Accrued Connectivity based Digital Map Using Geographical Information System (GIS) for Spatial Map

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ABSTRACT

Computer has become a global avenue that links one part of the world to the other. It has proved to be a way to solve many problems of paper works that can be converted to a computer-based works. One major way to manage spatial data is the Geographic Information System (GIS). An easy way to have access to an area is to digitally represent it; the GIS have played a major role in converting paper map work into a computer-based one. GIS is a system that uses spatial (geographically referenced) and non-spatial (attribute) data and includes operations that support spatial analysis; it is a spatial data management or handling system. The purpose of this paper is to develop a usable geo-database to store geographical information of an area. A geo-database data model was developed using Entity Relationship Approach (E-R) for the system development and physically realized utilizing Java programming language, MYSQL and POSTGIS. The data model was then tested against an existing traditional map to determine whether or not the geo-database model was functional. The results were encouraging as the data model was able to handle the majority of data types and their accompanying representation. The system will aid in locating the facilities within a geographical area, as well as help private, public and government to make more informed decisions on the available resources. Future work can be done on web-based system for easier accessibilities and very pontificate GIS software can be used to design the geo-database system for spatial map for a more secure system.

Keyword: Geographic Information System (GIS), Spatial map, POSTGIS, Entity Relationship, Digital map

Aims Research Journal Reference Format:

1. INTRODUCTION

Today, information has become speedily accessible because of technological advancements, with information technology someone can easily access information without having to go far before getting them. Computer has been proved useful in the area of information distribution and it can be access easily with the use of Internet. It is inevitable for the educatory institutions, where the basis of information is formed, to pioneer at the point of presenting information. In this content, presenting to the user information on institutions which are able to access information constitutes one of the most primary steps. Computers and electronic communication stand out as important components in terms of making information available. The computer environment is employed so as to ensure faster flow of information in the rapidly developing world. Geographical information systems are a part of this trend.

GIS supports the daily activities of automated mapping and facilities management with the applications for electricity, water, gas, telecommunications, and cable television and other utilities. GIS capture, edit, store, manipulate, and analyze a diversity of geospatial data that are used to create a management such as Internet mapping sites and smart phone spatial mapping. Technological development in the field of map and spatial database simplification is growing very fast, following the trend from manual cartography to computer-based cartography. Map generalization is an integral part of spatial data collection, representation and access. GIS are becoming an increasingly integral component of natural resource management activities nationwide.
GIS applications are tools that allow users to create interactive queries (user-created searches), analyze spatial information, edit data in maps, and present the results of all these operations. Geographic information science is the science underlying geographic concepts, applications, and systems. GIS is the merging of cartography, statistical analysis, and computer science technology.

Many researchers have used GIS to understand, analyze, and manage spatially distributed data mapped to a geographical region. The system started with the purpose of creating digital maps, it quickly became a valuable tool in the decision making process for various industries. GIS has been widely accepted by government agencies. The majority of GIS applications are found in areas of natural resources, socio-economic demographics, and urban planning and transportation. However, increasingly applications are found in almost all disciplines including: agriculture, business, engineering, environmental sciences, healthcare, law, and real estate (Rob, 2003). This paper try to represent the map of an area by develop a usable geo-database to store geographical information of the area, by this the user of the system can easily locate any part of the area without any assistant from the map or person.

2. RELATED WORKS

Since accessibility is one of the prominent issues to land, asset, farm lands, institutions and properties etc, several researches have proposed the used of GIS for easier accessibility in a like manner of this paper, to sift from problems of paper works and map that can be converted to a computer-based works. GIS has been the most widely used by many researchers during the 20th century. The maturity of GIS and the dramatic improvement of the geo-database have led to the proposal of geo-database to store geographical information of an area for easy accessibility. Multi-resolution spatial databases provide the ability to represent objects in multiple representations tailored towards the requirements of different users, especially for web applications. It should preserve spatial relations throughout scale changes (Tryfonas & Egenhofer, 1996).

(Alahakone, & Veera, 2009) presented the development of a geospatial information system for path planning and navigation of mobile objects, the system involves a GIS implemented using Google maps to visualize the routes of mobile objects acquired from GPS receivers over a GPRS network. (Jiang & Clarament 2002) proposed a generalization model of an urban street network that aims to retain the central structure of a street network by relying on a structural representation of this data employing graph modelling principles. The proposed method provides a flexible interactive solution to a street network because it incorporates the concept of a hierarchy-based generalization in terms of connectivity to an average path, length and measures.

(Rob, 2003) used and illustrated the services of GIS to spatially analyze the distribution of the prevalence of asthma among school children (13-17 years) in the New York City area. The researcher make used of the chi square inferential statistics and correlation matrix techniques to analyze the spatial data. (Buragohain, 2002) developed a land information system using integrated remote sensing and GIS Technology for Guwahati city, India, in order to come up with an advanced database management system (DBMS) for the city. The methodology adopted in the study was the map of Guwahati city and its surrounding areas were digitized. The industrial data comprised of the characteristics of the draining network, road and railway network as well as infrastructure facilities in the city.

(Doko, 2009) developed an integrated Web-based GIS system to support policy making for conserving biodiversity. The paper make used of spatially explicit inter-operational platform and data that are categorized into (a) base-map, (b) environmental layers, and (c) animal localities. As a result, the system is easily updated; and query cum analysis also easily carried out on situation of animal movement and habitat. (Gibbons & Machin 2005) use GIS to evaluate the proximity of properties to rivers, coasts, woodlands, roads, railway lines and airports in their study valuing rail access. Turning to the broader issue of spatial arrangement there are a number of potential areas of overlap between GIS and spatial economics which have only just begun to be explored by many researchers.
(Heo, et al. 2009) proposed the effect of spatial layout on nurses’ movement was modelled with far greater predictability and consistency. RFID tags were used to collect time-sequence spatial data for the analysis using both the Poisson distribution function and log link function for the said system. (Burchfield et al 2006) make used of GIS to calculate the percentage of the urban fringe defined as a 20 kilometer buffer around existing development that is lies above water yielding aquifers. The use of such buffers is in its infancy in socio-economic applications but has the potential to be very useful because it reduces the need for research to rely on arbitrary discretization of the study area of interest.

(Vatsavai, et al. 2000) also proposed a balanced client/server Web-based spatial analysis system that uses a Geospatial datasets for land management and its performance evaluation geospatial showed that land can easily be managed with web-based and for easy accessibilities. By the early 1980s, M&S Computing (later Intergraph) along with Bentley Systems Incorporated for the CAD platform, Environmental Systems Research Institute (ESRI), CARIS (Computer Aided Resource Information System), MapInfo (MapInfo) and ERDAS (Earth Resource Data Analysis System) emerged as commercial vendors of GIS software, successfully incorporating many of the CGIS features, combining the first generation approach to separation of spatial and attribute information with a second generation approach to organizing attribute data into database structures. In parallel, the development of two public domain systems (MOSS and GRASS GIS) began in the late 1970s and early 1980s.

In 1986, Mapping Display and Analysis System (MIDAS), the first desktop GIS product emerged for the DOS operating system. This was renamed in 1990 to MapInfo for Windows when it was ported to the Microsoft Windows platform. This began the process of moving GIS from the research department into the business environment. By the end of the 20th century, the rapid growth in various systems had been consolidated and standardized on relatively few platforms and users were beginning to explore viewing GIS data over the Internet, requiring data format and transfer standards. More recently, a growing number of free, open-source GIS packages run on a range of operating systems and can be customized to perform specific tasks. Increasingly geospatial data and mapping applications are being made available via the World Wide Web.

3. OVERVIEW OF THE METHOD

This paper involve the use of a descriptive conceptual approach. The work will be implement using Java Programming Language in implementing Geo-coding, POSTGIS, and MYSQL server so as to get a more reliable and efficient results for both the design and implementation of the area for geo-database. GIS systems are self-motivated and they allow rapid updating, analysis, and display. GIS use data from many various sources such as satellite imagery, aerial photos, maps, ground surveys, and global positioning systems (GPS) etc. But for the purpose of this paper the sources of the data used is from the map.

3.1 Logical Design
The logical design could be realized in so many forms depending on the approach to design the geo-database.

Entity Relationship (E-R) approach is going to be adopted in the scope of this paper, Modeling a geographic database using the E-R approach requires an expanded or extended concept for:
- Entity identification and definition; and
- Relationship types and alternate representational forms for spatial relationships.

The table below shows the modelled data items (list) obtained from the conceptual analysis and to be converted to real geo-database.
Table 1: Data List

<table>
<thead>
<tr>
<th>Category Object</th>
<th>Entity (Attributes)</th>
<th>Spatial Object</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land Records</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parcel</td>
<td>(parcel_id, parcel_name, subdivision_block, parcel_latPolygon, parcel_description, parcel_long, parcel_area, parcel_assessed_value,</td>
<td>Polygon</td>
</tr>
<tr>
<td>Building</td>
<td>(building_ID, date_builtFootprint, building_material, building_assessed_value, building_description, building_long, building_lat,</td>
<td>Polygon</td>
</tr>
<tr>
<td>Street system</td>
<td>Street_segment (street_id, street_name, pavement_type, street_length,</td>
<td>Polygon</td>
</tr>
<tr>
<td>Water system</td>
<td>Water_main (type, size, material, Line, installation_date)</td>
<td>Polygon</td>
</tr>
<tr>
<td>Valve</td>
<td>(type, installation_date)</td>
<td>Node</td>
</tr>
<tr>
<td>Hydrant</td>
<td>(type, installation_date, pressure, last_pressure_test_date)</td>
<td>Node</td>
</tr>
<tr>
<td>Service</td>
<td>(name, address, type, None, invalid_indicator)</td>
<td>Node</td>
</tr>
<tr>
<td>Natural feature</td>
<td>Soil (soil_code, area)</td>
<td>Polygon</td>
</tr>
<tr>
<td></td>
<td>Wetland (wetland_code, area)</td>
<td>Polygon</td>
</tr>
<tr>
<td></td>
<td>Plantation (plantation_code_area)</td>
<td>Polygon</td>
</tr>
<tr>
<td>Administrative areas</td>
<td>Traffic_zone (zone_ID#, area)</td>
<td>Polygon</td>
</tr>
<tr>
<td></td>
<td>Zoning (zoning_code, area)</td>
<td>Polygon</td>
</tr>
</tbody>
</table>

3.2 Mapping The Conceptual Database Design To Detailed Logical/Physical Specifications

The E-R diagram shown in Table 3.1 will be used to verify with the expected users the data content of the GIS and, by additional reference to the GIS needs analysis, the required spatial operations. Once verified by the users, the E-R representation can be mapped into a detailed database design as follows (Figure 3.3):

1) Each entity and its attributes map into:
   a) One or more relational tables with appropriate primary and secondary keys (this assumes the desired level of normalization has been obtained);
   b) The corresponding spatial entity for the “regular” entity. As most commercial GISs rely on fixed structures for the representation of geometric coordinates and topology, this step is simply reduced to ensuring that each corresponding spatial entity can be handled by the selected GIS package;

2) Each relationship into:
   a) Regular relationships (diamond) executed by the relational database system's normal query structure. Again, appropriate keys and normalization are required for this mapping.
   b) Spatial relationships implemented through spatial operations in the GIS. The functionality of each spatial relationship needs to be described, and if not a standard operation of the selected GIS, specifications for the indicated operation need to be written.
Figure 1: Sketch diagram for the Geo-database
3.3 Stages In The Digital Map Using Gis Database Development

Developing a GIS database is frequently thought of as simply replicating a map in a computer. As can be inferred by the nature and detail of the activities recommended up to this point in this write-up, building a GIS database involves much more than "replicating a map." While substantial portions of the GIS database will come from map source documents, many other sources may also be used, such as aerial photos, tabular files, other digital data, etc. Also, the "map" representation is only part of the GIS database. In addition to the map representation and relational tables, a GIS can hold scanned images (drawings, plans, photos), references to other objects, names and places, and derived views from the data. The collection of data from diverse sources and its organization into a useful database requires development of procedures to cover the following major activities:

- **Source of Geography Information:** This may include acquiring existing data from both internal and external sources, evaluating and checking the source materials for completeness and quality, and/or creating new data by planning and conducting aerial or field surveys. Often focused only on map source documents, this activity has been called "map scrubbing." Depending on the technology to be used to convert the map graphic image into its digital form, the source documents will have to meet certain standards. Some conversion processes require the map to be almost perfect which other processes attempt to automate all needed "fixes" to the map.

- **Converting to digital data:** The physical process of digitizing or scanning to produce digital files in the required format. The major decision here is whether or not to use an outside data conversion contractor or to do the conversion within the organization. In either case, specifications describing the nature of the digital files should be prepared. In addition to including the physical database design, specifications should describe the following:
  - Accuracy requirements (completeness required positional accuracy for spatial objects, allowable classification error rates for attributes).
  - Quality control procedures that will be conducted to measure accuracy.
  - Partitioning of the area covered by the GIS into working units (map sheets) and how these will be organized in the resulting database (including edge matching requirements).

- **Change control,** most map series are not static but are updated on a periodic basis. Once a portion of the map has been sent to digitizing (or whatever process is used), a procedure must be in place to capture any updates to the map and enter these into the digital files.

- **Digital Map and Data Integration:** Once digitizing has been completed, the sponsoring organization has a set of digital files, not an organized database. The system integration process (a subsequent guideline document) must take all the digital files and set-up the ultimate GIS database in a form that will be efficient for the users. The several considerations required for this process are covered under GIS Data Database Construction, GIS System Integration and GIS maintenance and use.
4. FUNCTIONAL COMPONENTS OF GIS

Spatial data plays a substantial role in decision making. With the advancement of the technology, the creation of spatial data has become much more upfront and easier (Kasturirangan & Ramamurthy, 2001); hence, many organisations create and maintain spatial data that very useful to public, private and government agency especially spatial data decision-makers.

The functional components of GIS are data capture and preparation, data storage, data analysis and presentation of spatial data. Figure 2 shows a diagram of these components, with arrows indicating the data flow in the system. For every GIS, all of these components must be present if not it must not be called a Geographic Information System, each of these components may provide many or only a few functions. It is important to note however, that the same function may be offered by different components of the GIS: for examples, data capture and data storage may have functions in common, and the same holds for data preparation and data analysis.

![Diagram of Functional Components of a GIS]

**Figure 2: Functional Components of a GIS**
Source of Geographic Information

- Paper Maps, Existing Printed Air Photo and Satellite images
- Field Mapping Products such as Sketch Maps
- Digital Air Photos and Satellite Images
- GPS Coordinate collection
- Existing Digital Maps

Data Conversion

- Digitizing
- Scanning
- Generate Lines and Polygons
- Raster to Vector Conversion (Automated or Semi-Automated)

Digital Map and Data Integration

- Editing Geographic Features
- Construct Topology for Geographic Features
- Georeferencing (Coordinate Transformation and Projection Change)
- Coding (Labelling) of Digital Geographic Features
- Combine and Integrate Digital Map Sheets
- Additional Delineation of EA Boundaries

Figure 3: Stages in the Digital Map Using GIS database development
4.1 Implementation Process
The development of the geo-database data model follows the outline described by (Arctur & Zeiler, 2004) and recommended by ESRI. The following information describes how this methodology was used in the context of this research.

Identify the information products to be produced from the geo-database.
Domain experts were solicited for information using a wide variety of methods. Google maps was explored for input on the conceptual design of the data model. Several responses were received and suggestions were incorporated into the overall design. Interestingly, many more responses were received offering data for testing purposes or expressing interest in the results produced by this research. Many individual stakeholders were also contacted. These conversations took place by email and phone.

Identify the base layers needed to support the information products.
The thematic base data layers for the GIS were identified from the map symbols. These symbols provide graphic representation for commonly found features in the selected environment. All thematic layers were defined as a graphic data type supported by the geo-database. The spatial characteristics of the geo-database are also important at this point of the conceptual design.

Specify the scale ranges needed and data types (point, line, polygon, raster).
The scale ranges for all feature classes were designed for large scale representation. Even at the common topographic map scale of 1:24,000. The larger scale representation also eliminated the need for multiple data types for a single feature class. Features that may have been represented as a point feature when using smaller map scales could easily be represented as polygons for the larger map scales. Line features appear to be minimally impacted by the scale range. Annotation feature classes were optimized for a 1:600 scale. The resolutions of the raster datasets utilized in this research were far lower than other data in the geo-database. As a result, the raster data was stored at maximum available resolution. The geo-database stores raster data with multi-resolution pyramids so that large datasets render more quickly.

Describe data-sets.
The final step in the conceptual design process was to group the feature classes into datasets. As discussed in step 2, the top level feature datasets were identified as roads, buildings, plantations, cross sections etc. These datasets are based on the base map symbols and feature classifications.

Define the tabular database structure and any behaviour for attributes.
Tabular datasets were defined for several feature classes. Effort was made in the creation of feature classes to organize features so that common attribute data could be collected for each feature. It is anticipated that a real world implementation of the data model would not necessarily utilize all available attributes. Subtypes were created for many feature classes to further classify features within various feature classes. The subtypes also assist the user in controlling the behaviour and appearance of features. A limited number of attribute domains were defined to limit the possible values for certain tabular attributes. It is expected that as the data model matures, there will be additional attribute domains suggested for incorporation to the model structure.

Define spatial properties for all datasets.
All feature datasets share common spatial properties. These properties are then subject to a geographical reference. The geographical reference should not be confused with the spatial properties of the geo-database. It may be useful to think of the spatial properties as a piece of paper, and the geographical reference as a position on a desk. The combination of these two parameters determines where the paper will be located on the desk. These settings are particularly important when topology rules are defined. Feature classes must share the same spatial properties or these topology rules cannot be enforced.
Create prototype geo-database design.  
This paper produced a prototype geo-database design. The prototype is based on the information products collected in step 1, the data types and structure outlined in steps 2-5, and the spatial properties defined in step 6. The prototype geo-database was created with MYSQL database. Background information for the data model was collected during the literature review process to better understand how other data models have been designed and implemented in other fields of study.

Document geo-database design using established methods.  
The geo-database data model was documented by several established methods.

![Flowchart for Implementation Processing](image)

*Figure 4: Flowchart for Implementation Processing*
5. CONCLUSION

The value of GIS lies in the ability to integrate disparate sets of data, visualize them in the form of a map and link to software that provides non-spatial functions, such as optimization schedules. Geographical information systems are available in a diversity of ways, generally designed to appeal to specific developed purposes and for particular functions. The term ‘GIS’ is used in a free technique to refer to the area for mapping software products and also to a particular sub-set of this area, complex, high-specification and expensive mapping software.

The computer offering a drastically different way to manage spatial data, with the used of GIS someone can easily represent a map on paper with a computer base system. The primary purpose of this paper is to develop geo-database for a spatial map. This phase (database design) of the GIS development process is to specify “how” the GIS will perform the required applications. Database planning and design involves defining how graphics will be symbolized (i.e. colour, weight, size, symbols, etc.), how graphics files will be structured, how non-graphic attribute files will be structured, how file directories will be organized, how files will be named, how the project area will be subdivided geographically, how GIS products will be presented (e.g., map sheet layouts, report formats, etc.) and what management and security restrictions will be imposed on file access.

The database planning and design activity is will be conduct concurrently with the pilot study and/or benchmark activities. Clearly, actual procedures and the physical database design cannot be completed before specific GIS hardware and software has been selected while at the same time GIS hardware and software selection cannot be finalized until the selected GIS can be shown to adequately perform the required functions on the data. Thus, these two activities (design and testing) need to be conducted concurrently and iteratively. The system will be very useful to both the management and the user for locating facilities on the establishment; also this will help in make quick decision on the facilities on represented area.

6. FUTURE WORK

Nowadays, developing with the Internet, the Web-Based GIS, which knob geographic information on the Internet, has emerged and is rapidly growing as Internet and Web technologies change, with this change a web-based system can be developed to make easier accessibilities. Also, very pontificate GIS software can be used to design the geo-database system for spatial map for a more secure system.
REFERENCE