I. INTRODUCTION

A. Background of the Study

The need for a better visualization of the geographical location associated with a specific study gave rise to the Geographic Information System (GIS). GIS applications are tools that allow users to create interactive queries (user created searches), analyze spatial information, edit data, maps, and present the results of all these operations [7]. GIS has been shown to be valuable in a wide range of situations such as urban planning, environmental resource management, emergency planning, transportation forecasting and as well as in health care. GIS are now also integrated into different websites which can be already browsed in the net and provides visualization of a place through satellite images.

There are already a number of free Web-mapping services available like the Google Maps which is the most commonly used free web-mapping service in the internet. Google provides an API for the Google Maps Web Application, a function that allows one to integrate Google Maps into their own application and websites. Web-mapping is one of the fastest trends nowadays when it comes to displaying data integrated into a map [2]. Web maps are often a presentation media in web GIS and web-maps are increasingly gaining analytical capabilities [19]. Web-mapping can now be integrated with a number of health information systems in order to enhance its functionality.

At present, providing accurate and current information important to researchers or public health authorities and of the Department of Health (D.O.H.) officials, and having a system that can enable them to visualize the area of coverage of a specific disease that is prevalent at the given point in time can help them better in carrying out their objectives like of surveillance of a prevalent or notifiable disease. Determining the extent of the disease can help the public health authorities or D.O.H officials to decide on where they should focus their attention especially in situations when there is an outbreak of disease. Having such system, it can give a more in-depth analysis about a certain disease. The researcher can determine the probable cause of the disease based on the topography or demographic profile of the place. They can also identify or predict other community problems; develop strategies to solve the problems; manage resources allocation; and, in turn, improve the quality of life in the community.

The system is also designed for a specific use, in particular for the National Telehealth Center (NThC). The lack of health information and services in the health industry of the Philippines is one of the problems that the University of the Philippines Board of Reagents wants to solve. A resolution was made by establishing NThC. Their main goal was to improve health care delivery to the general public through ideas and knowledge exchange utilizing information technology [13].

The NThC started to create a Telecenter that is based on a Triage. The triage is composed of three subsystems namely the Rx Box Readings, the Inbox (incoming messages), and the Knowledge base. The proposed Knowledge Base Module is composed of different existing systems under the NThC. These systems are Community Health Information Tracking System

(CHITS), Near Hospital Search Inquiry System (NHSIS), the Integrated Surgical Information System (ISIS), the Philippine National Health Information Infrastructure (PNHII) and other future systems under NThC.

The different existing systems under NThC will be merged into one system - the Metas ES. Metas ES is a meta-search engine that has an access with all the databases/systems (e.g. CHITS) registered in the Telehealth's Knowledge Base. The result of the query of a user will be the combined results coming from the different database.

The application of the web-mapping in NThC Knowledge base module is to show in the web-map all the possible hospital depending on the query (by specialization, facility, doctor etc.), the results will be coming from the Near Hospital Search Inquiry System (NHSIS) via Metas ES.

B. Statement of the Problem

One of the huge problems, when it comes to health services, is the lack of means to inform the people regarding the availability, specializations offered, facilities, doctors, etc. of hospitals within their vicinities. Most of the people commonly choose a hospital based on familiarity and not on the medical services that the hospital can provide, without knowing that there are other hospitals with good facilities and better doctors that can serve them according to their needs. Organizing and presenting in simple but shows all the information (like the services offered of all the registered hospitals and clinics) is a big factor that needs to be considered.

For research purposes, statistical reports can give substantial information if it is well generated and displayed. Collecting and analyzing the results from different databases (e.g. CHITS from different regions of the Philippines) is time costly especially if it is not organized or integrated into one display or output. Furthermore, providing a spatiotemporal analysis of data like of outbreaks of disease or some of the notifiable disease can have a large potential for informing public health authorities in an early stage of outbreaks of communicable disease, or tracking and determining the origin or the probable cause of it. Moreover, the data sets come from several sources such as socio-economic data, disease surveillance, healthcare utilization, healthcare resources, environmental, and health resource allocation. By integrating these data sets, the system can identify factors that affect the health of a population and determine the availability of resources within the community to adequately address these factors.

C. Objectives of the Study

The main objective of this special project is to create a system, "Telehealth's Geographic Information System (TGIS)", with the following functionalities.

1.) Allow the registered users namely DOH officials, NThC employees, public health authorities and researchers

   a) To use an online interactive map service (Google Maps) that can be used to show all the registered hospital available in the Philippines.

b) To perform query of hospital(s) with the following search criteria – name, location, department and medical service; or search for doctor(s) with the following search criteria – name, hospital and department.

c) To view the geographic spread of a specific disease over a given time period as taken from Metas ES.

d) To make a query or select from the list of notifiable diseases using/within Metas ES. The system will

   i. Display on the map the hospitals within a given vicinity (Region, Province, City or Municipality).

   ii. Generate the results from the Metas ES through the map, graph and tables.

   iii. Generate a graph representation specifically bar graph (based on query results of Metas ES) corresponding to the specific location of the place (region, province, municipality or city) in the map. This enables the user to visualize the results vis-à-vis its location on the map.

   iv. Generate 2 tables showing in the 1^{st} table all the data found by the Metas ES and the 2^{nd} table shows the total of each time interval per region.

2.) Allow also the unregistered users (Doctors or patients)

a) To display where in the map is(are) the hospital(s) matching the given search criteria.

b) To perform query in the map or choose from the list of regions of the Philippines and view information such as the list of available doctors, departments, etc. of hospitals within that portion only.

3.) Allow the System Administrators to

a) register new user

b) deactivate user(s)

c) edit information of the user

D. Significance of the Study

There are a lot of hospitals in the Philippines but only a few of them are recognized to offer medical care [12]. Finding and informing the patients, the doctor/medical practitioner or the relatives of the patients with the information that they need like the doctors, facilities, services etc. can help them in several ways.

The program can benefit the patients as well as the hospitals in many ways. It underscores the significance of determining the nearest hospital available from the location of the patient. Giving the right direction to get to the right hospital/clinic can save a life of a patient as well as the money. Based also from the database of all the registered hospital/clinic (NHSIS), one can decide on where the patient should be brought in terms of facilities, specialization, doctors etc. when in case of a problem or in an emergency situation (if this is possible to provide help at such situation). The hospitals can also update the records of their services, list of doctors etc. which will give the patient or the doctor a higher probability of choosing the most appropriate and most convenient hospital that could respond according to their needs.

Spatial analysis of data from the meta-search (Metas ES) can provide a timely and unique description of the data which can be used for surveillance of disease or tracking and determining the probable cause or origin of it. Presenting the data (based from the result of the Metas ES) in map or in charts can help the user analyze the statistical information better. For example, an analysis about a disease on a certain area could let the government know and decide on where they need to give more assistance to or priority in prevention of disease.

The public health decision-making process can be considerably enhanced by the development of such spatial-temporal analysis tools that allow spatial and multidimensional processing of information relatively quickly and easily. Like most countries, healthcare facilities and healthcare professionals tend to be concentrated in urban areas. Multidimensional analysis can provide information as to whether regions, provinces, cities, and municipalities are indeed underserved by healthcare professionals and facilities. It can also identify which rural areas are in greatest need of healthcare services.

The strength of multidimensional and spatial analysis is that it allows the user to see the information visually on a map that is otherwise hidden in the complexity of the data and variables. Since the information is presented visually and no statistical skills are required, this type of disease surveillance system can potentially be used by more users and higher level executives.

E. Scope and Limitations

1. The system only generates the hospital/clinical information based on the data provided by the Nearest Hospital Search Inquiry System (NHSIS) database.
2. Only registered hospitals/clinic will be shown in the result from the search. This will be the main need of the Telehealth, to provide assistance to the patients or doctors to the barrios. The DOH officials or the researcher can also use this to contact the hospitals during situations like outbreak of disease.
3. The statistical output is solely dependent from the meta-search result.
4. Real time street information (if needed) might not always be updated because of the static nature of satellite images, so unanticipated road changes or heavy traffic may result to inaccurate results.
5. The map is also limited to the Geocodes of the Google Maps and also to the major or minor streets created or present in the Google Maps. If the hospital or location did not show up in the map, the hospital or location may not have yet been encoded yet in the Google Map database.
6. Zooming capability is limited to what can be provided by Google Maps

II. REVIEW OF RELATED LITERATURES

The use of Geographic Information System (GIS) in different field of study is growing, a consequence of a rapidly evolving technology and having a wider audience [8]. The term GIS describes any information system that integrates, stores, edits, analyzes, shares, and displays geographic information. GIS applications are tools that allow users to create interactive queries (user created searches), analyze spatial information, edit data, maps, and present the results of all these operations. It includes mapping software and its application with remote sensing, land surveying, aerial photography, mathematics, photogrammetry, geography, and tools that can be implemented with GIS software [6].

As early as the late 1990's, GIS comes into a new stage, it tries to become a tool for information decision and manipulation [11]. Increasingly complex problems in the health field require increasingly sophisticated computer software, distributed computing power, and standardized data sharing. In this field, the use of GIS has given much attention; there is now a great concern within health surveillance [8]. The internet has emerged as an efficient way to share health information, enabling users to access and understand data at their fingertips [4].

This term GIS has been added to MeSH in 2003, a step reflecting the importance and growing use of GIS in health and healthcare research and practices. From a community health perspective, GIS could potentially act as powerful evidence-based practice tools for early problem detection and solving. When properly used, GIS can: inform and educate (professionals and the public); empower decision-making at all levels; help in planning and tweaking clinically and cost-effective actions, in predicting outcomes before making any financial commitments and ascribing priorities in a climate of finite resources; change practices; and continually monitor and analyze changes, as well as sentinel events [4].

The emergence of the GIS has made it available also in the World Wide Web, thus resulting to the emergence of web-map services. Web mapping is the process of designing, implementing, generating and delivering maps on the World Wide Web [15]. Different web-mapping further expands the availability of health information.

Web-based mapping applications like Google Maps and Google Earth allow multiple independently generated datasets encoded using the Keyhole Markup Language (KML) format to be mixed and displayed via a two-dimensional – 2D map (or three-dimensional – 3D globe in the case of Google Earth). Google maps and other free web-mapping service made it possible for anyone to create and share their own interactive online maps [2].

This technology has also been utilized by many scientists for research purpose like tracking avian-flu using Google Earth. HealthMap which was developed in Boston by Children's Hospital Informatics Programs which brings together disparate data sources within Google Maps to achieve a unified and comprehensive view of the current global state of infectious diseases and their effect on human and animal health [2].

Other examples combine the complex techniques of cartography and GIS and place them within reach of users. The benefit of such easy-to-use GIS applications is evident in an increasing diversity and quantity of publicly available geocoded health data and a growing interest in using GIS and other Web-based tools for mashup of public health data [2].

The availability of geographic information systems (GIS) with comprehensive mapping and spatial analysis capability for desktop and Internet mapping has greatly expanded the number of producers and consumers of health maps, including policymakers and the public [1].

Several web based health applications generate dynamic maps; to do this there is the need of data source description and the method used in the data analysis or statistical modeling. Goa *et.al.* developed a standard format to accommodate all fixed (location) and variable (gender, age, health incomes, etc.) indicators in the representation of health information. They designed a Health Representation XML (HERXML) schema that consists of the semantic (e.g., health activity description, the data sources description, the statistical methodology used for analysis), geometric and cartographical representations of health data. The HERXML has been proven to be an appropriate solution in supporting the Web representation of health information [5].

Due to the recent outbreak of deadly diseases like SARS, Bird Flu and the recent A(H1N1), the ability to strengthen health surveillance and disease control is a growing need [4]. Disease data sharing is important for the collaborative preparation, response, and recovery stages of disease control. Disease phenomena are strongly associated with spatial and temporal factors. Web-based GIS provide a real-time and dynamic way to represent disease information on maps. Gao *et.al* have designed an interoperable service oriented architecture based on Open Geospatial Consortium specifications to share the spatiotemporal disease information [4].

The basics for designing maps that communicate effectively are similar to the basics for any mode of communication. Tasks include deciding on the purpose, knowing the audience and its characteristics, choosing a media suitable for both the purpose and the audience, and finally testing the map design to ensure that it suits the purpose with the intended audience, and communicates accurately and effectively. Special considerations for health maps include ensuring confidentiality and reflecting the uncertainty of small area statistics. Statistical maps need to be based on sound practices and principles developed by the statistical and cartographic communities [1].

The GIS has also the capabilities to use other technologies such as SVG. The system developed by Kamadjeu *et.al.* is one good example, it contributes to accumulating evidence demonstrating the potential of SVG technology to develop web-based public health GIS in resources-constrained settings [7].

The GIS can be combined also to other systems like Knowledge-Based System, Intelligent System and Decision Support System making Geo-DSS like what Ranjana et.al. had done with their work - Exploring Spatial ARM (Spatial Association Rule Mining) for Geo-Decision Support System [15]. The Geo-DSS can also be integrated into an Intelligent Web-Based System and a Knowledge-Based System for easy access and sharing of information [4].

At the University of Pittsburgh, they have developed the Spatial OLAP (On-Line Analytical Processing) Visualization and Analysis Tool (SOVAT) for performing CHA. SOVAT combines Geographic Information System (GIS) technology along with an advanced multidimensional data warehouse structure to facilitate analysis of large, disparate health, environmental, population, and spatial data [14].

In the study, “Tracking the spatial diffusion of influenza and norovirus using telehealth data: A spatiotemporal analysis of syndromic data”, Telehealth systems have a large potential for informing public health authorities in an early stage of outbreaks of communicable disease. Influenza and norovirus are common viruses that cause significant respiratory and gastrointestinal disease worldwide. Data about these viruses are not routinely mapped for surveillance purposes in the UK, so the spatial diffusion of national outbreaks and epidemics is not known as such incidents occur. We aim to describe the geographical origin and diffusion of rises in fever and vomiting calls to a national telehealth system, and consider the usefulness of these findings for influenza and norovirus surveillance [17].

III. THEORETICAL FRAMEWORK

Geographical Information System

GIS is a technological field that incorporates geographical features with tabular data in order to map and analyze assess real-world problems. The key word to this technology is Geography – this means that the data (or at least some proportion of the data) is spatial, in other words, data that is in some way referenced to locations on the earth. Coupled with this data is usually tabular data known as attribute data. Attribute data generally defined as additional information about each of the spatial features. An example of this would be schools. The actual location of the schools is the spatial data. Additional data such as the school name, level of education taught, student capacity would make up the attribute data. It is the partnership of these two data types that enables GIS to be such an effective problem solving tool through spatial analysis [21].

GIS operates on many levels. On the most basic level, GIS is used as computer cartography, i.e. mapping. The real power in GIS is through using spatial and statistical methods to analyze attribute and geographic information. The end result of the analysis can be derivative information, interpolated information or prioritized information [21].

Components of GIS

- **Hardware** - comprises the equipment needed to support the many activities of GIS ranging from data collection to data analysis. The central piece of equipment is the workstation, which runs the GIS software and is the attachment point for ancillary equipment. With the advent of web-enabled GIS, web servers have also become an important piece of equipment for GIS [21].

- **Software** - Different software packages are important for GIS. Central to this is the GIS application package. Such software is essential for creating, editing and analyzing spatial and attribute data, therefore these packages contain a myriad of GIS functions inherent to them. Extensions or add-ons are software that extends the capabilities of the GIS software package [21].

- **Data** - Data is the core of any GIS. There are two primary types of data that are used in GIS. A geodatabase is a database that is in some way referenced to locations on the earth. Geodatabases are grouped into two different types: vector and raster. Vector data is spatial data represented as points, lines and polygons. Raster data is cell-based data such as aerial imagery and digital elevation models. Coupled with this data is usually data known as attribute data. Attribute data generally defined as additional information about each spatial feature housed in tabular format. Documentation of GIS datasets is known as metadata. Metadata contains such information as the coordinate system, when the data was created, when it was last updated, who created it and how to contact them and definitions for any of the code attribute data [21].

- **People** - Well-trained people knowledgeable in spatial analysis and skilled in using GIS software are essential to the GIS process [21].

GIS Techniques and Technology

- **Relating information from different sources**

  Location may be annotated by x, y, and z coordinates of longitude, latitude, and elevation, or by other geocode systems like ZIP Codes or by highway mile markers. Any variable that can be located spatially can be fed into a GIS. Several computer databases that can be directly entered into a GIS are being produced by government agencies and non-government organizations. Different kinds of data in map form can be entered into a GIS [7].

- **Data representation**

  GIS data represents real world objects (roads, land use, elevation) with digital data. Real world objects can be divided into two abstractions: discrete objects (a house) and continuous fields (rain fall amount or elevation). Traditionally, there are two broad methods used to store data in a GIS for both abstractions: Raster and Vector. A new hybrid method of storing data is point clouds, which combine 3d points with RGB information at each point, returning a "3d color image" [7].

- **Raster**

  A raster data type is, in essence, any type of digital image represented in grids. Anyone who is familiar with digital photography will recognize the pixel as the smallest individual unit of an image. A combination of these pixels will create an image, distinct from the commonly used scalable vector graphics which are the basis of the vector model. While a digital image is concerned with the output as representation of reality, in a photograph or art transferred to computer, the raster data type will reflect an abstraction of reality. Aerial photos are one commonly used form of raster data, with only one purpose, to display a detailed image on a map or for the purposes of digitization [7].

- **Vector**

In a GIS, geographical features are often expressed as vectors, by considering those features as geometrical shapes. Different geographical features are expressed by different types of geometry:

  - Points - Zero-dimensional points are used for geographical features that can best be expressed by a single point reference; in other words, simple location.
  - Lines or polylines - linear features displayed at a small scale will be represented as linear features rather than as a polygon. Line features can measure distance.
  - Polygons - Two-dimensional polygons are used for geographical features that cover a particular area of the earth's surface [7].

- **Non-spatial Data**

Additional non-spatial data can also be stored along with the spatial data represented by the coordinates of a vector geometry or the position of a raster cell. In vector data, the additional data contains attributes of the feature. In raster data the cell value can store attribute information, but it can also be used as an identifier that can relate to records in another table [7].

- **Cartographic Modeling**

  Cartographic modeling refers to a process where several thematic layers of the same area are produced, processed, and analyzed. Operations on map layers can be combined into algorithms, and eventually into simulation or optimization models.

- **Map Overlay**

  The combination of several spatial datasets (points, lines or polygons) creates a new output vector dataset, visually similar to stacking several maps of the same region. These overlays are similar to mathematical Venn diagram overlays. A union overlay combines the geographic features and attribute tables of both inputs into a single new output. An intersect overlay defines the area where both inputs overlap and retains a set of attribute fields for each. A symmetric difference overlay defines an output area that includes the total area of both inputs except for the overlapping area [7].

- **Geocoding**

  Geocoding is interpolating spatial locations (X,Y coordinates) from street addresses or any other spatially referenced data such as ZIP Codes, parcel lots and address locations. A reference theme is required to geocode individual addresses, such as a road centerline file with address ranges. The individual address locations have historically been interpolated, or estimated, by examining address ranges along a road segment. These are usually provided in the form of a table or database. The GIS will then place a dot approximately where that address belongs along the segment of centerline [7].

- **Web-mapping**

  In recent years there has been an explosion of mapping applications on the web such as Google Maps and Bing Maps. These websites give the public access to huge amounts of geographic data [7].

Google Map

Google Maps is a Google service that offers powerful, user-friendly mapping technology and local business information which includes driving directions, contact information and business locations. It has following features [12]:

- Integrated search results – location and contact information integrated on the map.
- Draggable maps – click and drag to view adjacent areas immediately
- Satellite imagery – views a satellite image that can be zoomed
- Terrain maps – view physical features with elevation shading
- Street view – navigate within street-level imagery
- Keyboard shortcut – pan left, right, up and down with the arrow keys; pan wider with the Page Up, Page Down, Home and End keys; zoom in and out with the plus (+) and minus (-) keys.
- Double-click to zoom functionality – double left-click to zoom-in, and double right click to zoom out
- Scroll wheel zooming – use the mouse scroll wheel to zoom in and out

IV. DESIGN AND IMPLEMENTATION

A. Context Diagram

The Context diagram is shown in Figure 1. It includes all the users interacting in the Telehealth's Geographic Information System for the Knowledge-Base Module of the National Telehealth Center of the Philippines. The system is divided into six main groups namely: The Metas ES, the System Administrator, D.O.H. Officials/Researcher, Public Health Authorities, NThC employees and the unregistered users or guests.

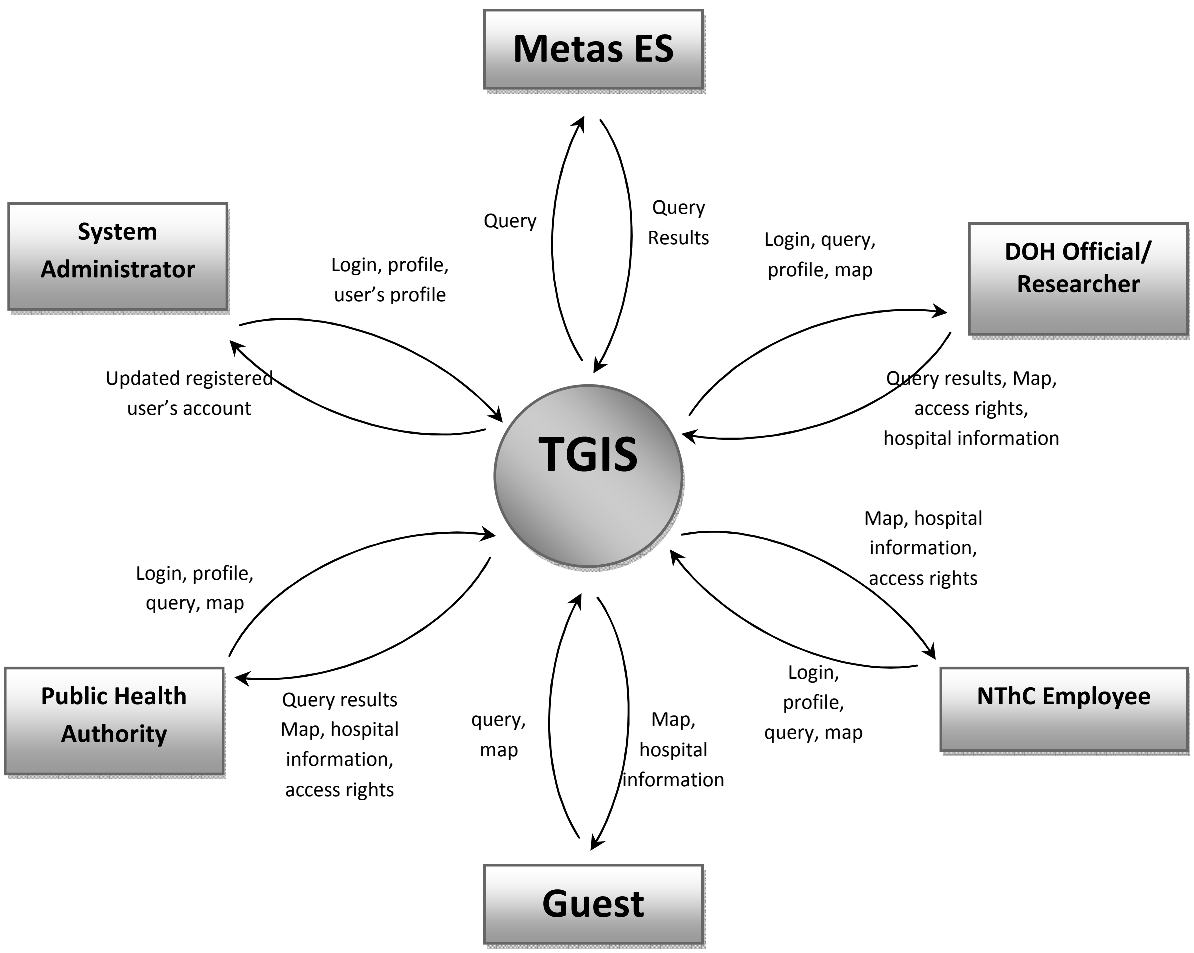


Figure 1. Context Diagram. Telehealth's Geographic Information System (TGIS) for the Knowledge-Base Module of the National Telehealth Center of the Philippines

B. Data Flow Diagram

The Top-Level Data Flow Diagram is shown in Figure 2. It presents all the general processes available on the system. As seen at the diagram, the registered users must login first before performing other functions.

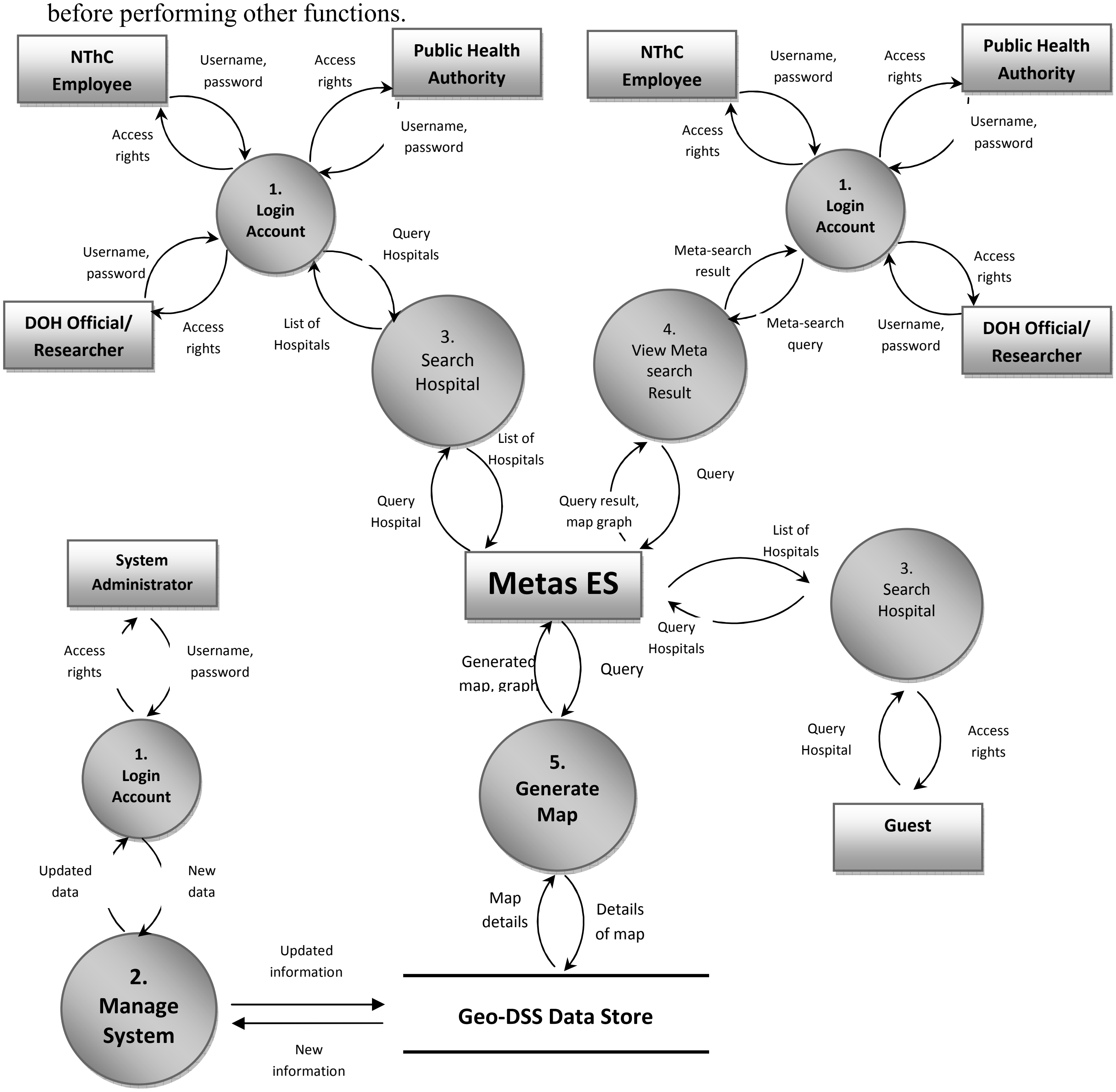


Figure 2. Top Level Data Flow Diagram. Telehealth Geographic Information System (TGIS) for the Knowledge-Base Module of the National Telehealth Center of the Philippines

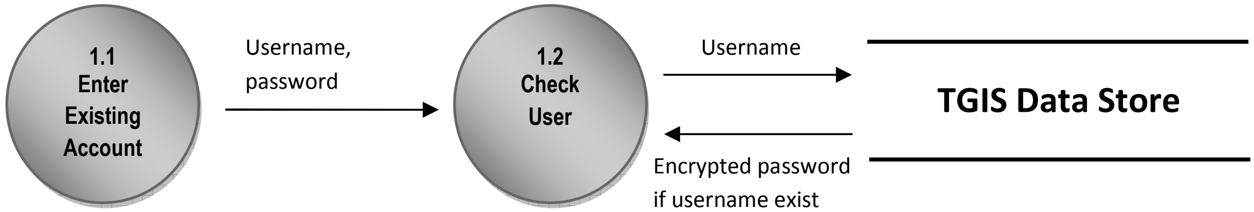


Figure 3. Sub-explosion of 1.0 Log in Account.

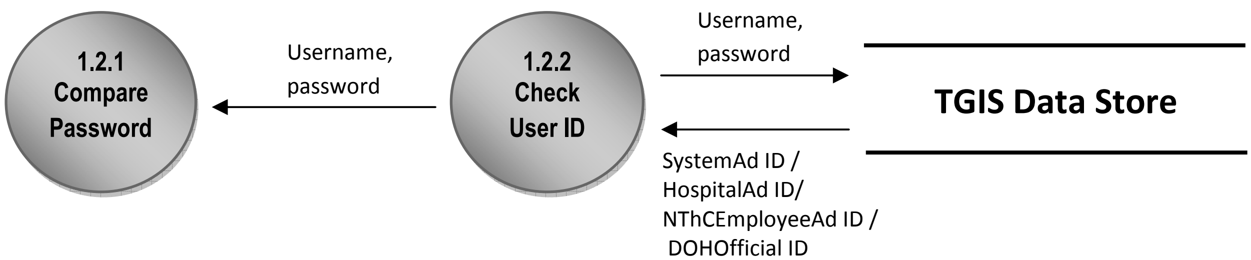


Figure 4. Sub-explosion of 1.2 Check User.

Shown in figure 3 and 4 is the sub explosion of the 1.0 Log in account and 1.2 Check User. The system verifies if the user has an account in the system and checks whether the user is a system administrator, DOH official/researcher, public health authority or NThC employee. The System Administrator needs to login in order to update manage information in the database. The NThC employee, DOH official/researcher or public health authority needs to login to search hospital, perform research and can use the system in order to view the meta-search result or rather the occurrence of disease or for the study of a certain disease.

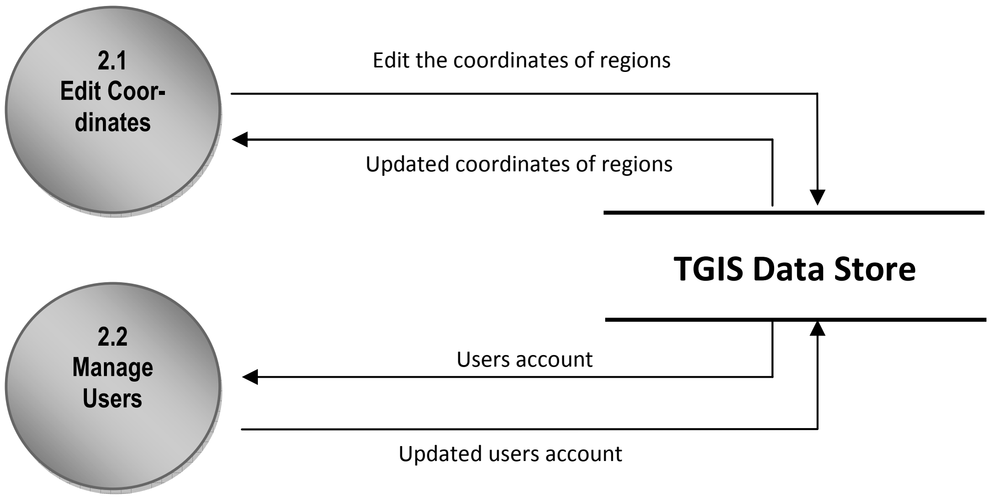


Figure 5. Sub-explosion of 2.0 Manage System.

Shown in figure 5 is the sub explosion of the 2.0 Manage System. The entire system is maintained by the System Administrator. The System Administrator will be the one to update the coordinates of the regions. The System Administrator will also be the one to manage the accounts of the users.

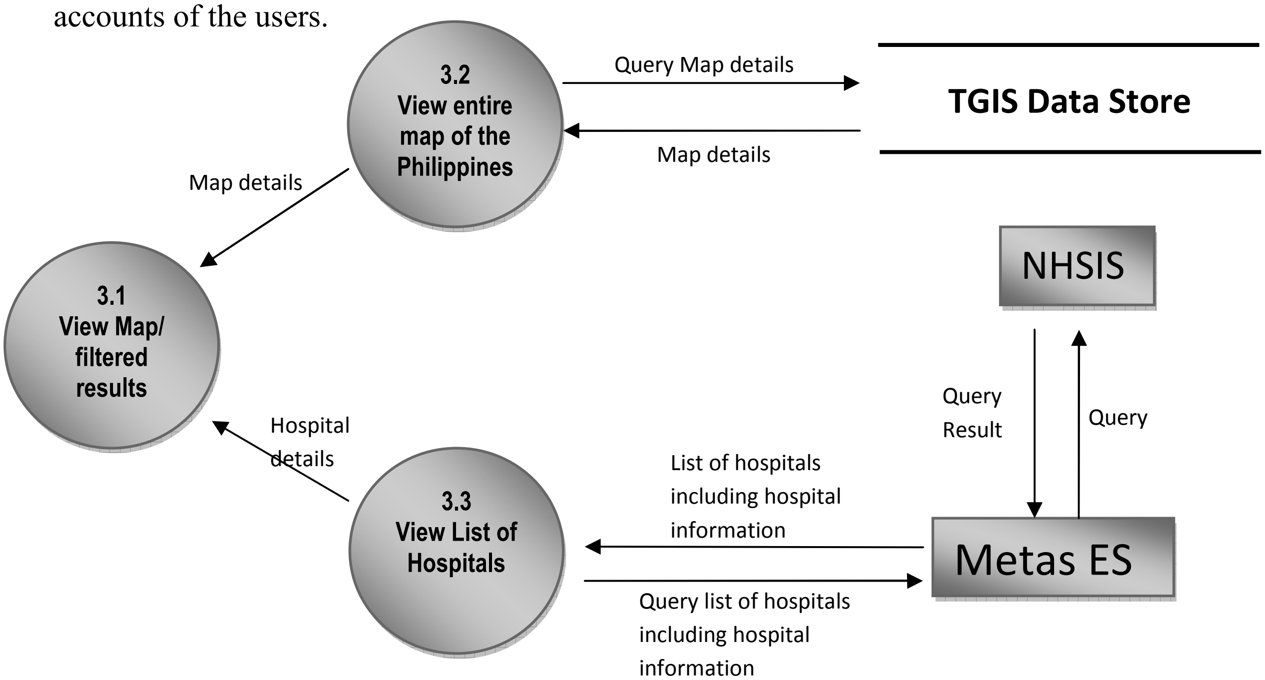


Figure 6. Sub-explosion of 3.0 Search Hospital.

Shown in figure 6 is the sub-explosion of the Search Hospital. The user has an option to view the entire map and manually click and drag the mouse to his/her desired location, or click the result from the Metas ES (specifically coming from the NHSIS) and view the entire list of hospitals based from the query result or in the map accompanied with the hospitals information.

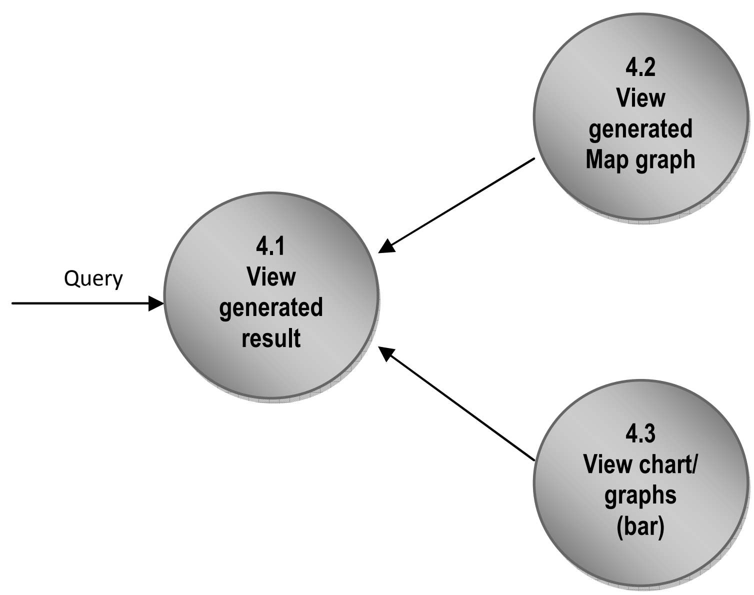


Figure 7. Sub-explosion of 4.0 View Meta-search Result.

Shown in figure 7 is the sub explosion of View meta-search result. This function is for the DOH employee/Researcher, Public Health Authority and NthC Employee. The user may generate graph specifically bar graph form the query result.

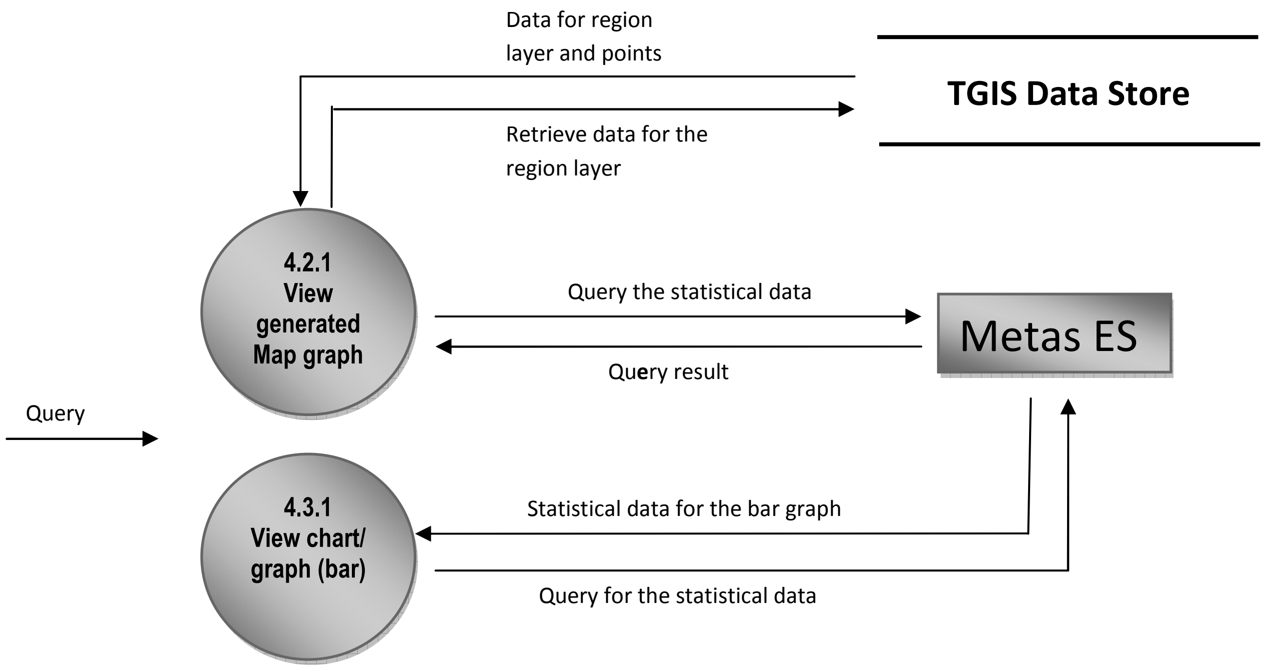


Figure 8. Sub-explosion of 4.2 View Generated Map Graph and 4.3 View chart/ graph (bar).

Shown in figure 8 is the sub explosion of view generated map graph and view chart/ graph (bar). The statistical data will be coming from the Metas ES. For the view generated map graph, the region points or layer will be coming from the Data Store.

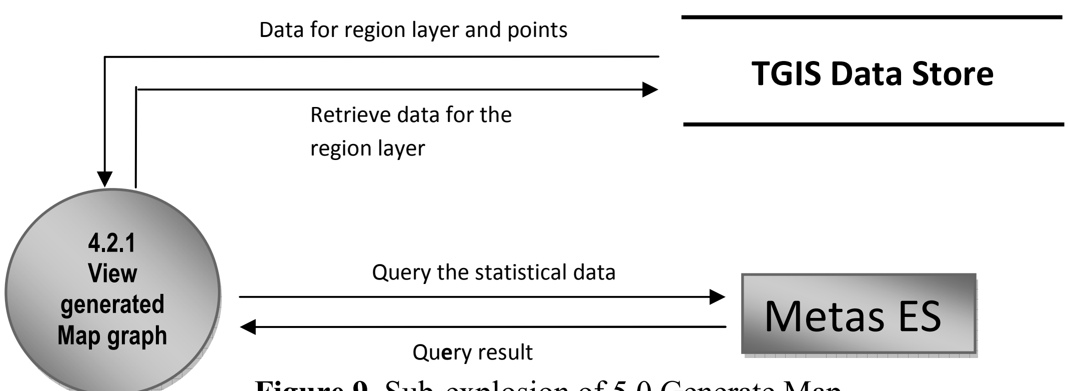


Figure 9. Sub-explosion of 5.0 Generate Map.

The data used to show layers in the map is fetched from the database, other information such as the hospital information and statistical data will be coming from the Metas ES

C. Entity Relationship Diagram

The Entity Relationship Diagram (ERD) for the TGIS is shown in figure 10. The ERD shows the entities in the system and the relationship between them. The database of the system has 3 entities (tables); account, coordinate and region.

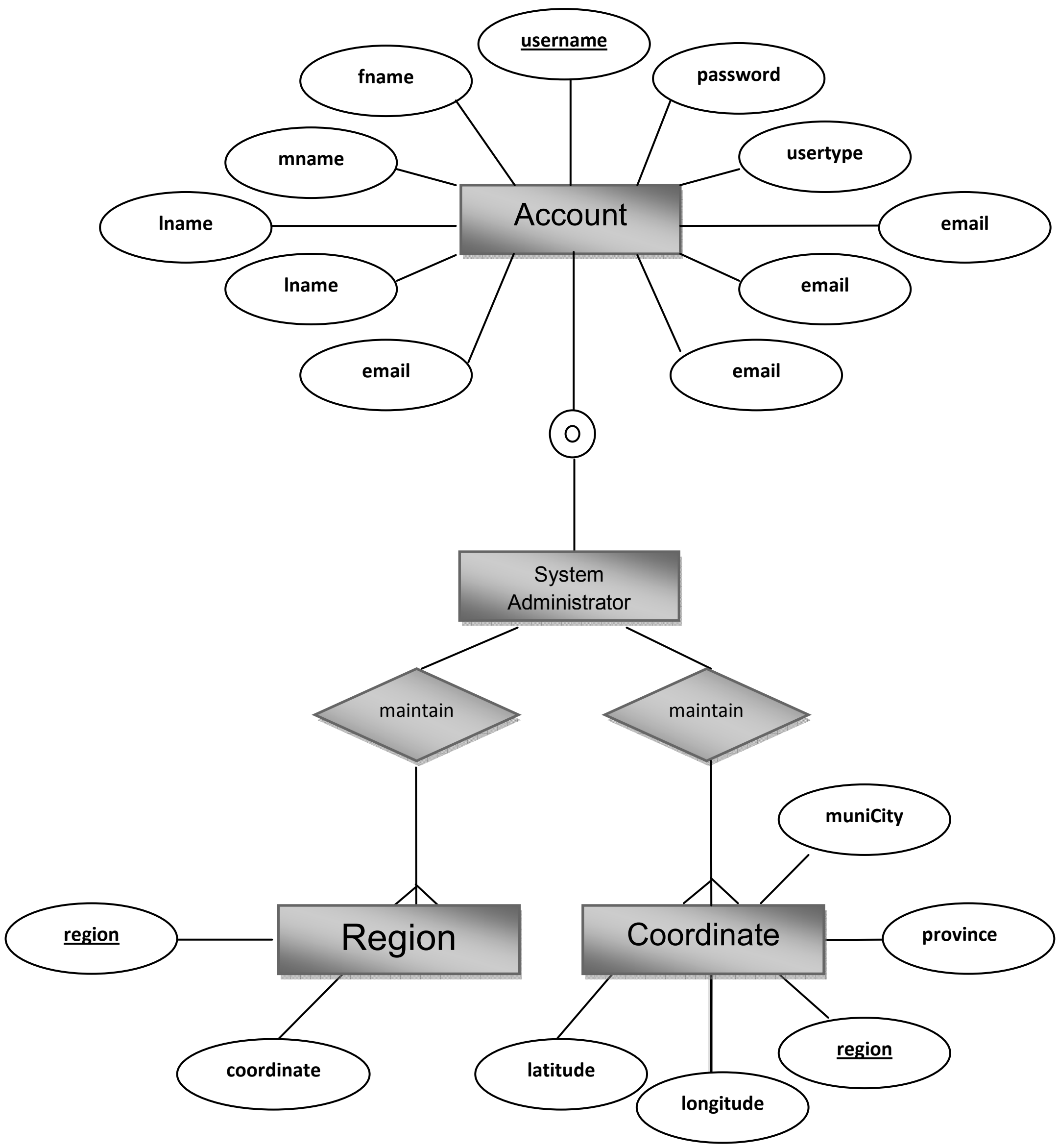


Figure 10. Entity Relationship Diagram of TGIS.

D. Data Dictionary

The tables below define the entity attributes presented in the Entity Relationship Diagram for the TGIS (Figure 10)

Account

– Contains all the information about the registered user – System Administrator, NThC Employee, DOH officials/researcher and public health authority. The user is determined by its usertype.

Field	Type	Definition
username	varchar(15)	Uniquely defines the user
password	varchar(15)	Specifies the user's password
usertype	varchar(10)	Specifies the type of user
fname	varchar(30)	First name of the user
mname	varchar(30)	Middle name of the user
lname	varchar(50)	Last name of the user
email	varchar(50)	Email address of the user
since	date	The date the user was added in the database
Birthdate	date	The birthday of the user
Status	Varchar(50)	Determine whether the user is active or inactive
sex	Varchar(50)	Sex of the user

REGION

- Contains the geocodes or the coordinates of per region which will be used to determine the boundaries of each region.

Field	Type	Definition
region	varchar(15)	Uniquely defines the region
coordinates	varchar(15)	The boundaries or geocodes of the region

COORDINATE

- Contains the geocodes or the coordinates of region, province or district, municipality or city which will be used to determine the location.

Field	Type	Definition
region	varchar(15)	Uniquely defines the region
province	varchar(15)	Uniquely defines the province
muniCity	varchar(15)	Uniquely defines the municipality or city
Longitude	Float	The longitude coordinate
Latitude	Float	The latitude coordinate

E. Technical Architecture

The TGIS is a web-based that can be accessed by the users through the internet. The system is implemented on a Microsoft Windows Vista (Home Basic) Operating System. The system is tested using Mozilla Firefox, Internet Explorer and Goggle Chrome browser. The database used is stored in the server. The following is the minimum configuration

Client Side:

1. Pentium IV processor or its equivalent
2. 64mb video card
3. 128mb system of memory
4. Microsoft Windows 2000/XP/Vista or Linux
5. Broadband /DSL/internet connection
6. Internet Explorer/ Firefox installed
7. JavaScript enabled

Client Side:

1. Pentium IV processor or its equivalent
2. 64mb video card
3. 128mb system of memory
4. Microsoft Windows 2000/XP/Vista or Linux
5. Broadband /DSL/internet connection
6. Internet Explorer/ Firefox installed
7. JavaScript enabled
8. XAMPP installed or PHP (at least 5.3.1), MySQL (at least 5.0.51a) Apache Server (at least 2.0)

V. RESULTS

The Telehealth's Geographic Information System (TGIS) is an online website which is a part of the Knowledge Base Module of the Telehealth Center of the Philippines. Figure 11 shows the home page of the TGIS. For general or unregistered users, there is no need to login; only the Map, Search and Sign up are accessible to them. Registered users may login in the login part of the page.

Figure 11. Home page.

When the user clicks on the Map, two options are displayed along with the map centered on the Philippines (Figure 12). On the right side is the option to view the hospitals in the map, categorized by region, through checking one or more checkboxes. On the left side is the Google map API, the map has a multicolored layer showing the distinct boundaries of each region. The map controls appear when the mouse hovers on the map. The map can change from normal view to satellite view to hybrid (overlapping normal and satellite view) and can be zoomed in and out.

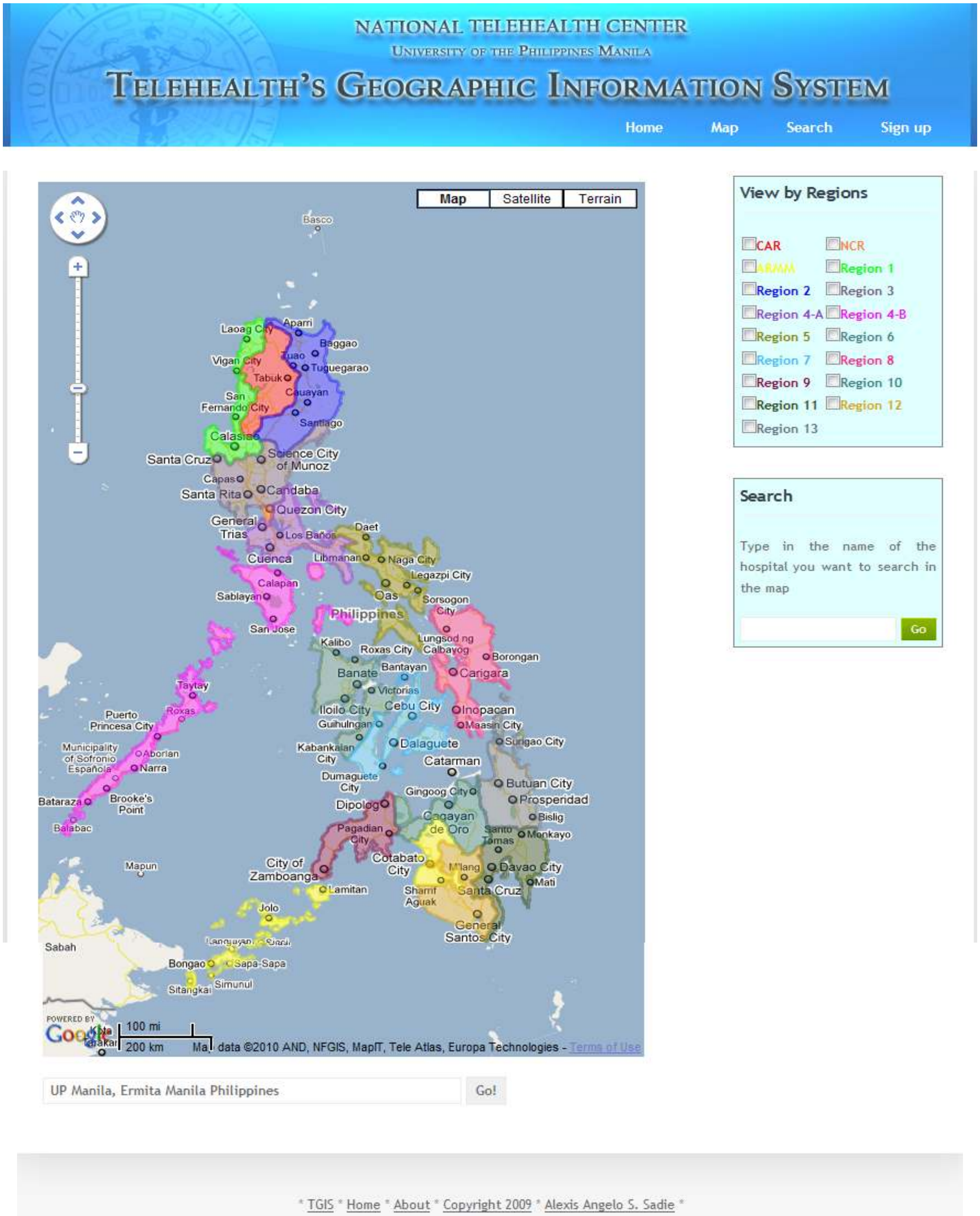


Figure 12. Map.

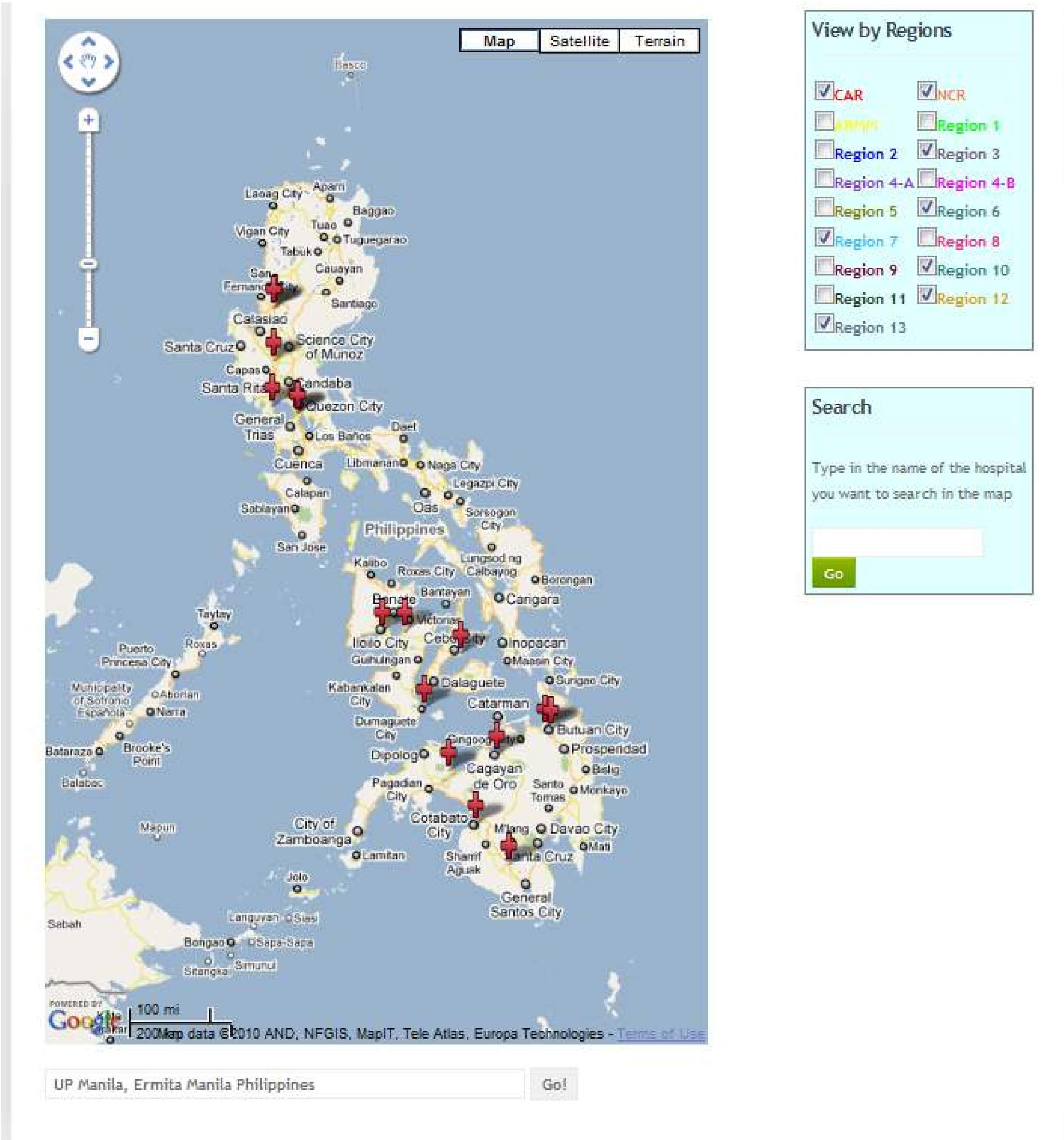


Figure 13. Regions are selected from the checkboxes.

Regions are selected from the checkboxes and the markers (using a hospital symbol) are shown in the map (Figure 13). Each marker is clickable and corresponds to one hospital (Figure 16). When clicked, the hospital's information is displayed.

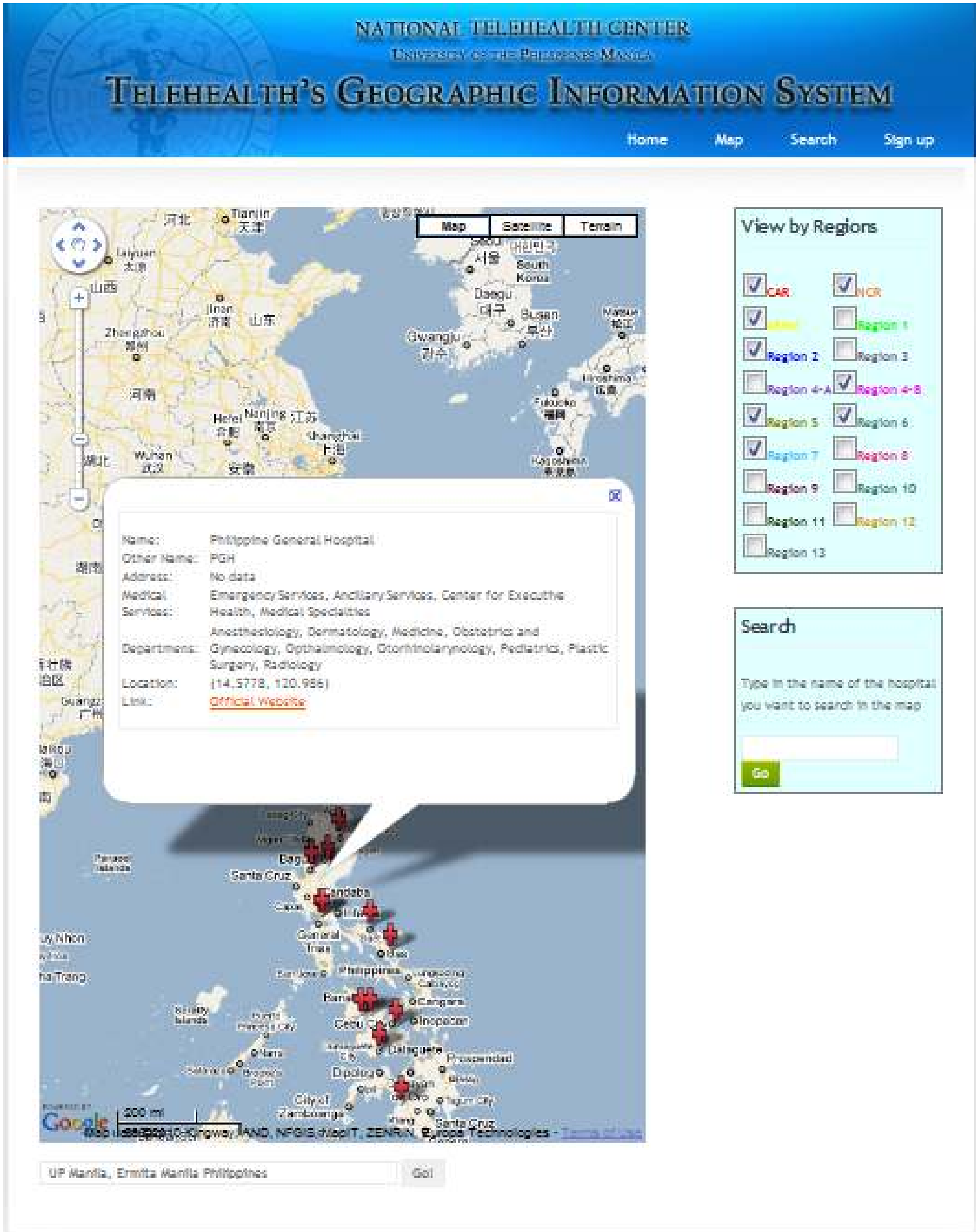


Figure 14. a marker is clicked and the hospital's information are displayed.

The default zoom level is set to six; the markers are better seen if they are apart from each other, if the map is zoomed in (Figure 15).

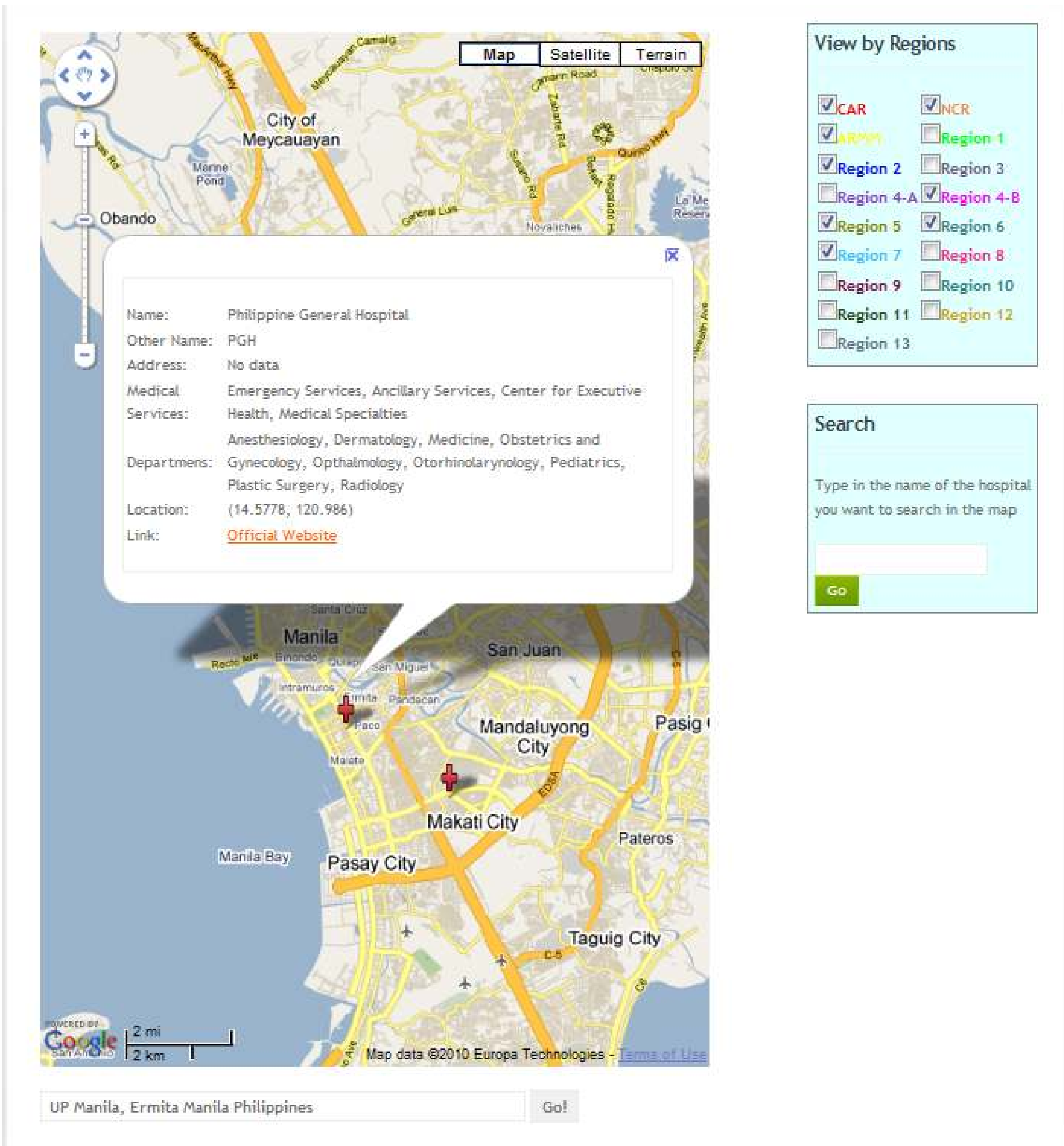


Figure 15. Zoomed in map.

The exact position of the hospital can be viewed if the maximum zoom level is reached. The maximum level is 17 (Figure 16).

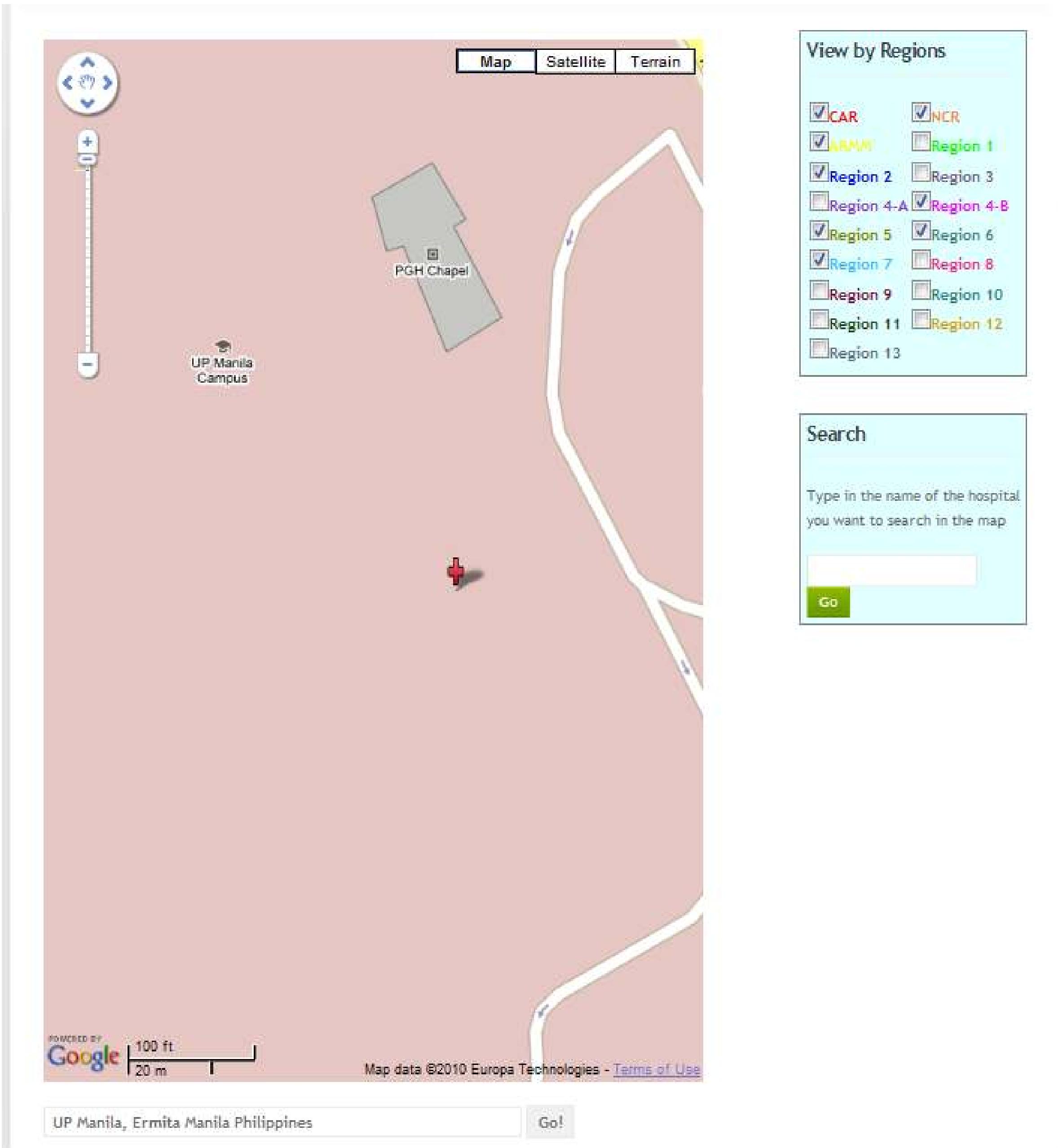


Figure 16. Zoomed in map at maximum level.

If the user wants to search for a specific hospital in mind, he/she can just use the search section to type in the hospital name. A marker will appear for the searched hospital which is also clickable if the user wishes to view the details for the hospital. The user can also type region, province, city or municipality to view the hospitals in that place (Figure 17).

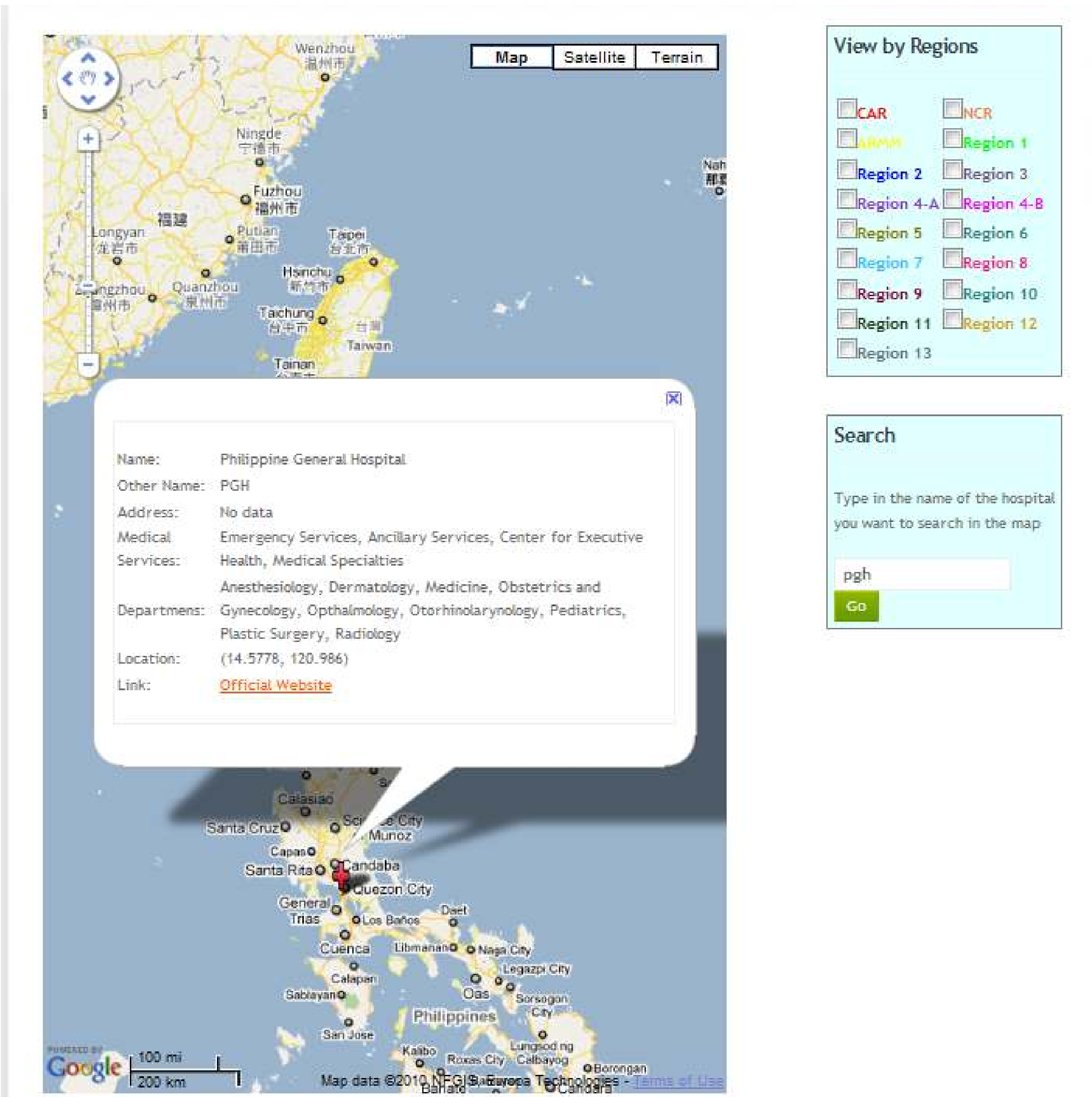


Figure 17. Search bar for hospital name, region, province, municipality or city.

When the user clicks on the Search tab, there is a single drop down. The user can choose between searching for a hospital and searching for a doctor (Figure 18).

Figure 18. Search for hospital or doctor.

Figure 19 shows the second drop down that appears if the user has selected from the first drop down, in this case, "search for hospital". The user can choose to match the keyword from any of the options. Similarly, this second drop down appears for "search for doctor"

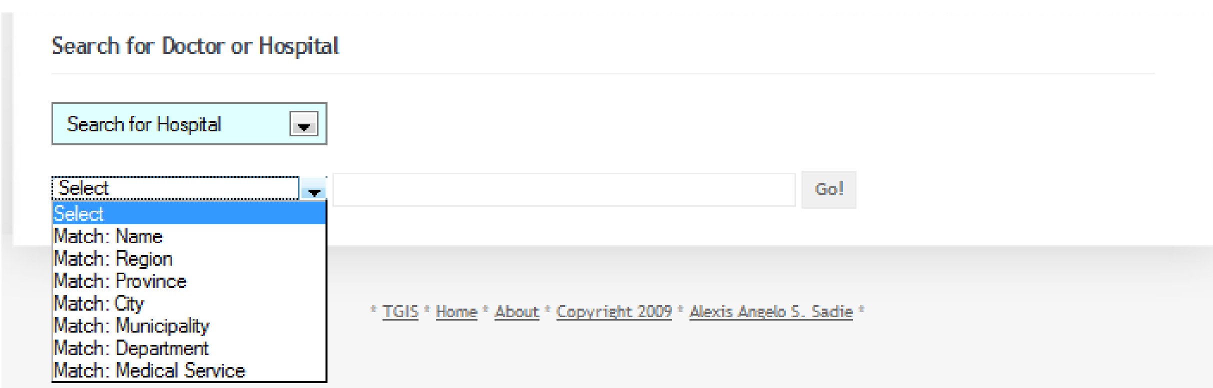


Figure 19. Search for hospital, detailed.

Figure 20 and 21 show the sample search result if the user chooses to search for a hospital or a doctor respectively. If the user wants to sort the table according to name, region, province, city, etc, just click the corresponding column header.

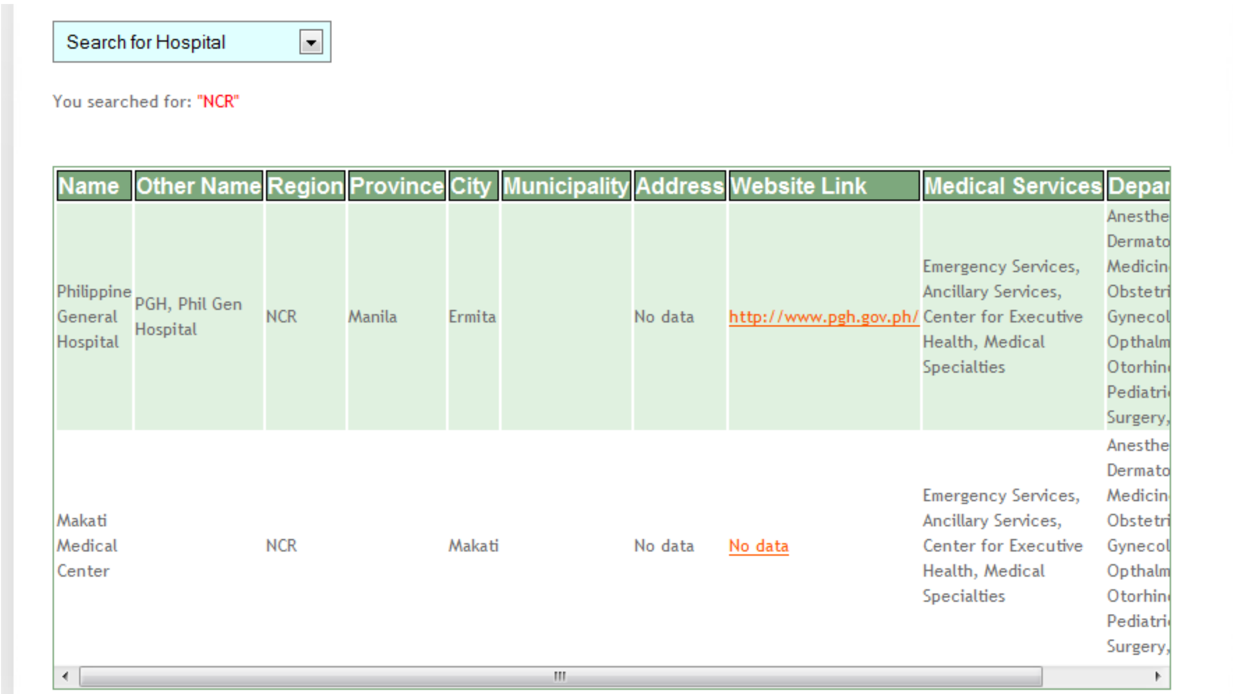


Figure 20. Search for a hospital, result.

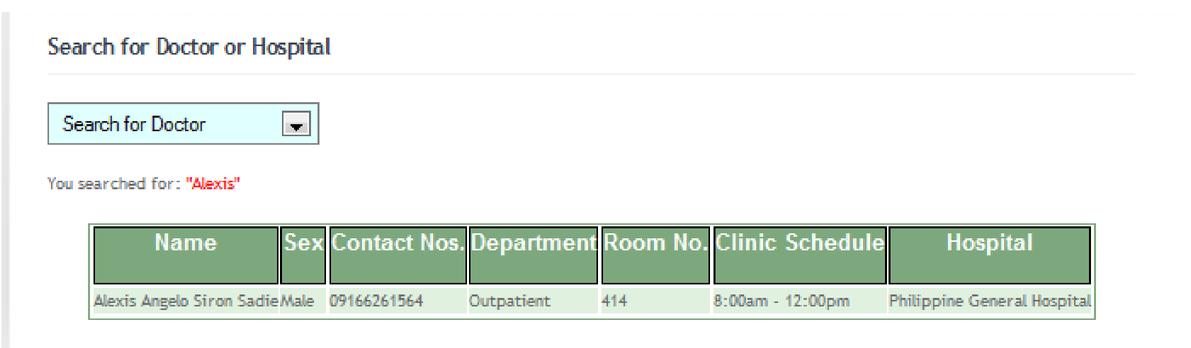


Figure 21. Search for a doctor, result.

For registered users, there is a need for them to login their username and password on the homepage. After successful login, on the right side, details of the user's account are displayed (Figure 22). Also the research tab appears in the menu where they select a certain notifiable disease and it will be passed to Metas ES to perform the search (Figure 23).

Figure 22. home page of the registered user.

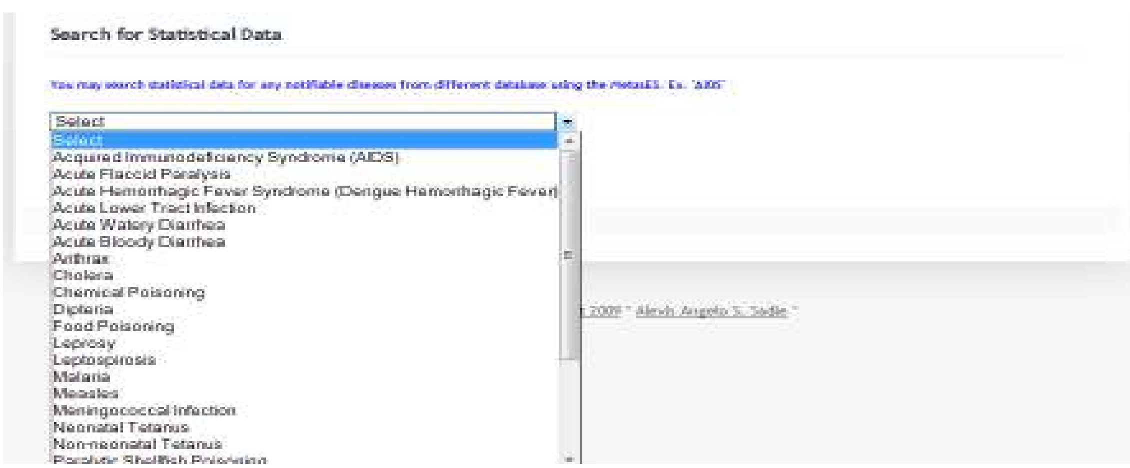


Figure 23. Selecting notifiable disease.

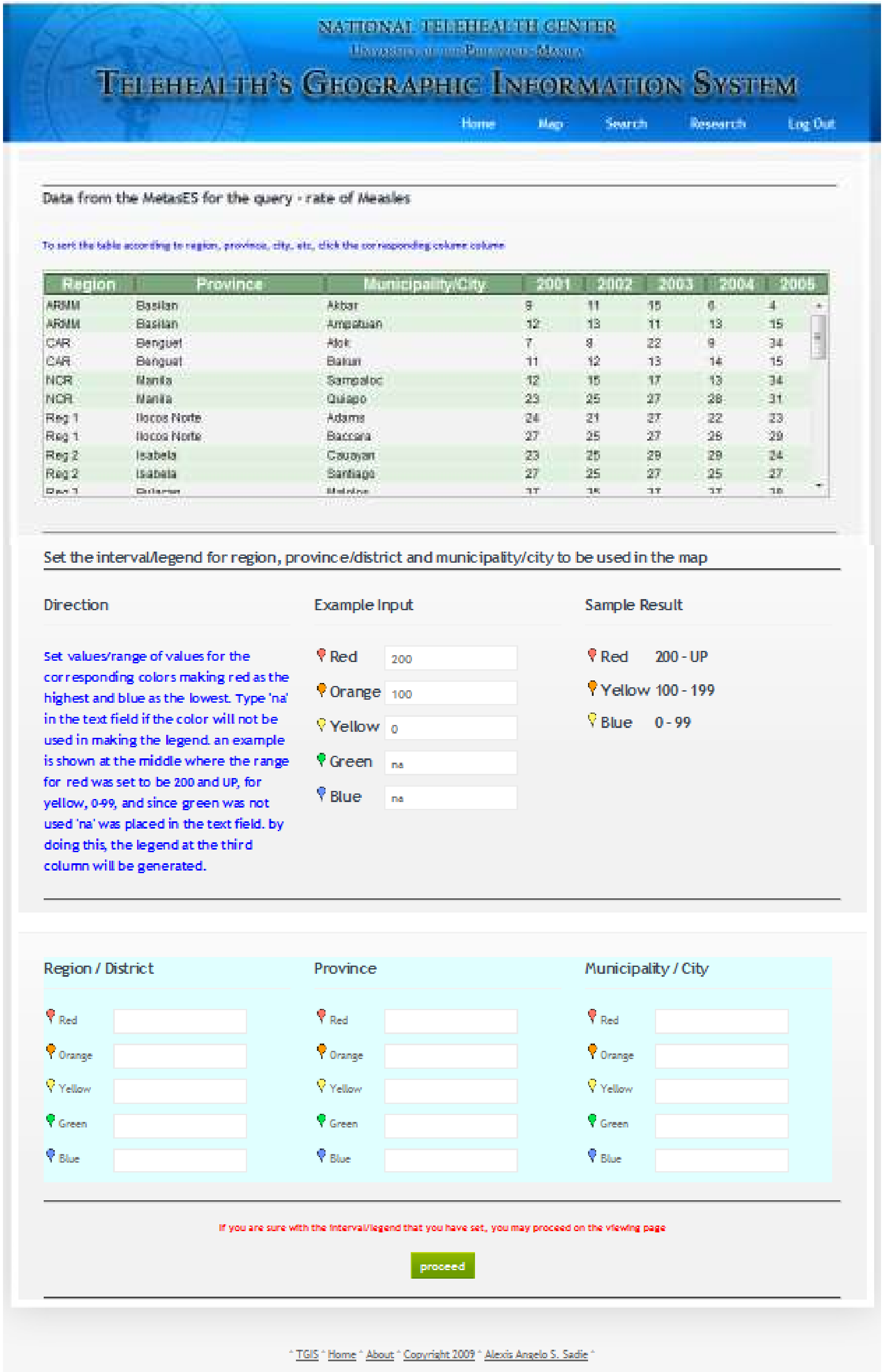


Figure 24. shows a table of data retrieved from Metas ES and set the corresponding legend.

Figure 24 shows result of the query (if successful) or the data gathered by the Metas ES. In the first part or the upper part shows all the found data in a table form having region for the 1st column, province/district for the 2nd column, municipality/city for the 3rd column and the succeeding columns are for the time interval found, example is year, month or day. The middle part shows an instruction on how to create legends for region, province/district or municipality/city which will be used later as a guide in the map. The last part is where the user will input values, Set values/range of values for the corresponding colors making red as the highest and blue as the lowest. Type 'na' in the text field if the color will not be used in making the legend. An example is shown at the middle where the range for red was set to be 200 and UP, for yellow, 0-99, and since green was not used 'na' was placed in the text field. By doing this, the legend at the third column will be generated. Figure 25 shows the sample input for creating legends.

Figure 25. Sample input for the legend which will be used in the map.

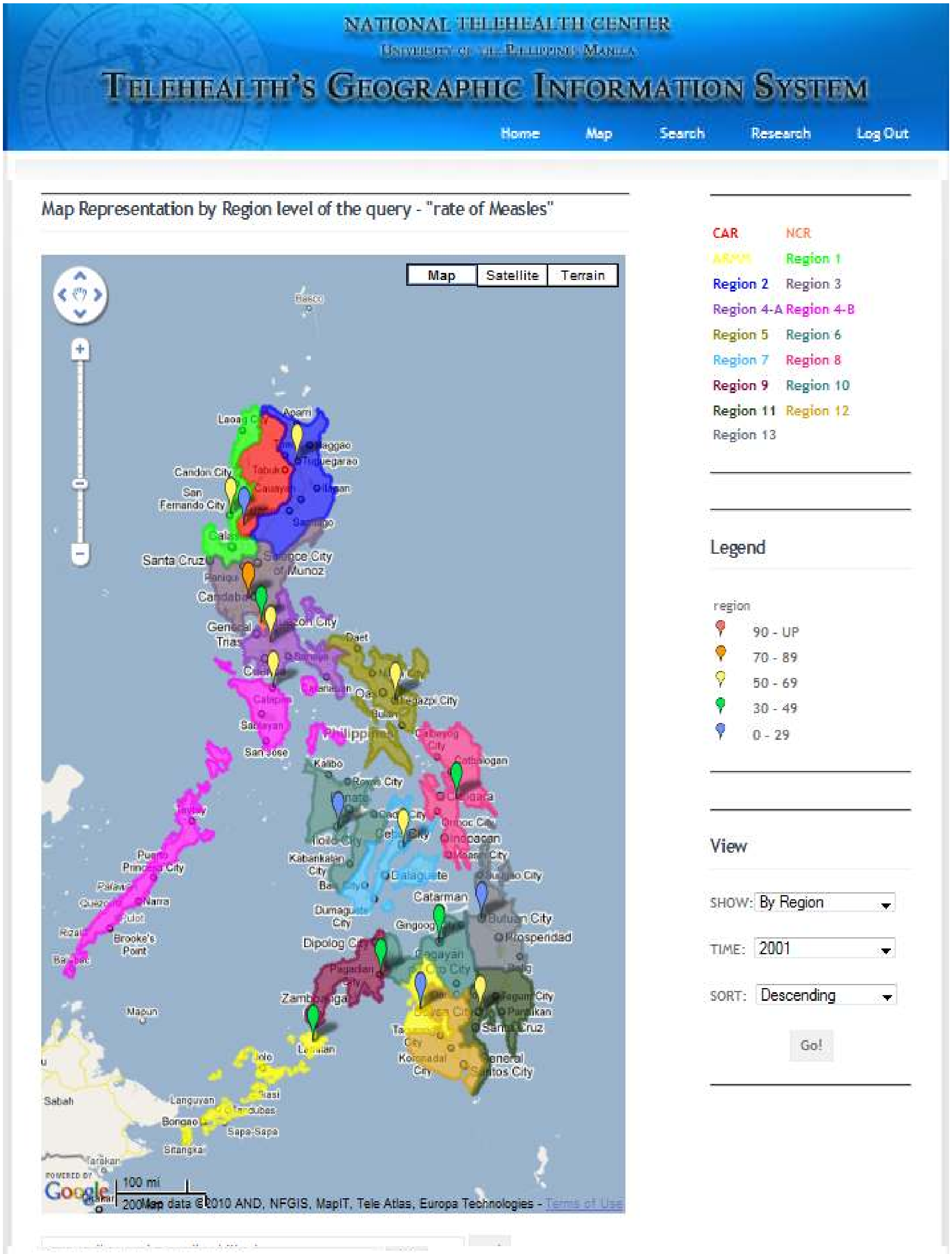


Figure 26. shows the map part representation for the data retrieved from the Metas ES.

Figure 26 shows the first part of the result page of the query from the Metas ES. The leftmost part shows the map with a multicolored layer showing the regions distinctively. The upper right part shows the list of regions in the Philippines, having the font color the same with the colored layer in the map indicating the boundaries or where is that region in the Philippine map. The middle right part is the legend, initially, the legend for the region is first shown in the first load of the page. The legend is used for the color of the marker and the data in a certain region, province, and municipality/city. Each marker is also clickable to know the name of the place where the marker is placed and the data corresponding with it (Figure 27).

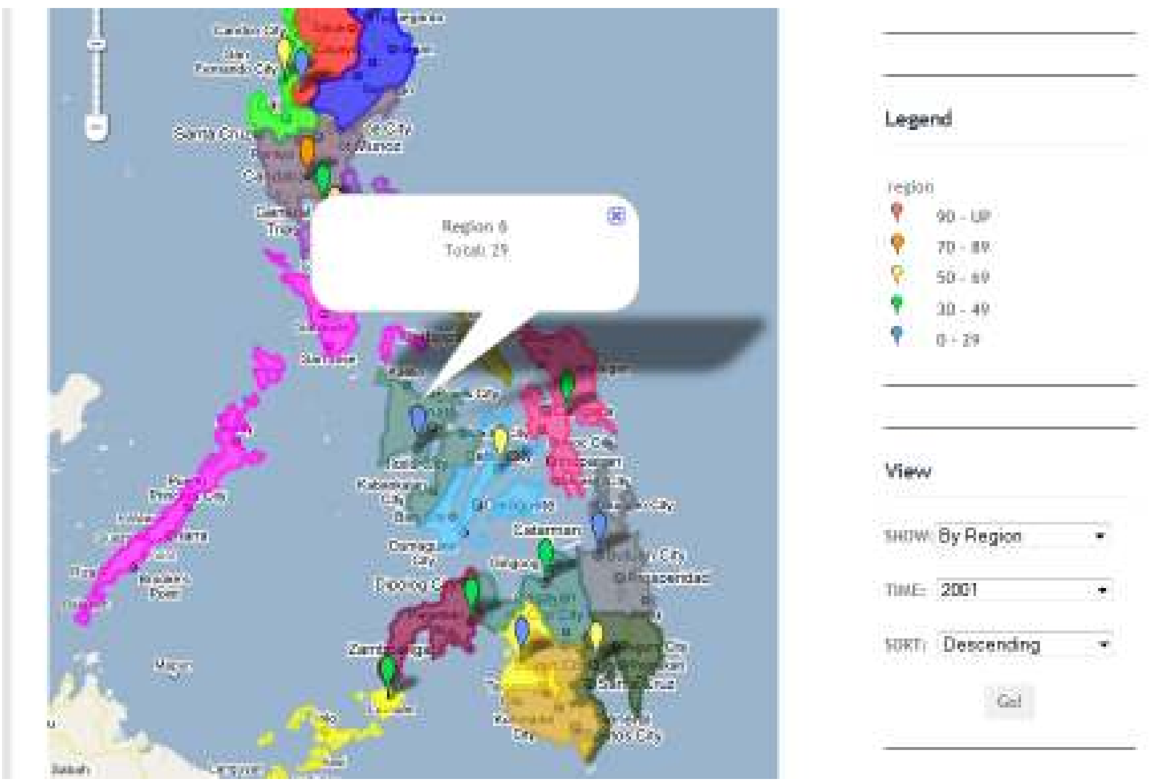


Figure 27. clicked marker showing the name of the place and the data from the research

The lower right part or view part of the page allows you to select which will be viewed in the map as well as in the graph representation. The user may select to view by region, province/district or municipality/city level (Figure 28). The system will also allow the user to select the time interval (year, month or day) he/she may wish to view; initially the map will show the first time interval (Figure 29). Then, specifically for the graph representation, the user may sort the graph either ascending or descending order, initially the graph will show descending order or from the largest value to smallest value (Figure 30).

Figure 28. Select which will be shown, by region, province/district or municipality/city.

Figure 29. Select which time interval will be shown.

Figure 30. Shows how the data in the graph will be displayed, either by descending or ascending.

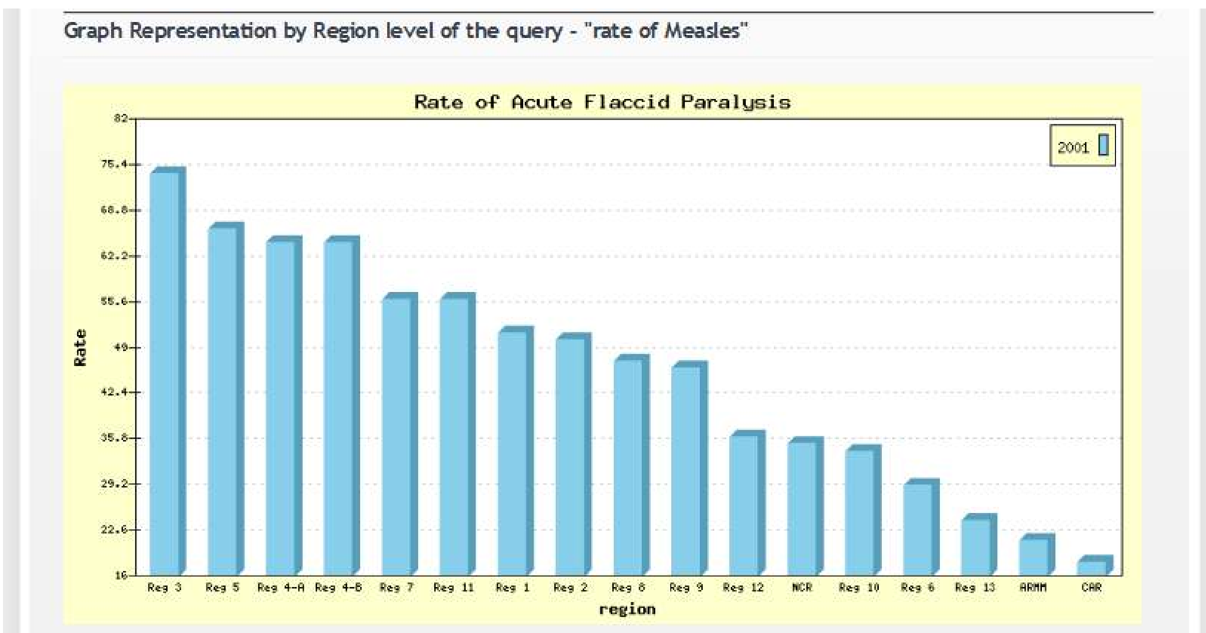


Figure 31. The Graph Representation for region.

Figure 31 shows a generated bar graph of the data which can be viewed by region, province/district or municipality/city, the set time interval and either by descending or ascending order. The size of the graph adjusts to allow all the data to be seen in the graph.

Table Representation by Region level of the query - "rate of Measles"

To sort the table according to region, province, city, etc, click the corresponding column header

Region	Province	Municipality/City	2001	2002	2003	2004	2005
ARMM	Basilan	Akbar	9	11	15	6	4
ARMM	Basilan	Ampatuan	12	13	11	13	15
CAR	Benguet	Atok	7	8	22	9	34
CAR	Benguet	Bakun	11	12	13	14	15
NCR	Manila	Sampaloc	12	15	17	13	34
NCR	Manila	Quiapo	23	25	27	28	31
Reg 1	Ilocos Norte	Adams	24	21	27	22	23
Reg 1	Ilocos Norte	Baccara	27	25	27	26	29
Reg 2	Isabela	Cauayan	23	25	29	29	24
Reg 2	Isabela	Santiago	27	25	27	25	27

Total per Region

Region	2001	2002	2003	2004	2005
ARMM	21	24	26	19	19
CAR	18	20	35	23	49
NCR	35	40	44	41	65
Reg 1	51	46	54	48	52
Reg 2	50	50	56	54	51
Reg 3	74	70	74	72	74
Reg 4-A	64	67	72	66	66
Reg 4-B	64	61	62	61	58
Reg 5	66	88	40	45	38
Reg 6	29	45	51	25	46
Reg 7	56	78	40	45	29
Reg 8	47	76	54	80	74
Reg 9	46	86	50	64	70
Reg 10	34	66	48	44	57
Reg 11	56	59	44	67	46
Reg 12	36	28	50	27	37
Reg 13	24	27	32	27	28

Figure 32. Table Representation.

Figure 32 shows two tables of all the data retrieved from the query. The first table is similar to the page before this was shown. The second table shows the total per region in each time interval. All tables can be sorted by region; province/district, municipality/city etc. just click the corresponding column header.

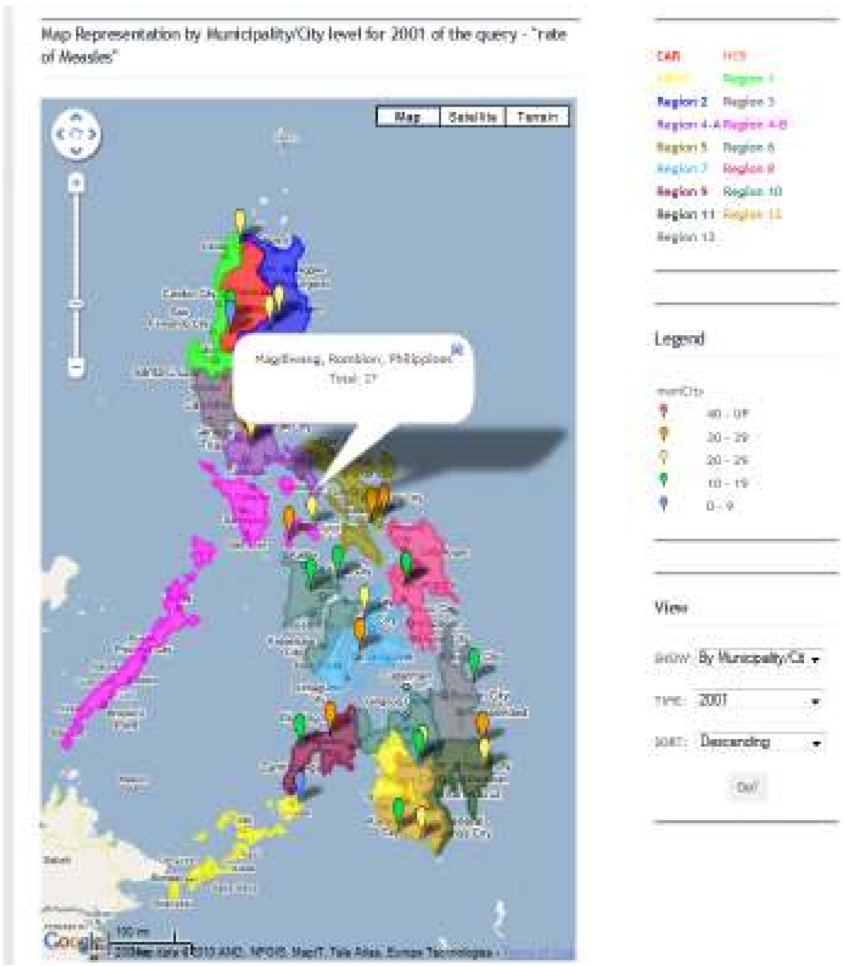


Figure 33. Map showing all the Municipalities/Cities in the map

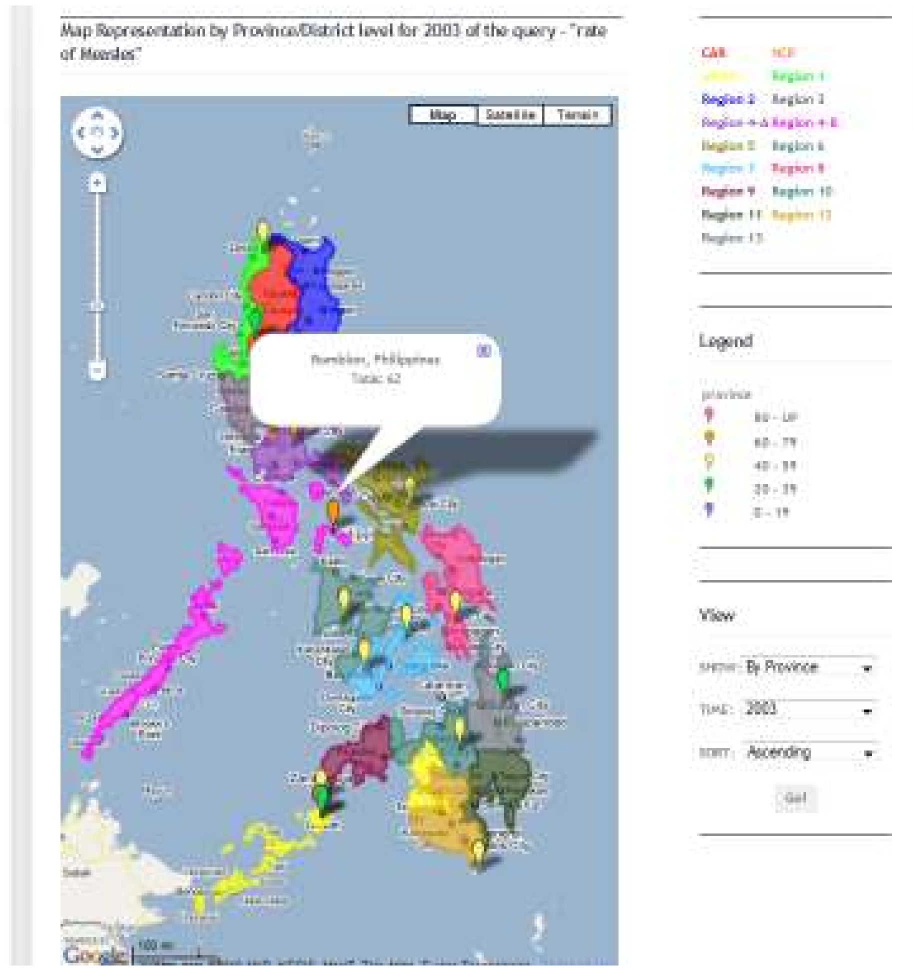


Figure 34. Map showing all the provinces in the map

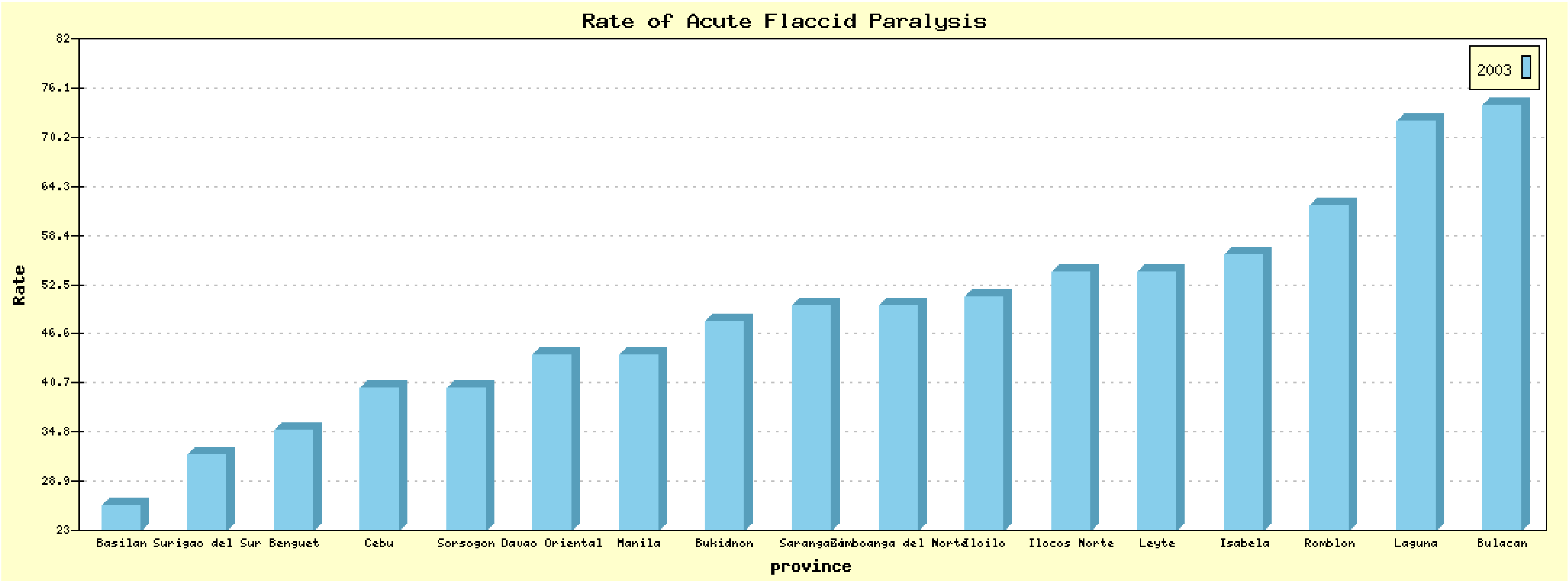


Figure 35. Sample graph for the province

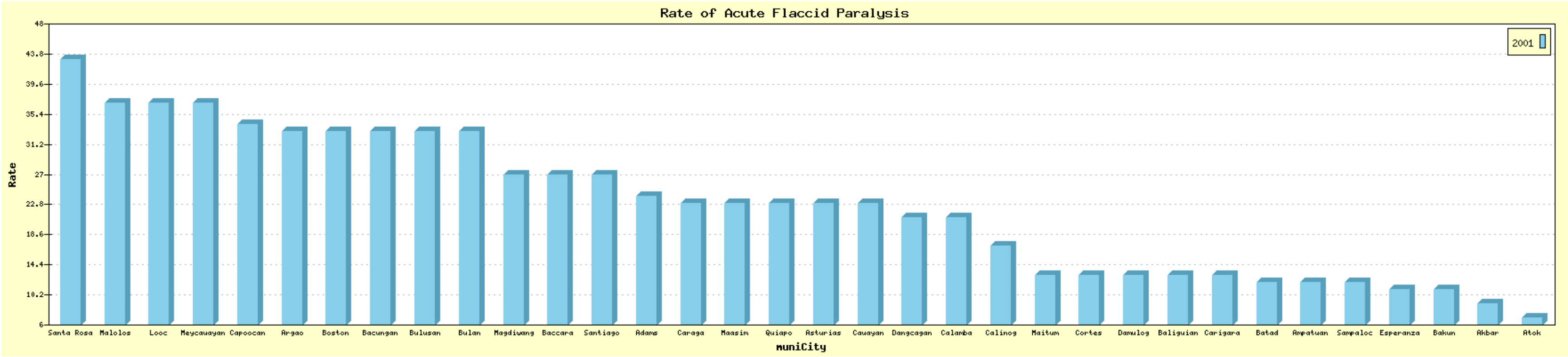


Figure 36. Sample graph for the Municipality or City

Figure 33 shows all of the municipalities/cities present in the data retrieved while figure 34 shows all of the provinces present. Figure 35 shows a sample graph of all the data per province and sorted by ascending order while figure 36 shows a sample graph of all the data per municipality/city and sorted by descending order.

Figure 37. Home page of a System Administrator.

Figure 37 shows the home page of system administrator. After successful login, a list of functionalities available for the system administrator is shown in a list on the left side. On the right side, details of the administrator's account are displayed.

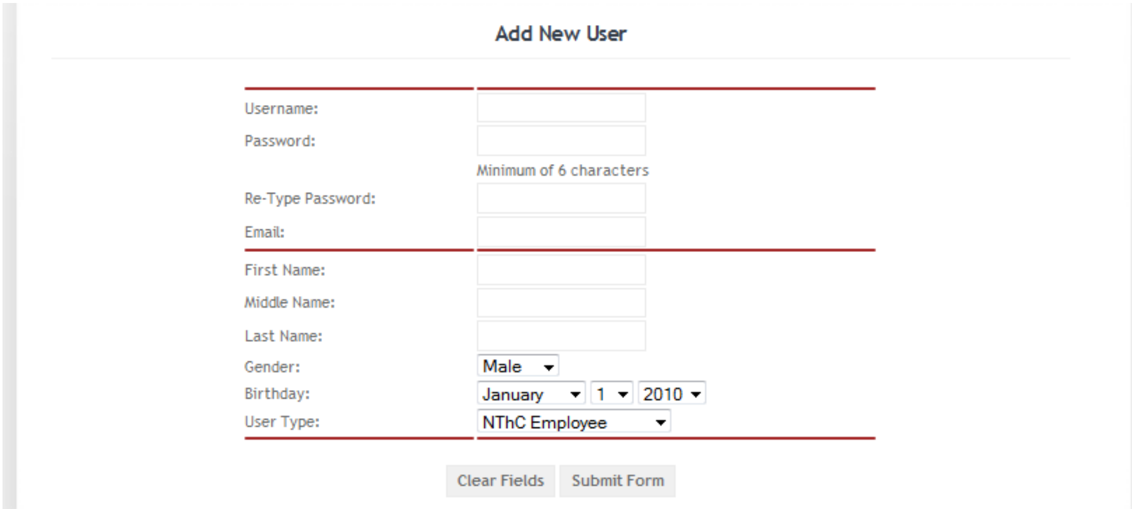
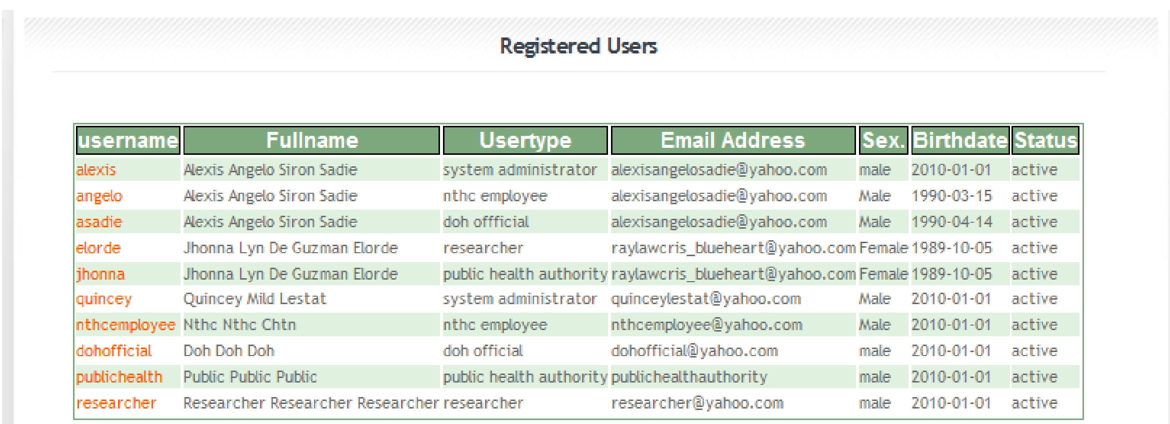


Figure 38. Add new user.

Only the system administrator can add a new user account. One record can be added at a time by filling up all the fields.



Registered Users

username	Fullname	Usertype	Email Address	Sex.	Birthdate	Status
alexis	Alexis Angelo Siron Sadie	system administrator	alexisangelosadie@yahoo.com	male	2010-01-01	active
angelo	Alexis Angelo Siron Sadie	nthc employee	alexisangelosadie@yahoo.com	Male	1990-03-15	active
asadie	Alexis Angelo Siron Sadie	doh offficial	alexisangelosadie@yahoo.com	Male	1990-04-14	active
elorde	Jhonna Lyn De Guzman Elorde	researcher	raylawcris_blueheart@yahoo.com	Female	1989-10-05	active
jhonna	Jhonna Lyn De Guzman Elorde	public health authority	raylawcris_blueheart@yahoo.com	Female	1989-10-05	active
quincey	Quincey Mild Lestat	system administrator	quinceylestat@yahoo.com	Male	2010-01-01	active
nthcemployee	Nthc Nthc Chtn	nthc employee	nthcemployee@yahoo.com	Male	2010-01-01	active
dohofficial	Doh Doh Doh	doh official	dohofficial@yahoo.com	male	2010-01-01	active
publichealth	Public Public Public	public health authority	publichealthauthority	male	2010-01-01	active
researcher	Researcher Researcher Researcher	researcher	researcher@yahoo.com	male	2010-01-01	active

Figure 39. List of Editable registered user.

If the system administrator chooses the edit/delete user option, he/she can edit/delete by choosing among the registered users on the list (Figure 39).

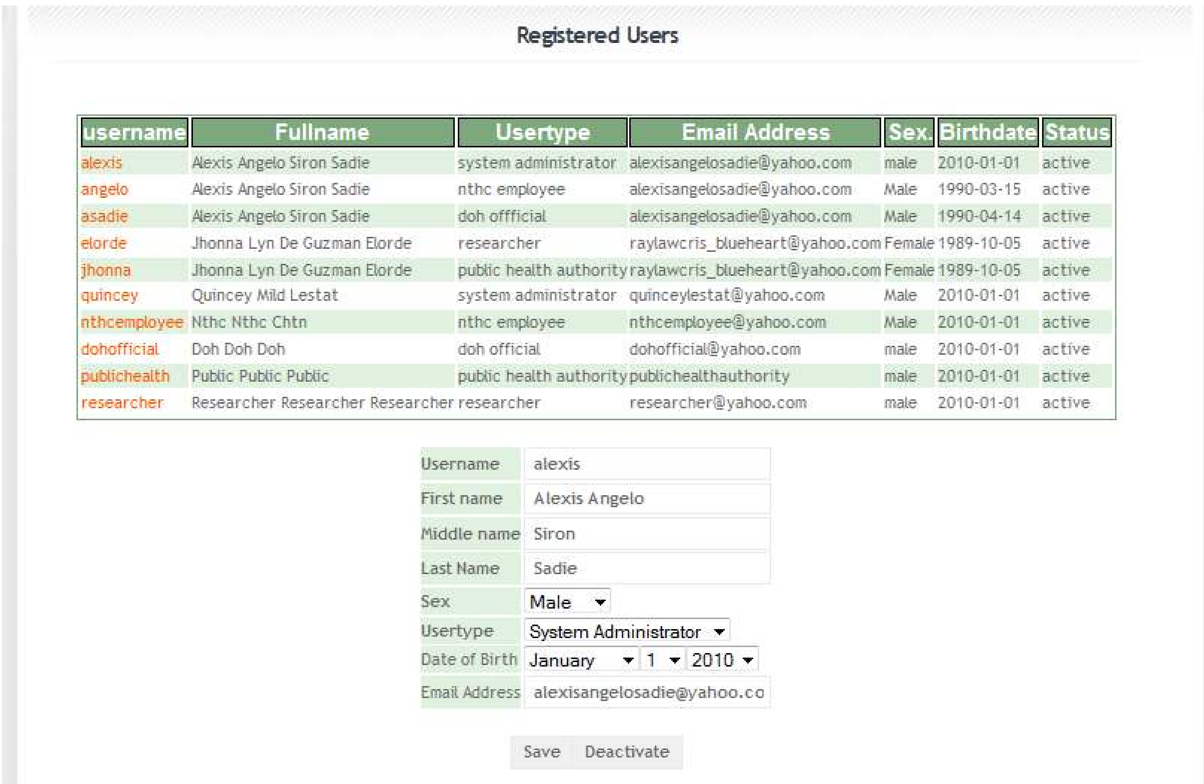


Figure 40. Editing user account.

Clicking on the username will show a section below where the system administrator can edit the information of the user except the username. The system administrator can also activate or deactivate a user.

VI. DISCUSSION

The Telehealth's Geographic Information System is an online website which uses Google Maps and specifically designed for the Knowledge base module of the National Telehealth Center of the Philippines. This system allows users to search the database of NHSIS using Metas ES for names of doctors and hospitals, navigate the map and to view hospitals on the map via point-and-click interface. The system also allows the users to make research of statistical data of a certain selected disease which will be passed to the Metas ES which will perform the searching of the data and return an xml file which will be parsed by the system in order to view the result of the query by map, graph and table representation.

The T.G.I.S. has six levels of user's namely unregistered user or guest, researcher, DOH official, public health authority, NThC employee and system administrator. General users or guests need not have an account in the website while the registered users must have one, in order to perform other functionalities.

All users can zoom in, out, or navigate the map, see and click the markers (Red Cross symbol) which are tiny representations of hospitals in the map categorized according to the region they belong, and search the map for specific hospital or doctor. Guest or unregistered users only have these capabilities while the other registered users have more access to other functionalities.

Registered users namely, NThC employee, researcher, DOH Official and Public Health Authority, in addition, can perform research of statistical data of a certain selected disease using the other part of the Knowledge base module which is the Metas ES (Meta Search Engine System). Figure 41 shows how the two systems will interact in order to perform the research.

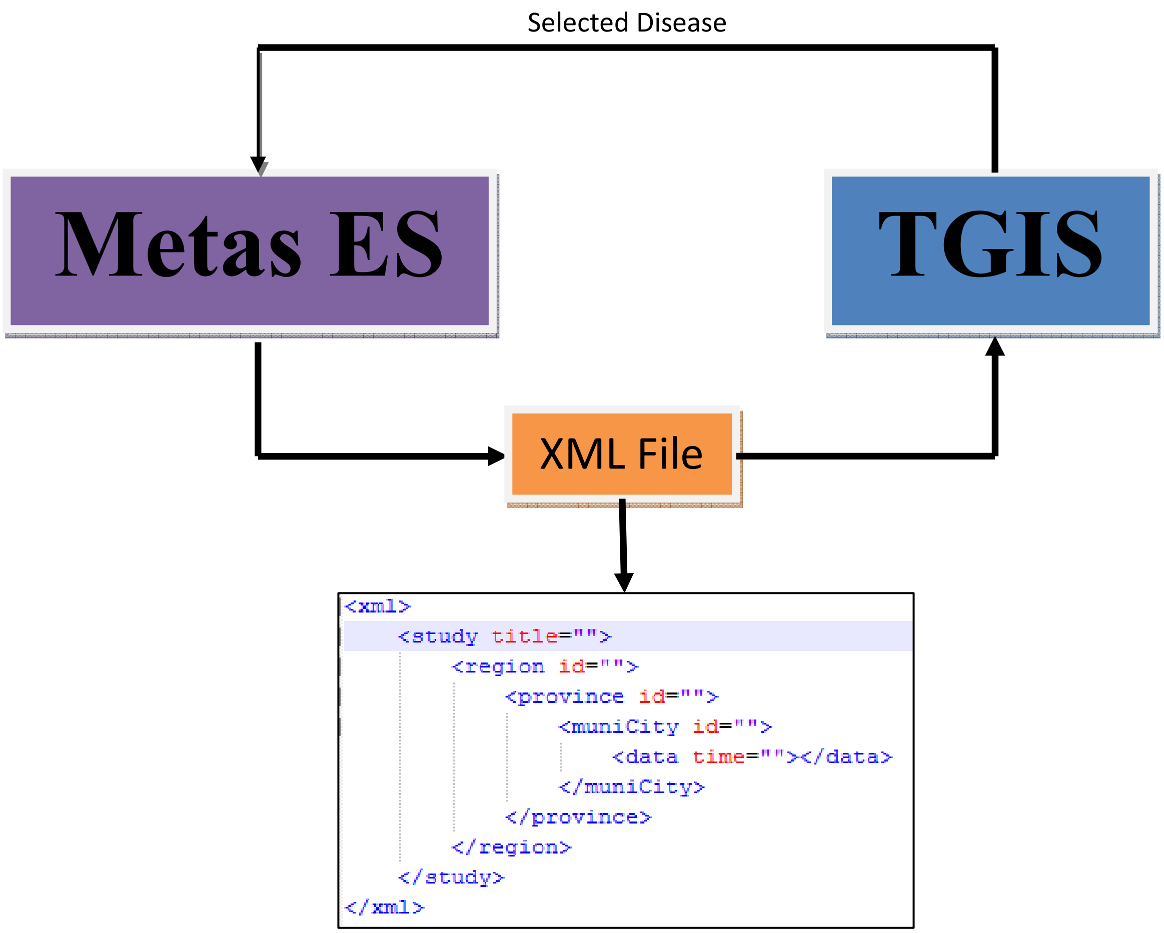


Figure 41. Simple Diagram of how the Metas ES and TGIS will communicate.

In the research part, the selected disease will be passed into the Metas ES where it will search the different databases registered in it. The Metas ES will process all the data retrieved from the different databases and return an xml file with the following tags as shown in the figure 41, and with the filename same with the selected disease. The TGIS then will parse the xml file to able to produce a map, graph or table representation of the data from the parsed xml file. The user can then view the frequency or the rate of disease per region, province/district or municipality/city in the map and the graph depending on the selected time interval.

The communication between Metas ES and TGIS when it comes to information of the hospitals and doctors that are shown in the search page or in the map is performed by AJAX. The exact location of the map is not saved in the database. However, it uses one certain functionality of Google map which is called *Geocoding*, a process where in the system will pass the address of the hospital, and the Google Map itself will find the address and place the marker in the exact position. The advantage of this is that, the location of the hospital will be checked by many moderators and users of Google Map. The disadvantage is that, if the system passed the address and the Google map did not return anything or did not place a marker in the map, it indicates that the hospital has not been added in the database of Google Map but the hospital can be added by registering in the Google Map Maker and the user itself may have the privilege to be the first to put that hospital in the map.

The system administrator is like the other user but he/she is the only one that manages the user's accounts. He/she can add, edit, activate or deactivate any registered users account. Additionally, same with other account, he/she can edit his own information in the database.

The map contains markers; each marker corresponds to one hospital in the Philippines, the marker uses a Red Cross symbol indicating it is a hospital. Clicking on the marker causes an info window to appear, like a speech balloon. The window contains all the information of the hospital as retrieved from the NHSIS.

The map is derived from the existing Google Map, the whole map of the Philippines is shown in the map. At times, it can be noticed that the map is a bit slow to load. This is primarily because billions of people are accessing the Google Maps worldwide at that same time and map itself loads multicolored layer.

TGIS manages data effectively, easily and communicates well with the other knowledge base module – Metas ES. Data are passed from forms to the PHP scripts dealing with MySQL commands through JSON or AJAX so it loads faster and reduces bandwidth use.

VII. CONCLUSION

Telehealth's Geographic Information System (TGIS) is a system that serves as a hospital and doctor directory as well producing good imagery of statistical data. It allows all kinds of users to view records of all hospitals in the Philippines and all doctors that work in these hospitals. Hospital records include the complete address, the medical services, the departments as well as the website of the hospital. The creation of this web-map, through the use of an online interactive map service, will greatly help Filipinos and even overseas and foreign users when they want to check on the hospitals first before visiting them personally. The search function is also helpful if users are looking for a specific doctor or department.

The system allows the registered user to use online searching of statistical data from different database through the use of Metas ES. They can view the statistical data retrieved from the Metas ES through map, graph and table representation which can help them in their decision making about what to do to a particular disease. Through the map they can visualize much better the scale of a certain disease or how fast and where the disease spread.

The system allows the system administrator to perform, addition, modification, and activation/deactivation of registered user accounts.

VIII. RECOMMENDATION

The system can be further improved if it could map all the health facilities in the Philippines like clinic, drugstore etc not only the registered hospitals present in the NHSIS.

The system itself relies or is dependent on the Metas ES, it would be better if it has its own search engine for it to have a direct and faster way of retrieving data. In line with this, it would be better as well if there is a hospital administrator user which can update the database of hospitals directly from this system.

The system is only good for viewing result and no other functionality, it would be better if the system has its own database where in it can save the result from its research of statistical data.

IX. BIBLIOGRAPHY

[1] Bell BS, Hoskins RE, Pickle LW, Wartenberg D, Current practices in spatial analysis of cancer data: Mapping health statistics to inform policymakers and the public. *International Journal of Health Geographics* 2006.

[2] Boulos K MN, Scotch M, Cheung K, Burden D, Web GIS in practice VI: a demo playlist of geo-mashups for public health neogeographers. *International Journal of Health Geographics* 2008.

[3] Boulos K MN, Towards evidence-based, GIS-driven national spatial health information infrastructure and surveillance services in the United Kingdom. . *International Journal of Health Geographics* 2004.

[4] El-Konray A, El-Bhanasy K., A Multi-Agent Framework to facilitate Knowledge sharing, Journal of Artificial Intelligence

[5] Gao S, Mioc D, Anton F, Yi X, Coleman DJ, Online GIS services for mapping and sharing disease information. *International Journal of Health Geographics* 2008.

[6] Gao S, Mioc D, Anton F, Yi X, Oldfield E, Coleman DJ: Towards Web-based representation and processing of health information. *International Journal of Health Geographics* 2009.

[7] Geographic Information System, Retrieved February 2009 from http://en.wikipedia.org/wiki/GIS

[8] Kamadjeu R, Tolentino H, Web-based public health geographic information systems for resources-constrained environment using scalable vector graphics technology: A proof of concept applied to the expanded program on immunization data. *International Journal of Health Geographics* 2006.

[9] Kamadjeu Raoul, Tracking the polio virus down the Congo River: a case study on the use of Google Earth™ in public health planning and mapping. *International Journal of Health Geographics* 2009.

[10] Kamel Boulos MN, Burden D: Web GIS in practice V: 3-D interactive and real-time mapping in Second Life. *International Journal of Health Geographics* 2007.

[11] Kamel Boulos MN, Web GIS in practice III: creating a simple interactive map of England's strategic health Authorities using Google maps API, Google earth KML, and MSN virtual earth map control. *International Journal of Health Geographics* 2005.

[12] Monsales E, 2009. “Web-Map of Hospitals in Metro Manila”, University of the Philippines, Manila.

[13] National Telehealth Center. National Telehealth Center-University of the Philippines Manila. National Telecenter, 2006. Web.2009 August 17, http://www.telehealth.ph/

[14] Paramanto B. et al, Spatial and multidimensional visualization of Indonesia's village health statistics, International Journal of Health Geographics, 2008.

[15] Radut C. and Chitu R., Geographical Information Systems and Urban Management. [http://www.um.ase.ro/No11/9.pdf].

[16] Ranjana V., Lokesh K. and U.S. Tiwary, Exploring Spatial ARM (Spatial Association Rule Mining) for Geo-Decision Support System, Journal of Computer Science 3 (11): 882-886, 2007.

[17] Regan M. et al, Tracking the spatial diffusion of influenza and norovirus using telehealth data: A spatiotemporal analysis of syndromic data, BMC Medicine, 2008

[18] Types of Decision Support System Retrieved 20 October 2009 from http://www.gdrc.org/decision/dss-types.html

[19] Web Mapping, Wikipedia 2009, http://en.wikipedia.org/wiki/Web_mapping

[20] What are Information System, Retrieved from 20 October 2009 http://www.geocities.com/jameswanderi/articles/infosys/IS.html

[21] What is GIS Retrived 20 October 2009 from http://gislounge.com/what-is-gis/