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Developing and Consuming Mobile Location-Based Systems

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Abstract

The convergence of the internet, wireless and location technologies has been creating new opportunities for mobile devices. Mobile location-based system (MLBS) has emerged as a critical field of study in mobile communication. The study investigates the technologies used to develop Location-Based Systems (LBS) and describes various methods of consuming such systems. It features significant programming logics and processes needed to successfully implement an adequate Location-Based System. To explore this cutting-edge technology in a user-friendly manner, a real-world application was developed to demonstrate the processes and platforms deployed to consume LBS. The demo which could be deployed on seven different platforms including Android, Blackberry, Symbian etc, utilizes legacy data storage based on Microsoft.Net Windows Communication Foundation WCF (Restful Services) and MS SQL Server. The developed product is a hybrid application that helps mobile user find businesses and places closest to them or in their suggested area in order of proximity. The work demonstrates practicable solution to developing and consuming multi-platform, light weight, cross-domain mobile enabled Location-Based Systems.

Keywords

Location Based System, Geospatial Data, Central Server, Visual Application and Mobile Device

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1. Introduction

1.1. Background of Study

Just over twenty years ago, barely anyone had a mobile phone, (Abowd G. D., et al., (1997)). Since then, developments in cellular network technologies and the mobile phone market have been enormous leading to emergence of significant number of mobile telecom companies and mobile phone manufacturers around the world, (Aloizio P. D., (2002); Amitay E., et al, (2004)). Right now, nearly everyone in the western world and about 70% of working class Nigerians own at least one mobile phone, and it is expected that this trend will continue to increase in the future, (Barnes S. J., and Huff S. L. (2003); Borriello G., et al, (2005); Brimicombe, A. J., (2002)). According to the ITU [2004], the number of worldwide mobile phone subscribers (1.14 billion) already surpassed the number of landline telephone subscribers (1.10 billion) in 2002, and is still growing, (Aalto L., et al., (2004). The usage of the mobile phone and its applications will continue to grow, and at the moment with still unforeseen areas of use, as new technologies become available, (Palmer, J., (2013); Pourhomayoun, J. and Fowler (2012)). The increasing use of mobile devices has led to the development of many resource applications that runs on the mobile phone medium. Many of such applications provide helpful Location-Based services to

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mobile consumers, (De Montjoye, Y., et al., (2013)).

This work features the development of a mobile application that retrieves client location data from a mobile unit, sends it with user specification data as SQL parameters to a database enabled server via WCF service hosted on the internet and returns JSON formatted location details geo-positioned on Google map in order of proximity to the client at that moment.

1.2. What is Location-Based System

In a fairly broad sense, Location-Based Systems can be defined as a system that extends spatial information processing or GIS capabilities to users via the internet and / or wireless network, (Khalil A., et al., (2006); Lennart Ostman (2001); Munnelly J. (2005)).

In a more narrow sense, Location-Based System/Service sometimes called Location aware service or system are context aware service that utilize the location of the user to adapt the service accordingly. (Kaasinen E., (2003); Nikolay Tkachuk1, et al., (2011)).

A similar definition for LBS is given by the international OpenGeospatial Consortium (OGC, 2006 & 2007) as: *A wireless-IP service that uses geographic information to serve a mobile user.*

Location-Based Services as defined by (Location Inter-Operability Forum, 2001) as "A service that will allow mobile users to receive personalized and lifestyle-oriented services relative to their geographic location"

Or simply any application services that exploits the position of a mobile terminal. These definitions describe LBS as an intersection of three technologies (Figure 1). It is created from New Information and Communication Technologies (NICTS) such as the mobile telecommunication system and hand held devices, from Internet and from Geographic Information Systems (GIS) with spatial databases, (De Montjoye, Y., et al., (2013)).

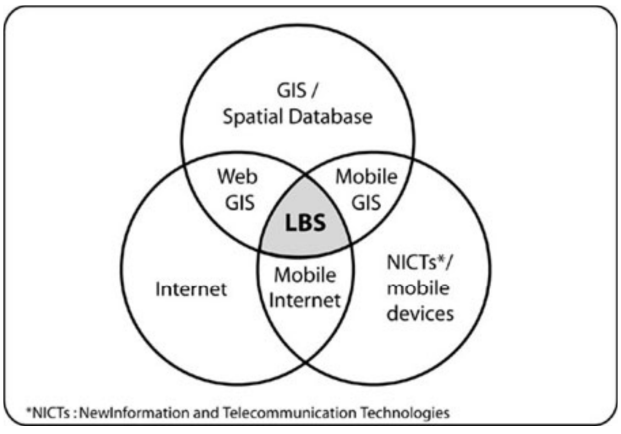

Figure 1. LBS as an intersection of technologies (Brimi-combe 2002).

1.3. Challenges of Location-Based Service

As Location-Based Services are technologies and businesses in development stage, lots of problems are awaiting solutions. Here are some of the examples, (Ratcliffe J. H. (2001); Palmer, J., (2013); Pourhomayoun, J. and Fowler (2012)).

1.3.1. Technical Improvement

Location accuracy is still the main issue to combat, (Cheverst K., et al., (2000); Costanza E and Leinss M. (2006)). While different parties are trying different ways to deal with location determination and data manipulation, they should work together to come up with unique standards and specifications, (Dan Foster. GPX: the GPS Exchange Format, (2004); David M. and Jonathan R., (2001); Douglas W., et al., (2004)).

1.3.2. Privacy

The ability of constantly monitoring the position of an individual in real time is a critical privacy concern. One may disclose lots of information about his/her private life. Mobile users can be tracked without knowing it, which may lead to dangerous consequences, (De Montjoye, Y., et al., (2013)). Some location privacy laws are established to restrict the use of information from LBS. Details include businesses can only use location information according to user's wishes; businesses should seek permission from users to expose their information to third parties; users should be notified the collection of their information (Michael A. (2011); Palmer, J., (2013); Pourhomayoun, J. and Fowler (2012); De Montjoye, Y., et al., (2013)). However, further efforts should be made from wireless operators and service providers to prevent location information from being stolen and used illegally.

1.4. Research Aim and Objectives

The Aim is to show by practical demonstration, relevant technologies that can be employed to develop and consume mobile location-based systems.

The following are the research objectives:

- Proof that Mobile Location-based Service can be used to serve large geospatial data via a light weight / client application.
- Demonstrate key technologies needed to interact with core functionality features onboard most modern phones (smart phones).
- Show important technologies needed to ensure secure communication between multi-client devices and a central server.
- Exploring virtual application testing techniques using

Android compliant Nexus One emulator.

- Use multiple data sources from the Internet and from mobile device to consume location-based services.

1.5. Overview of Research

For this thesis a system has been built to realize the functionality described in the research objectives. An integrated system that can detect your current location, acquire user specifications and send these data as SQL parameters using an Asynchronous javascript Xml (AJAX) call to online server via the internet.

This system will combine data from different sources on the mobile phone, (Flickr. M., (2007); Google. Google maps API, (2007); Palmer, J., (2013)). The work describes the process necessary in developing the major segments of the system: the client-side and the server-side. And finally describes the trends that lead to LBS, the techniques necessary for building them, and the problems encountered when working with location based data. A system like this can be typically used for end-user queries like:

- Where are my friends?
- What movies are playing near my current location?
- What is a good place to have dinner around here?
- What sights are there to see near me?
- What is the history of this building?
- What experiences have other people had at this location?
- Where is business X located around me or in/around place Y

1.6. Scope of Research

This work will focus on developing and consuming LBS for Nigeria mobile phone users. The mobile devices targeted will be smart mobile phones running Android, Black berry, Apple IOS, Windows Phone, Symbian, Bada and WebOS operating systems. This system works better on phones utilizing fairly high network speed (1G and above).

A good example of a modern 3G mobile device is the Samsung Y young Duo Android phone (Figure 2) which will be used to test the application physically. It consists of onboard GPS, Wifi, 3G, wide screen, on-screen key board.

- Video Player & Music Player
- Dual SIM, GSM + GSM
- Bluetooth Yes, v3
- 832 MHz Qualcomm Scorpion Processor
- Primary Camera Yes, 3 Megapixel
- Li-Ion, 1300 mAh Battery
- 3.4 Inch(8.1cm) TFT
- GPS and GPRS
- Expandable Memory Upto 32GB
- Android v2.3 (Gingerbread) OS

The application developed will be available for download and testing through online application stores. Communication between client application and web server will be facilitated by WCF (Restful) service, (Google Keyhole. KML, (2007); Harter A., et al., (2002)). Data to be transferred from and to the client application will be in Java-script Object Notation (JSON) format.

Figure 2. Applications physical testing device.

- Video Player & Music Player
- Dual SIM, GSM + GSM
- Bluetooth Yes, v3
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- Primary Camera Yes, 3 Megapixel
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The application after installation on smart phone utilizes network connection and data plan supplied by the telecom operator, or a WiFi connection, and have the ability to provide geographical location information (e.g. longitude/latitude variables) over the wireless network.

2. Literature Review

The rapid developments in mobile phone engineering are at the moment noticeable by looking at the wide range of available so-called pocket pc's and smart phones of the third

generation (3G) of mobile phones, for example the Apple Iphone, HTC Google G1, Samsung Omnia, the Blackberry Storm, or the Nokia N97. The latest developments include touch-screen or sometimes multi-touch functionality, accelerometer sensors, compass sensor, handwriting recognition, fast wireless access, and increased computing power, (Pourhomayoun, J. and Fowler (2012); De Montjoye, et al., (2013)). This increase in computing power and speed of data-transfer in cellular networks has been commendable over the past five years.

2.1. LBS Components

If the user wants to use a location based service, some infrastructure elements are called into play. In Figure 3, the five (4+1) basic components and their connections are shown:

- Mobile Devices: A tool for the user to request the needed information. The results can be given by speech, using pictures, text and so on. Possible devices are PDA's, Mobile Phones, Laptops etc but the device can also be a navigation unit of a car or a toll box for road pricing in a truck.
- Communication Network: The second component is the mobile network which transfers the user data and service request from the mobile terminal to the service provider and then the requested information back to the user.
- Positioning Component: For the processing of a service, usually the user position has to be determined. The user position can be obtained either by using the mobile communication network or by using the Global Positioning System (GPS). Further possibilities to determine the position are WLAN stations, active badges or radio beacons. The latter positioning methods can especially used for indoor navigation like in a museum. If the position is not determined automatically it can be also specified manually by the user, (Want R., et al., (1992); Yahoo! Maps Web Services. Yahoo! Maps GeoRSS, (2007)).
- Service and Application Provider: The service provider offers a number of different services to the user and is responsible for the service request processing. Such services offer the calculation of the position, finding a route, searching yellow pages with respect to position or searching specific information on objects of user interest (e.g. a bird in wild life park) and so forth, (Hightower J. and Borriello G. (2001); Reid. E., (1991); Rekimoto J. and Ayatsuka Y., (2000)).
- Data and Content Provider: Service providers will usually not store and maintain all the information which can be requested by users. Therefore geographic base data and location information data will be usually requested from the maintaining authority (e.g. mapping agencies) or business and industry partners (e.g. yellow pages, traffic companies).

2.2. What Do You Need to Develop a Mobile Location Based System

The following are needed to successfully develop a MLBS:

a Mobile device: this consists of hardware and software including operating system and applications software on mobile devices.

b Carrier: this is simply an entity with a wireless network that provides service to users.

c Wireless protocol: specifies the way that a mobile device can be used for exchange of information through internet access including electronic mail, the world wide web(www), newsgroup and internet relay chat (IRC).

Methods of determining the Mobile User's (MU) Location: with the use of wireless protocols, carriers, users can be provided with access to specific information and services through one or more technologies that determine the location of the users, (Rizos C., (2005); Palmer, J., (2013); Pourhomayoun, J. and Fowler (2012)).

2.3. Focus of the Research

This research aims to describe in detail the aforementioned technologies used to develop a suitable Mobile Location-Based System MLBS. It demonstrates the technologies by walking followers through principles to be considered when creating MLBS, (Welbourne E., et al., (2004); Wikipedia. Wikiproject geographical coordinates, (2007)). Because there are no better ways to explore these technologies other than through practical approach, a mobile application will be developed to show how the various technologies fuse together to bring about the Mobile Location-Based System/Service, (Figure 3).

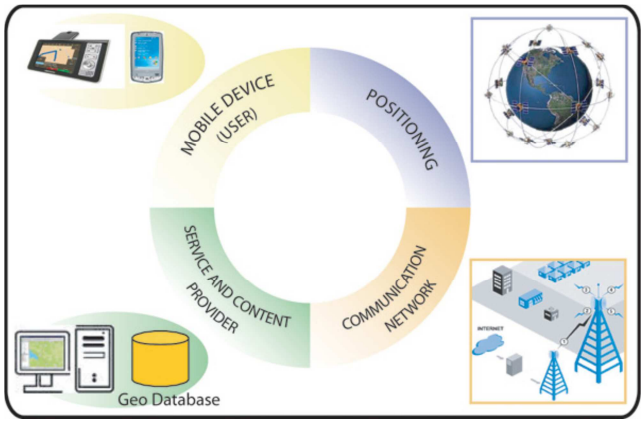

Figure 3. The basic components of LBS: User, Communication Network, Positioning, Service Provider and Content Provider.

3. Methodology

This section will describe the location-based system and the application that has been built, which is called geo-locator,. (Robbert K., and XML-SQL, (2007); Rohs M., (2005); Sebastiaan W. Janssen. Mobile location-based services (2009); Shafranovich Y., (2005)). Geo-locator can be used to show local businesses and places closest to a mobile user's location or suggested location in order of proximity to the mobile user. Geo-locator is a small mobile application targeting mobile operating systems like Android, Black berry, Symbian, Apple IOS, Bada, WebOS and Windows Mobile. The application is built from the combination of HTML5, Javascript and CSS3 compiled together as an installation file. The installed file connects to a GPS device. It receives its current location's coordinates from the GPS, and transmits them together with other user specifications over GPRS or other data carriers and the Internet to a central webserver, that decode the transmitted data as sql parameter on the webserver over a MSSQL database. The sql query retrieves a list of locations details in order of proximity to the user from the database and return to mobile user's device. This process is repeated every time a user sends a query from the application. The data flow can be seen in Figure 4, (Varshavsky A, et al., (2006); Yahoo! Yahoo Maps API, (2007); Palmer, J., (2013)).

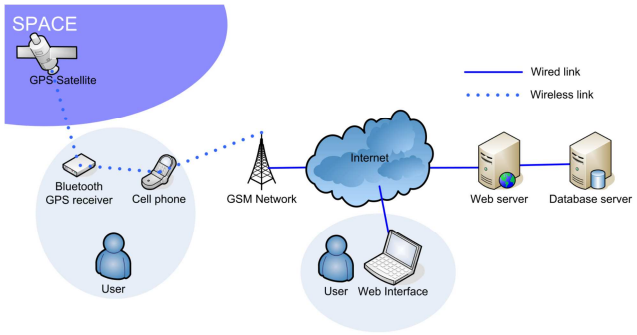

Figure 4. Overview of the geo-locator system.

The database consists of some Five thousand business and place locations with their coordinates gathered over a long period of time.

3.1. Design Principles

While building the system, there were several design principles:

- Work on as many phones as possible, which lead to the adoption of PhoneGap.
- GPS & wifi functionalities will be activated on mobile phones.
- Easy installation by users
- Be Internet based
- Feasible within my resources (time and budget wise)

As mention earlier, the application connects with a backend database on webserver. This meant that 3rd party web hosting site was consulted and subscription arrangements were concluded. The backend database is a Microsoft Structured query language database MSSQL 2008.

- The design principles led to the following minimal specifications for the current implementation, which works with wifi and GPS onboard the mobile device. As mention earlier, the phone running the software has to support:
- HTML5, Javascript and CSS3
- WIFI and GPS
- Internet connectivity (GSM/GPRS/EDGE/UMTS/WiFi/etc)
- Mobile web browser with XHTML support.
- Special care was taken to support the lowest end mobile web browsers. These specs can be met by all but the very lowest-end phones on the market today.

3.2. Conceptual Framework

Geo-locator uses the conceptual framework of Baldauf (Baldauf, 2006). As shown in Figure 4, the framework consists of five layers, in which data starts at the lowest layer, and flows to the higher layers. This model is distributed between the phone and the server. The data starts at the phone and is preprocessed there before being send to the server. The server builds a result set, based on the data the phone sends. The result is send back to the phone, to be displayed. This application is shown below:

3.3. Overview of Application

This section will show the user features of geo-locator. The user runs a small program on his phone. This program retrieves its current location, and transmits this together with other required user data to the webserver to implement database query and return query result for locations close to the user to the mobile user device. The system consists of two segments:

- The Client-Side and
- The Server-Side

Now that I've walked you through configuring and setting up PhoneGap in Eclipse for Android with help from http://www.adobe.com, I will like to move to the part of the system installed on the Mobile user's (MU) device as an application. It has been carefully designed to deal appropriately with user's needs on the fly. The controls used

on the interface are:

- Text box
- Option button
- Label
- Command button
- Div and
- List view

The codes in APPENDIX I and APPENDIX II have been used in the client side application.

The server-side segment of this system may not be necessary but because the application as described earlier has to post MU's location and other user detail to a webserver through the internet, hence the need for web application hosted on a webserver. This webserver is MSSQL enabled because business and place locations have to be stored in a database because of it large number (; Stefan, S., et al., (2006); Tomi, T., et al., (2013)).

4. Result and Analysis

This section describes the results obtained and the proof that the system built conformed to research objectives and design. The testing setup for the system is also described alongside with the results obtained for the demo application: geo-locator.

4.1. WCF Service Testing

At this stage, WCF Restful service had been developed to connect the "geo-locator" client application to the hosted server in order to query remote geospatial MSSQL database deplored on the server. A significant amount of time was expended on this stage with varying challenges, but breakthrough was recorded after much work.

To confirm the successful execution of this stage, query string urls were written to return sql result from the database online in JSON format. The querystring urls are as follow:

http://realestatewcf.com.m6.net/GetEmployees.svc/?lat1=6.602&long1=3.355&srad=5.5&lname=bank

Result:

[{"Address": "Mobolaji Bank-Anthony Way", "Country": "Nigeria", "LGA": "Ikeja", "Latitude": "6.59", "LocationId": 21564, "LocationName": "The Nigeria Police (Mounted troop)", "Longitude": "3.355", "State": "Lagos"}, {"Address": "Mobolaji Bank-Anthony ……

4.2. Virtual Testing

As the name suggest, it is a testing platform that comes short of deploying on a physical mobile phone device. In other words, these are systems that help the developer test most functionalities of the application virtually without deploying on physical devices. Examples of these systems are simulators and emulators. At this stage the android "Nexus One" emulator developed by Google was used to test the application locally on the workstation. Some of these testing are captured below in Figure 5.

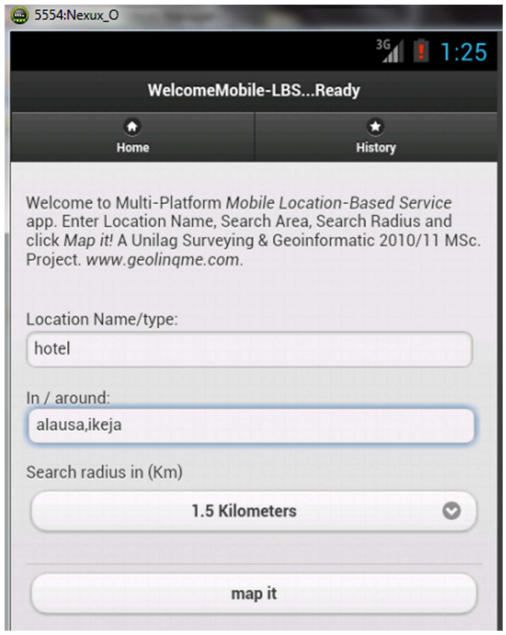

Figure 5. Inter-face query for Hotel in and around Alausa, Ikeja, Lagos with a search radius of 1.5km.

4.3. Physical Testing

I had to procure a Samsung Android mobile device which I used to test the system remotely. There are two major testing stages in this project:

- Development-time Testing
- Online Build Testing

The Development-time testing stage was made possible with the procurement of Android mobile device and as a result of using Java-based Eclipse Android SDK to develop the application. This possibility made testing during development easier as I only have to update the application, compile and send the. apk application file to physical device.

Online Build testing stage has to do with uploading the finished Android copy of the application to phonegap build service for compiling in the cloud service. The phonegap build service compile the Android copy or any other copy originally developed and generates applications copies targeting other platforms for example: Apple IOS, Google Android, LG WebOS, Nokia Symbian, Microsoft Windows Mobile 7, BlackBerry 5,6 and above. This testing stage was performed last so as to ensure that the application to be

uploaded was working fine.

4.3.1. Build one Target Many

As described in the methodology section of this project, the Phonegap framework has been used extensively. Phonegap has been considered from the planning and design stage to the development stage and finally at the deployment stage of the project. The reason for choosing Phonegap is not farfetched; it is because of its multi-platform capabilities.

4.3.2. Application Deployment

Downloaded applications were uploaded to mobile phones and installed on mobile device. The steps required for installing on mobile phones were quite straight forward and easy to follow. After installation, the GPS, Wifi and internet services were activated on the phone. Snap shots describing the deployment are as shown in Figures (6, 7 and 8).

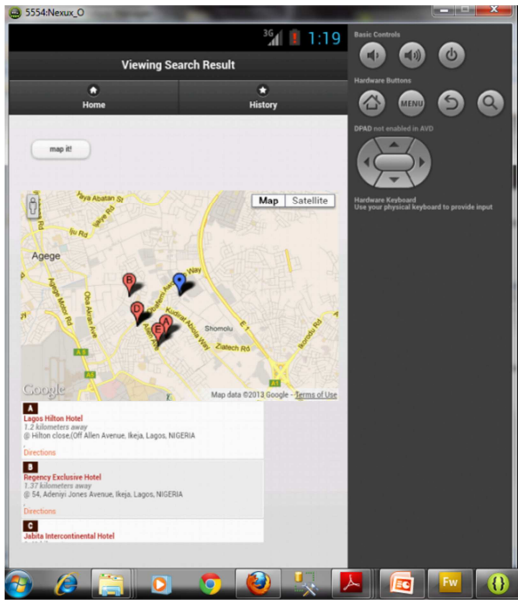

Figure 6. Inter-face showing search result for Hotels within 1.5km from Alausa, Ikeja.

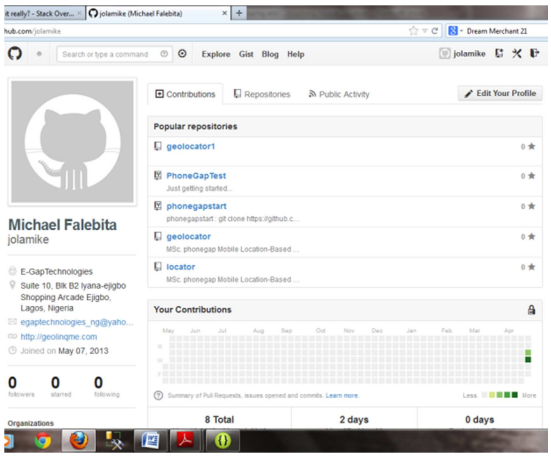

Figure 7. GitHub account and created repositories.

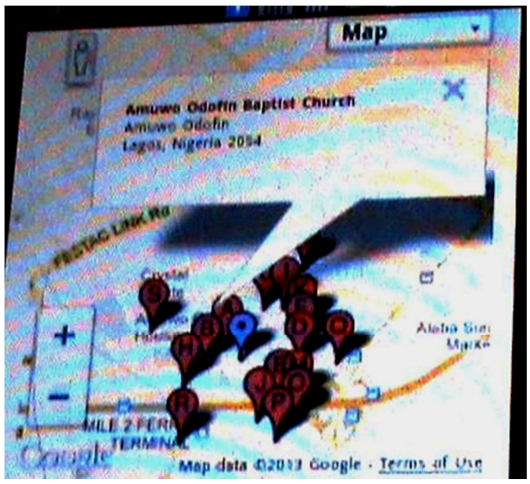

Figure 8. Query result returned from online geospatial database server.

5. Conclusion and Recommendation

This section presents a summary of the work, conclusions drawn from the study, challenges encountered, and the recommendations for future work.

It was discovered that current services being provided to mobile phone users are relatively primitive. But with wireless markets exploding, there is need to provide cutting-edge, GIS-enabled services to mobile users so as to utilize optimally critical modern capabilities built into mobile phone devices to address some of today's geospatial challenges.

This study led to the development of a complete framework for providing distributed services to mobile devices. More generally, the framework is a step toward handling a broad range of mobility issues. The framework mainly involves Java-based applications and can be extended to other services.

The choice for communication with client devices was through the internet (edge, 3G network). This introduced further issues related to mobile communication via internet, including provision of internet service by Telecoms operators. The data transfer framework was developed as a prototype system to transport data between the client and server application. The prototype system works well under reasonable loads. The system was created and tested for commercial viability.

Overall the implementation conformed to the original design objectives of the research and provides a prototype that can be commercialized.

5.1. Conclusions

We can make several observations based on this work.

- In a world of proliferation of different mobile platforms,

there is need for the development of technologies that facilitate cross-platform hybrid application that can deploy on multiple systems. One of these technologies is the Phonegap system.

- One of the concerns with this solution was that the IDE used was new to me i.e Eclipse Android SDK, but I found out that it is possible to learn the programming languages and platforms needed with the right will resolve and motivation.
- Location-aware capabilities have to be handled at the application level (client-side), either by automating location detection or requiring the mobile user to suggest their location.
- Communication between client-side application and server-side application is easier and more efficient with WCF restful service. JSON data format for data transfer to and from these applications is more efficient than XML format for the reason itemized earlier.
- The system developed can serve as a prototype for a commercial system to provide application layer service provisioning for mobile devices. The system can utilize modern internet technologies.
- And finally, although Mobile Location-Based services are at their preliminary acceptance stages in Nigeria, they are increasingly identified as critical service resources in the Nigerian market. Mobile Location-Based services need more awareness and investment for it to blossom.

5.2. Recommendations for Future Work

While the study has shown that Location Based Systems can be built with today's technology, there is still much interesting research to be done. We are still at the beginning of an era of great possibilities with ubiquitous computing system, and with these new powers come great responsibilities for the builders of these systems. Never before in history has technology enabled us to track real-time situations based on user's current location. While I think and hope these technologies bring more good than evil, they do raise new privacy issues.

This thesis has had more focus on the technical aspects of showing and revealing location. But a system that will be used by people from all works of life, privacy and the management of it should seriously be considered. Also in the technology field there is still much work to be done. While new locating techniques have been invented, most of them are still in the prototype phase, and need a lot of work and research to become useful. Even the working techniques, such as GPS have their drawbacks in terms of coverage and signal strength requirements. Some techniques need easier access and better business models to become viable solutions. Characteristics of modern GPS receivers in daily life should be looked at to further fine-tune the system. More effective technologies to support GPS, WIFI and Bluetooth services should be developed to facilitate indoor locating for mobile devices.

On the software level there are many limits, differences and quirks that make systems like HTML5, Java-script and CSS3 not really live up to the word "Standard". If these were to disappear or these systems improved on so that many mobile device manufacturers embrace a standardize platform the mobile phone would be a much more attractive environment to build on. While I have built a fully working system prototype, the user interface and interaction could be considered as a mock-up. There is need for further research and subsequent improvement.

This work has already started. An interesting road still lies ahead.

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