DESIGN AND IMPLEMENTATION OF A WEB-BASED GIS FOR PUBLIC HEALTHCARE DECISION SUPPORT SYSTEM IN ZARIA METROPOLIS

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ABSTRACT

This study focuses on the development of a web-based GIS for public healthcare system. The development of this system is motivated to provide opportunities for the healthcare workers to gain access to vital information that can aid him/her in the location of viable hospitals for the patients to fully enjoy available enhanced healthcare services. Currently, three major problems still exist in the healthcare geographic applications. This relate to health mapping methods, reusability of health applications, and interoperability issues. To handle these problems, we design a Web-based GIS for Public healthcare system to support health data sharing and representation. The developed model makes it possible to locate the nearest hospitals as well as the services they rendered. This study explored the use of open source software, web server is Apache extended with support for PHP, MySQL and ARCGIS 9.2. Authentication is built into the system as security pass mark for accessing information in the data base**.**

Keywords: *Web-based GIS, Public healthcare, Decision Support System.*

1. INTRODUCTION

GIS is becoming a vital tool in healthcare applications covering database management, planning, risk assessment, service area mapping, location identification etc. One of the reasons for this sudden surge of GIS usage in healthcare application is spatial dependency of health related factors and limited resources of ever increasing demand.
Currently, many determinants such as booming population, environmental pollution, rapid urbanization, convenient transportation, and global warming are improving the conditions for disease outbreaks. To prevent and mitigate the risk of disease, it is important to build a robust health system to support evidence based decision making. The sharing of essential health information is one of the most feasible routes to achieve global public security (WHO, 2007).
The health applications using spatial components of diseases can be traced to 1854 when Dr John Snow combined geospatial information to analyze the cholera deaths and found clusters around water pumps (Mcload, 2000).

Fig 1.John Snow map of cholera death in London (Gilbert, E.W.,1958)

There are three important functions of Geographic Information System (GIS) in health research and policy analysis: Spatial database management, visualization & mapping, and spatial analysis (Cromley and McLafferty, 2002). Database management include linking, integrating and editing many kinds of data that are located on the earth's surface, such as health,social,environmental data.Vitualization and Mapping can explore the spatial patterns and correlations of diseases in many factors such as health and environment. Spatial analysis utilizes the spatial relationship to generate new health patterns. When a disease appears, GIS can represent disease information rapidly and analyze the spread of disease dynamically.

The rapid development of the internet promotes the popularity of web-based GIS, which itself shows great potential networks. Distributing and sharing health maps via the web helps decision makers across health jurisdictions and authorities collaborate in preventing, controlling and responding to a specific disease outbreak.

2. PROBLEMS ASSOCIATED WITH HEALTH GEOGRAPHIC APPLICATION

In spite of the continuous development of geographical health applications, the following three problems still need to be handled: Firstly, the methods to generate maps from health related activities need to be considered. There are different kinds of health activities, such as hospital observation, laboratory tests and results, healthcare and medication services, training and education for patients. Many web-based health applications dynamically generate maps, but they lack data source description, and method declaration on how the maps are generated.

Secondly, integrating and reusing current health applications are constrained to a large extent, (Zeng *et al,* 2004) pointed out that the isolation of existing stand-alone disease management systems lead to data sharing problem. Most of the health information systems have a closed architecture even the ones that use web-based technology are difficult to integrate.Typically,users can only access maps from such a health application, and it is difficult to integrate dataset from these applications

Thirdly, different health application lacks interoperability between them. Interoperability makes it easy to communicate, execute programs or transfer data among various systems in a unified manner. With closed and centralized legacy architecture, a web-based GIS system can not fully adapt to current distributed, heterogeneous network environments, and is unlikely to provide users with the needed data and services due to its lack of interoperability, modularity and flexibility (He *et al.*, 2005).In health decision making, it is important to access various kinds of data Such as hospital locations and available services through standard interface.

3. MATERIAL AND METHODS

An online web-based GIS system will be designed and implemented using MySql as the database. Apache will be used as the server to provide basic functionality of the web service.PHP will be used as a scripting language to program the server side that manipulates the knowledge in the database. ARCGIS 9.2 was used to geocode the coordinates of the hospitals locations.

4. ARCHITECTURAL DESIGN

The architecture of the system developed is made up of four major components and follows architecture similar to other web-based system such as that described by (Bapna and Gangopadhyay, 2005). An overview of the architecture can be seen in figure 3.1 below. The architecture consists of four tiers; a presentation layer, an application layer, a data layer and a map-generation layer.

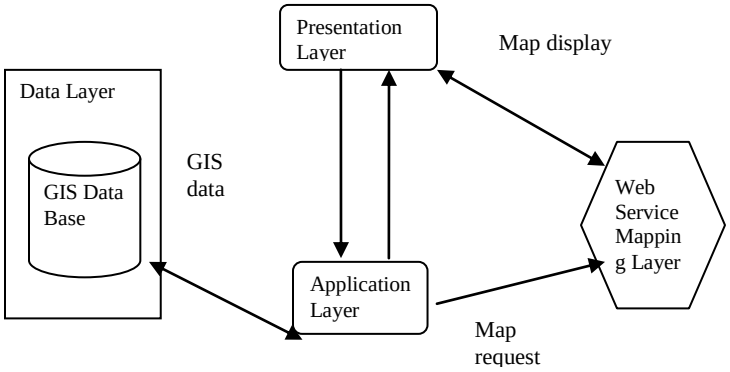

Figure 2.Web-based System Architecture

The application layer forms the centre of the architecture and oversees the relationship between other components in the system, as well as determining how the system functions. It extracts the data requested by a client from the data

layer and then processes it. This is then passed to the presentation layer to display to the client. The application layer is also responsible for performing modifications to the database layer that are requested by the client.

The presentation layer displays the combined output of the application layer and the map generation layer to the client. The Internet and HTML are used to transport this information and allow the communication between these components. In addition to the display of information, change requests are also posted to the application layer through the presentation layer. Essential system operations such as the setting of marker positions are handled through this mechanism.

The data layer is responsible for the storage and provision of data to the application layer. Databases employ Database Management Software (DBMS) that handle a number of issues including concurrent user access, and the efficient storage of data (Adam and Gangopadhyay 1997). It was necessary to create a distinctly separate database to store GIS specific information due to the distributed nature of development of this project. It was not possible to gain direct access to central database due to security concerns. The existing database already provided most of the data necessary for the GIS, including a temporal database that recorded a history of data readings.

The main function of the web service mapping layer is the generation of the visual map according to the variables passed to it. The geographic co-ordinates that are passed to it determine the map that is generated. Mapping services are implemented using a combination of different languages and technologies and allow the generation and display of maps. Currently, two varieties of raster image formats are supported for display on the Internet. These are Graphic Interchange Format (GIF) and the Joint Photographic Experts Group (JPEG) based format. Technologies that mapping services implement includes Web servers, GIS rendering and Geo coding databases**.**

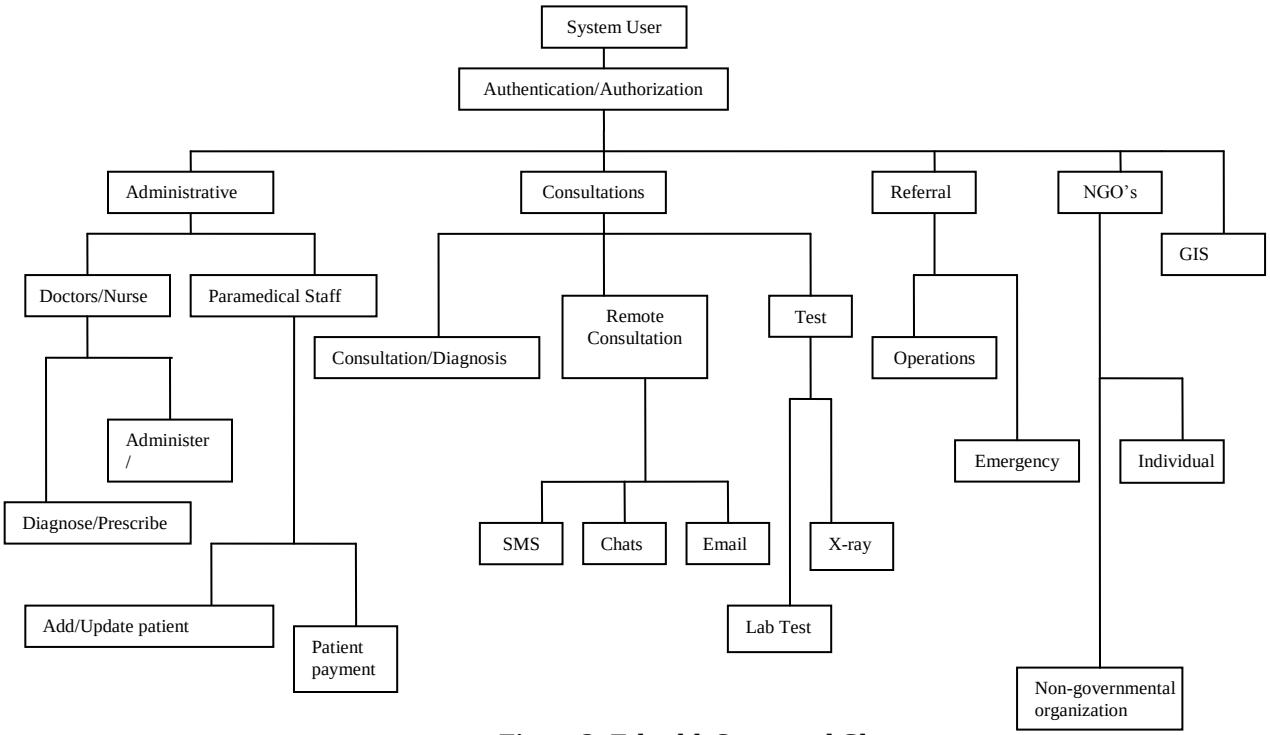

Figure 3: E-health Structural Chart

5. IMPLEMENTATION AND RESULT

The system consists of five major modules. These are Administrative, Consultations, Referral, NGO and GIS map modules. The above modules require that user is authenticated.

6. AUTHENTICATION AND AUTHORIZATION

Authentication in e-health services has to do with ensuring that the identity of a user cannot be forged or altered. Hence, authentication focuses on the verification of the identity of users of E-health data. Put simply, the identities

of users of E-health data must be true and verifiable, where as authorization in the E-health care context means ensuring that e-health data can be accessed only by authorized users.

The Authentication page consists of a script that is handled using simple html, which allows system user to input their user name and password on loading the home page. The security process is ensured by the use of personal identification number. To register, the user supplies his identification number, and the preferred username, password and password confirmation via an html form, and if the patron identification number is found in the table and both password and password confirmation are the same, then registers the username and password in the user table otherwise it reports error messages.

Registered users now login by supplying their username and password details into an html form and submit, the entries will be processed and the user will be logged on if the authentication is successful. Users are also allowed to change their passwords; the system also deals with a situation in which a user has forgotten his/her Password.

Enter Valid User Name and Password		
User Name		
Password		
	Login	**New User**

Enter Valid User Name and Password		
User Name		
Password		
	Login	**New User**

Fig. 4 User Authentication

a. Administrative Module

This module consists of two sub-modules, which allow Doctors/nurses to diagnose/prescribe and administer/take care of patients. Whereas the Paramedical staff add/update patient's database and enter payment made by the patients.

The major objective of this module is to improve the workflow of healthcare practitioners, both clinically and administratively. In essence, this will provide support for clinical and administrative services, investigation of request, result retrieval, diagnosis, treatment, drug prescriptions, etc. All the functions of this module will contribute directly towards the on-ground support of medical practitioners, thereby allowing more accurate and informed diagnosis, effective treatment and enhanced level of healthcare.

c.Consultation Module

The module is divided into three sub module: consultation/diagnosis, remote consultation and lab test sub module.

b. **Consultation/Diagnosis**

The consultation/Diagnosis module is used by the attending Doctor to create and store daily transaction carried out for each of the visiting patients in the clinical table according to the clinical problem presented. Diagnosis refers to a classification process in which a service provider assigns a clinical case to one or more prespecified illness or disease categories based on the patient's symptoms and information collected for the case.

d. Remote Consultation

The remote consultation module make it possible for people's healthcare routine across the world, home-bound patients communicates daily with specialist. The web-based E-health system has the capability to support a very large number of patients who need specific health support locally. This is achieved by sending SMS through the net, with a terminal setup in a patient's home and connected or on internet, or the use of instant chatting messages or by sending Emails all through the net. There are a few ways to sending mail. The Technologist chooses this option by clicking the *New Message* button. He can send a new message, reply to, or forward mail Fig. 5

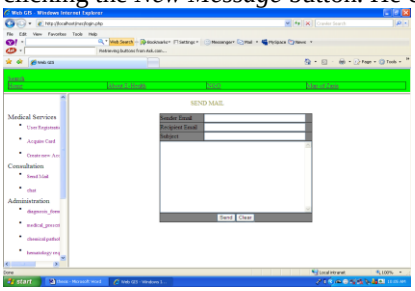

Figure 5. New messages

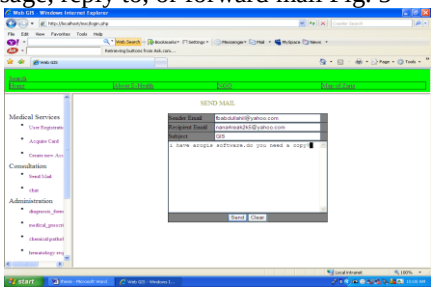

Figure 6 Reply message

The test module allows the technicians to record the result of the medical examination and X-ray images of any patient into the lab test table and the X-ray image table in the database respectively. The physician thereafter loads the result from the database and uses it to diagnose the patients in question.

e. Referral Module

This Module is subdivided into two sub-modules, i.e. Emergency and Surgical Operations. Referring a patient to another physician or another hospital is one of the most common transactions in healthcare. When a patient is referred due to emergency or surgical operation, a subset of his/her record is transmitted to the appropriate specialists or hospitals through the E-health network.

f. Map of Zaria Module:

Fig. 4.9 shows an html form displaying Map of Zaria. When a patient points the mouse to a location on the map, it will display the name of that location. Upon clicking on the location, it will display the hospital name, the services rendered as well as the nearest hospitals. This module enables physicians to know also the nearest hospital as well as the services rendered. For instance, incase a patient who is admitted in a hospital needed to be referred to another hospital, all that the physician needs to do is to click on Map of Zaria, find out the nearest hospital with the available services, if the nearest hospital does have the services required, the physician can further scroll down to check for the hospital with the required services.

Fig. 4.10 shows an html form displaying the output when a hospital say "ABU Teaching hospital" is clicked.

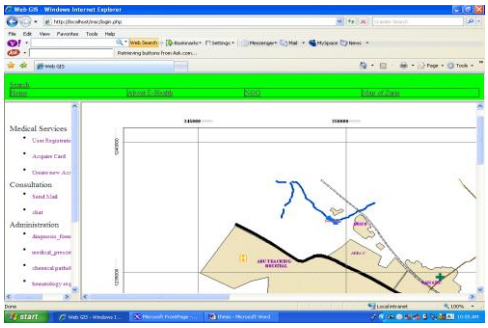

Fig 8 Html form of Map of Zaria

Fig 9 Html output

7. SUMMARY AND CONCLUSION

As technology advances, particularly in the area of information and communication keep growing on daily basis, taking advantage and keeping abreast of these technologies is a paramount concern to users for solving societal problems. The research work describes the Design and Implementation of a Web-based GIS for Public healthcare System environment that could be used to locate the nearest hospital, specifying the service they rendered and aid decision making. In this research, we designed and implemented a service oriented Web- based GIS for Public healthcare system that is loosely coupled. This architecture supports reusability of health data mapping and analysis. It provides opportunities for the healthcare practitioners to obtain access to information that can aid in the diagnosis of patient's health conditions or the development of suitable treatment plans and for the patients to enjoy an enhanced level of healthcare services. This work has been able to bring healthcare services closer to us. Major hospitals in Zaria are now digitized; thereby locating specialists are easily accessible.

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