navigation, point-of-interest search, track and trace, and many others. Positioning is one of the most important components of any LBS. Therefore information about features around the user can be

given to him or her, and be changed as a function of where the user is. According to ARC Group Consultants (2003), it is expected that LBS will be the most widely used mobile services by 2007. A location based service is implemented as part of an architecture including at least these five components: a mobile device (e. g. a smartphone or PDA), a communication network, a positioning component (e. g. a GPS receiver), a services and applications provider, and a data provider. The mobile device is used by the user for requesting data. It can be a cell phone, a PDA, a notebook PC, or even a car navigation unit. It can be placed in one of two categories: single-purpose and multi-purpose devices. The first includes devices which are built for a specific purpose and cannot achieve any other. The second includes devices that can also be used for purposes other than LBS, such as cell phones, PDAs etc.


Figure 2. Location based infrastructure

**2.1 Forms of Open Location Service**

According to Deidda et al. (2003) the various forms of Open Location Services (OLS) include:

- Directory Service (Spatial Yellow Pages): This service provides to the members an Internet directory where to find one specific location, product or service (or the closest one).
- Gateway Service: It is useful for requiring the current position with different modes (e.g. single or multiple terminal, periodic or immediate position).
- Location Utility Service: This service carries out a "geocoding" operation, determining a geographic location given an address, name of place, or postal code.
- Presentation Service: This service converts the geographic information in a representation for displaying on the mobile terminal. This service provides the map of your area of interest.
- Route Service: This service calculates a route for the user. The applicant has to indicate the start point and the destination.

**2.2 Positioning Technologies**

- **Global Positioning System Based** (GPS): GPS does not operate well (or at all) in dense 'urban canyon' areas, or inside buildings. Yet these are often the very areas where demand for location-based services is the highest.
- **Assisted GPS (A-GPS):** Enables GPS positioning even in urban and indoor areas.
- **Network-based Positioning:** The network may be a Wireless Wide Area Network (WWAN) such as e. g. the GSM, a Wireless Local Area Network (WLAN) such as IEEE 802.11 or a Wireless Personal Area Network (WPAN) such as Bluetooth.
- **Mobile Phone Network:** Uses the *cell ID* technique. The mobile phone connects to the network through the base station and a signal is sent to a central database that a mobile phone has entered a cell.
- ***WLAN TECHNOLOGY***
- A WLAN is composed of fixed Access Points (AP). These antennas allow to access the wireless LAN and through this to wired networks or the Internet.
- These wireless APs must have a direct connection to the network and must be configured with an IP address.
- The connection between the AP and the user device occurs only if the necessary connecting card, drivers and security pass are installed in the mobile device.

- As the user moves out of range from one AP, another AP must be closed enough to guarantee continuous connection.
- The highest the signal strength is, the shorter the distance between the user and the APs.

**2.3 Database Management System**

In order to store data for a GIS or LBS system, a DBMS is used and will be explained in this section. A database is a collection of related data, corresponding to facts that can be recorded and that have explicit meaning. A database management system, or DBMS, is software designed to assist in defining, constructing and manipulating large collections of data. Defining a database involves specifying the data types, structures and constraints for the data to be stored in the database (Loney, 2000). Constructing the database is the process of storing the data itself on some storage medium that is controlled by the DBMS. Manipulating a database includes such functions as querying the database to retrieve specific data and updating the database (Elmasri, 2000).

**2.3.1 DBMS Standard Language: SQL**

In current DBMSs, a comprehensive integrated language is used; it has statements for data definition, query and update. But storage definition is kept separate. IBM Research developed and defined SQL (Structured Query Language), and ANSI/ISO has refined SQL as the standard language for relational database management systems. SQL uses respectively the terms table, row and column for relation, tuple and attribute of the relational model. The SQL commands for data definition are create, alter and drop. SQL has one basic statement for retrieving information from a database: the select statement. Many options can be used with the select statement. Usually the basic query is structured by this way:

SELECT <attribute list>
FROM <table list>
WHERE <condition>;

SQL is a standard language for relational DBMS and was first specified in the 1970s and underwent enhancements in 1989 and 1992. The language is continuing its evolution toward a new standard called SQL3, which adds object-oriented and other features (Elmasri, 2000).

**3. Research Methodology and Procedures**

This section explains the procedures, GIS data formats and the technology used for the preparation of data and design of the project. It also describes the entire system of the project. The structure of the spatial data of the Micro-routing and the procedure from data editing to loading data into the database is described, and some necessary data processing are also discussed.

**3.1 Data and Relevant Technologies and Applications for the Study**

The political Maps of Lagos State form the base for data regarding Local Government Area boundaries, roads, and settlement locations and their names. Other input layers include: Roads, Traffic, Recreation, Police facility, Churches, Schools, Medical, Markets, Services, LGA, LCDA, Settlement, and Water. Relevant technologies and applications used in the development of the project include: ArcGIS 9.3, Oracle 11G for the database development, Oracle SQL developer, Acqua data studio, Netbeans IDE 6.8, Quanta 12.3, Macromedia fireworks, Java, Map server, OS- Windows XP, Windows 7 ultimate, Linux.

**3.1.1 Oracle 11g Database Component**

The oracle spatial component of oracle 11g was used for this application. The oracle11g database is object-relational and designed to support and leverage the capabilities of the Internet. It can be visualized as a set of data tables. However, an object-relational database supports all of the features of a relational database while also supporting object-oriented concepts and features (specifying both the structure of the data and the ways of operating on it). Hence, an Oracle database is a collection of data treated as a unit. In general, a database server reliably manages a large amount of data in a multiuser environment so that many users can concurrently access the same data. All this is accomplished while delivering high performance.

**3.1.2 Pre-processing the Dataset**

Before loading the created data into Oracle, some specific tasks were carried out. First, all layers were georeferenced to the same global coordinate system. In this case, the global coordinate system is the Universal Transverse Mercator system (UTM, zone 31N) used for the storage of the data in the database. The second step was editing the shapefile layer in ArcMap using the editor function. The snapping function is very useful to obtain different elements together. This will make the display look better on the web page and there will be no overlapping of layers. The last step is to create the topology for polylines and polygons. Elements such as lines can be drawn at different times, but have to be one element defined by the topology. After cleaning processing, ArcGIS produces attributes automatically. They are perimeter and area for polygon, length and nodes for polyline. The polyline shapefiles are now a suit of segments that possess after cleaning a from-node and tonode attributes. Before using the clean tool, shapefile formats need to be converted into a Coverage format. A conversion tool in ArcToolbox, the *export from shapefile* or *import to coverage* does this. The opposite conversion is done after cleaning, if the results checked in ArcMap are good enough.

**3.1.3 Dataset Construction and description**

ArcGIS is the family software used for the creation of the shapefiles in this application. The Point of Interest layer regroups different kinds of features, which can be useful to provide information to the user via the Micro-routing. Figure 3 shows the sample points of interest (POI) extracted for this project. The POIs list was received as a map. The map contains all the POI features with an ID number, their names, description and their coordinates with reference to the provided map. All these POIs were converted to point shapefiles with their respective attributes. However, for the facility to use and display them in the web page, they are merged together in one point shapefile. The POIs were grouped into 11 classes (layers).

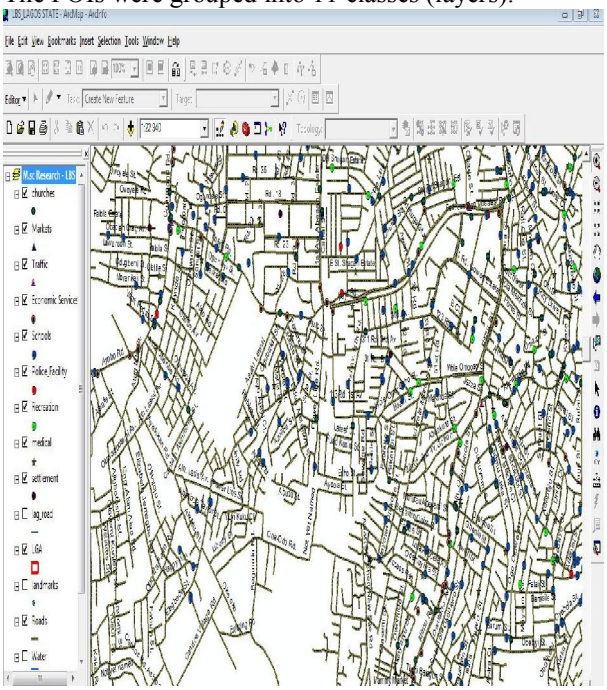

Figure 3. Points of Interests in ArcGIS environment showing the different themes used in the project

### 3.1.4 Loading Spatial Data into the Oracle Database

This part describes how to load spatial data into the database. The process is called bulk loading and can import large amounts of ASCII data into the Oracle database, with the help of the SQL*Loader utility. SQL*Loader control files are used for loading spatial data. The ASCII data consists of a file with delimited columns and separate rows fixed by the limits of the table. The Acqua data import utility tool can also be used for the bulk loading of spatial data into oracle database. See the steps as shown below in Figure 4 and others.

### 3.1.5 Map server

MapServer is a popular Open Source project whose purpose is to display dynamic spatial maps over the Internet. In its most basic form, MapServer is a Common Gateway Interface (CGI) program that sits inactive on your Web server. The most basic functionality of MapServer is its ability to read in a map file and create an image showing the map. Mapserver currently supports Java, Php, python etc. Java mapscript was used for this project. When a request is sent to MapServer, it uses information passed in the request URL and the Mapfile to create an image of the requested map. The request may also return images for legends, scale bars, reference maps, and values passed as CGI variables. MapServer was configured and used as a GIS server for this project. A simple MapServer application consists of; Map File, Geographic Data, HTML Pages, and HTTP Server. Mapserver for Linux was used. It was configured with oracle spatial capability making it possible to read data in oracle spatial database.

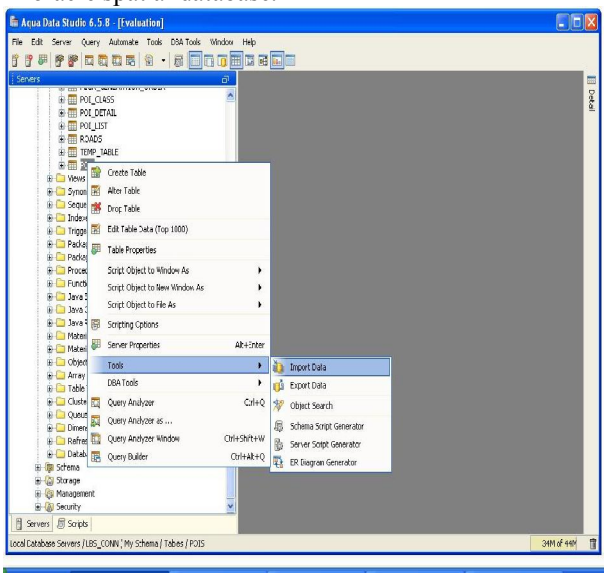

Figure 4. Acqua data import utility showing the import process

### 3.2 System Model and Architecture

The structure of the Micro-routing used in this project is presented in Figure 5. Following the client/server architecture, the Micro-routing is composed of a client with his interface on one side, and the server, with the database and some middlewares on the other side. The web components are distributed in the two sides: web browser for the client and web server for the server side.

### 3.2.1Client Side Components

A web client consists of two parts: dynamic web pages containing various types of markup language (HTML, XML, etc), and a web browser, which renders the pages received from the server. The interaction between a web client and a web application is illustrated in Figure 5. The client sends an HTTP request to the web server. A web server that

implements Java Servlet and Java Server Pages technology converts the request into an HTTPServletRequest object. This object is delivered to a web component, which can interact with JavaBeans components or a database to generate dynamic content. The web component can then generate an HTTPServletResponse or it can pass the request to another web component. Eventually a web component generates a HTTPServletResponse object. The web server converts this object to an HTTP response and returns it to the client. The user interface created for the Micro-routing is a HTML page. Other technologies like JavaScript or JSP pages are also used. The last language has the functionality to request information from the database. JSP pages are text-based documents that execute request/response as servlets but allow a more natural approach to creating static content (Java Technology, 2003).

**3.2.2 Server Side Components**

The first component needed is a database for storing all the spatial features with their attributes. The web server is one of the main features that give availability to the LBS demonstrator, because the latter is provided by the Internet medium. It will be briefly described in the following sub-section. Middlewares are components that connect the database to the client. The first one is the JDBC API (Java DataBase Connectivity Application Programming Interface), which permits spatial and non-spatial queries from the user to the database through SQL statements. API is a virtual interface that facilitates exchanging messages or data between two or more different software applications. It combines error recovery, data translation, security, and queuing. Map server represents the middleware component that is responsible for map displaying and rendering (see Figure 5). The map server was configured with oracle spatial and that makes it possible to establish connection with the oracle database.

**3.2.3 Web Server**

A web server retrieves web pages to clients across the Internet or an Intranet. See the model in Figure 5. The web server hosts the pages, scripts, programs and multimedia files, and serves them using HTTP (Hypertext Transfer Protocol), a protocol designed to send files to web browsers and other protocols. The HTTP protocol defines the requests that a client can send to a server and the responses that the server can send in reply. Each request contains an URL (Uniform Resource Locator), which is a string that identifies a static object such as an HTML page, or an active component like a JSP page or servlet.

**3.2.4 Java Database Connectivity Application Programming Interface**

The java database connectivity application programming interface **(**JDBC API) is used to send SQL statements to relational database systems within a Java technology (JSP pages, servlet, and applet) used in a web page. The advantage of the JDBC API is that an application can access virtually any data source and run on any platform with a Java virtual machine. To use the JDBC API with a particular database management system, a JDBC technology-based driver ("JDBC driver") is needed to mediate between JDBC technology and the database. A JDBC driver makes it possible to do three things:

• Establish a connection with a data source

• Send queries and update statements to the data source

• Process the results

Oracle database management system supports the JDBC API to access the data it stores. See the system model in Figure 5 below.

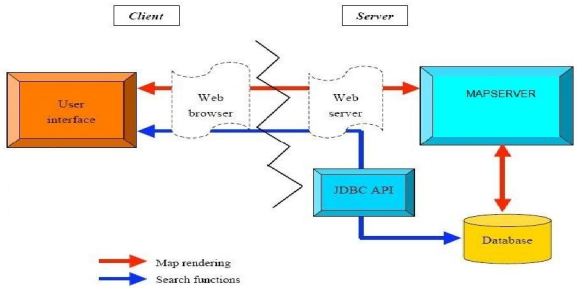


Figure 5. Location Base System Model

**4. Results and Discussion**

This chapter summarizes the results and functionality of this application. First, the problem of localization is explained. This component is an important part of Location Based Services, permitting to retrieve information about the surroundings of the user.

**4.1 Location Information of the User**

In this application, the location information of the user is the proximate POI to his current position which would be retrieved from the listed POI's in the oracle database. That is to say ,a list of likely and possible POI's within Lagos state alongside with their geographic positions have been included in a menu box and can be accessed through the Link named 'Open' on the left of the map frame. The POI's have been categorized and classed, so the user needs to select the category that is relevant to him. Figure 6 shows the coordinate listings of various points of interest locations. In this case the user clicked on the link 'open' and the popup menu showed the different classes of which he selected schools. Thereafter the various schools and their coordinate locations were displayed of which he chose Empire International School as his proximate location. After that another dialogue box tells him of his action of changing nearest POI coordinate. Figure 6 shows another

Current User Location At Ikeja Club from the POI listings.

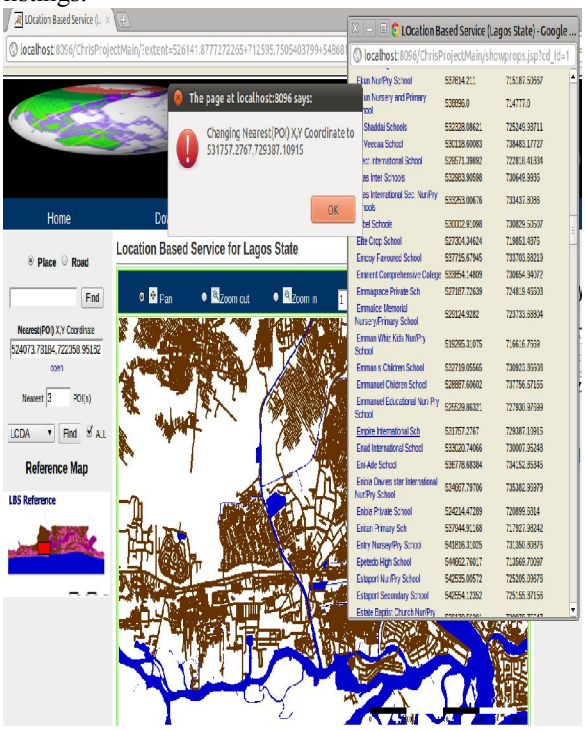


Figure 6. Map Frame Showing Coordinate Listings Of Various Point Of Interest Locations

Figure 7 shows the result for 3 nearest markets within the vicinity of the user. Similar user-request can be submitted for churches and other listed POI's. Three closest churches were retrieved with respect to a user's location and the result showed that four square gospel church and Mountain of fire and miracle ministries were the two closest churches to that hotel facility (see Figure 8). The multi-criteria implication is that the user can view POI's and access certain information within a particular service area and this information can be the basis for certain decision analysis by the user. Figure 7 shows another user who selected his current location as Ikeja club.

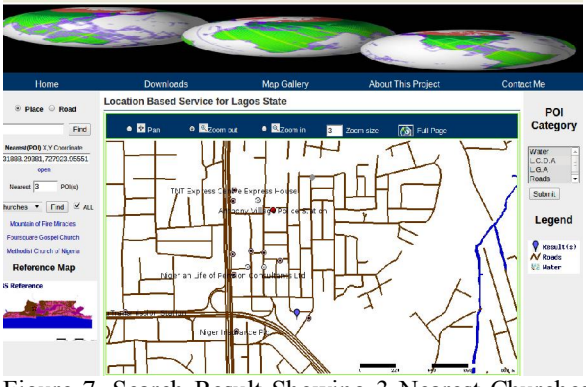


Figure 7. Search Result Showing 3 Nearest Churches on the left frame To A Hotel Facility

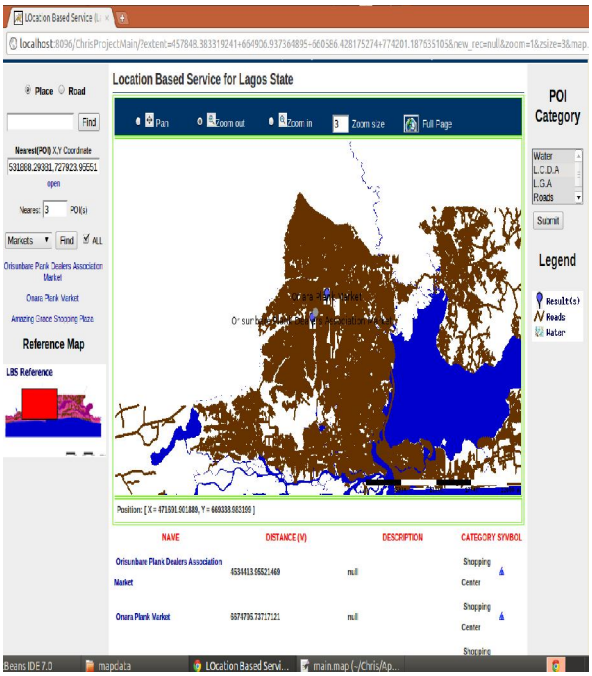


Figure 8. Result For 3 Nearest Markets Within The Vicinity Of The User as displayed on the left of the map frame

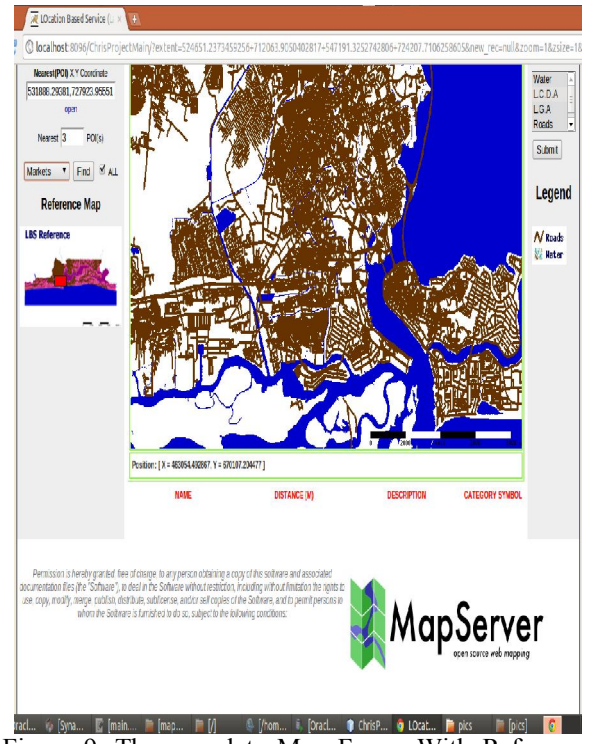


Figure 9. The complete Map Frame With Reference Map displayed on a web browser

**4.2 Design for Pc/Laptop**

The first step is to retrieve information from the user through Internet, via a PC. All kinds of programming technologies can be used, as the fixed Internet permits it. The main components for the construction of a web site are HTML, JavaScript and JSP pages. The web page is defined by a JSP file. It divides the web page into frames. The Header Frame located in the top part represents the title. Then the web page is composed mainly of three frames: the left is composed of two search engines which are used to request the information the user wants, the middle frame is responsible for the map rendering and right frame is made up of the POI category display button which retrieves the corresponding response in the form of a map. Also included on the right frame is a dynamic Legend that shows current items on the map (see Figure 9).

**5. Conclusion**

Location Based Services is a new service along with the development of wireless communication and GIS. With this project, GIS can be taken to a level where we have an increased participation and under the driving of requirements and technology, Location Based Service will have much more wide spread application area .This research was primarily meant to develop a geodatabase for the design and implementation of Location Based Services (LBS) for Lagos State.

This application is made easier to use and can run on both internet and intranet platforms. So far in the design and implementation of this work, users within Lagos environ can access and retrieve geographic information within their location. Location is a strategic asset of wireless carriers. Leveraging this information will help the user to experience value-added services and the mobile network operator to offer differentiation and incremental profitability Location-based service (LBS) provides value added service to the users and society at large. With the development of Location based services, the Internet is now becoming a portal for GIS functionality as well as data distribution.

The integration of GIS and Internet technologies has made it possible to access geo-information without burdening end users with complicated and expensive software and dedicated hardware. Location based services deliver geographic information and geo-processing power between mobile and/or static users via the Internet and/or wireless network. Development of GIS, as integral components of location-based services remains the complex task so the availability of Internet GIS application framework is crucial to achieve greater scalability, and reliability.

LBS is a major area which has got developers and businesses energized. Its range is unfathomed and its technology is progressing rapidly. It has giving an impetus to the demand for rich GIS data and leading way to refined and sophisticated mapping solutions and further making people come together for services, not only for commercial benefits but to assist humanity as a whole.

**References**


1. ARC Group (2003), http://www.arcgroup.com/index.html.
2. Beaubrun, et al. (2007). An Architecture for Delivering Location-Based Services. *International Journal of Computer Science and Network*, 7,7.
3. Beinat E. (2001). *Location-based Services, Market and Business Drivers*, Geoinformatics Magazine.
4. Bernhardsen, T. (2002). *Geographic Information Systems: An Introduction*. John Wiley & Sons, New York, ISBN 0-471-41968-0, 428pp.
5. Collin, S. (1997). *Setting Up A Web Server*, Digital Press, Bath, ISBN 1-55558-174-9, 274pp.
   Elmasri, R. & Navathe, S. B. (2000). *Fundamentals of Database Systems*, Addison Weasley, USA, ISBN 0-8053-1755-4, 955pp.
6. Hjlem, J. (2002). *Creating Location Services for the Wireless Web*, Wiley, New York, ISBN 0-471-40261-3, 431pp.
7. Isabelle, K. (2003). *Development of a Location Based Service for a University Campus: A Case study of University of New South Wales, Sydney ,Australia*. Location-based Services, Mobile in a Minute™ :(www.mobileIN.com)
8. Java Technology (2003). Host website http://www.java.sun.com.
9. Loney, K. & Koch, G. (2000). *Oracle 9i The Complete Reference*, Osborne/McGraw-Hill, Berkeley, ISBN 0-07-212364-8, 1300pp
10. Maxim, M. & Pollino, D. (2002). *Wireless Security*, McGraw-Hill/Osborne, Berkeley, ISBN 0- 07-222286-7, 32pp.
11. Meitner, M. J. (2002). UBC Forestry,
12. http://www.ideal.forestry.ubc.ca/cons340/Lecture04.pdf
13. Scott, M. (2002). Java Technology website: http://www.developer.java.sun.com/developer/technicalArticles/Programming/jsp/