An Integration of Interoperability and Persistency into GIS Data Analysis for Developing Map Engine

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Abstract- **The use of Geographic Information Systems is increasing rapidly now-a-days. The availability of remotely sensed data is effecting the applications of GIS greatly. Especially the creation and analysis of maps based on spatial data has been proved to be an outstanding field of research for the past decade. Map visualization is used to render maps. It provides an easy way to integrate functionally rich interactive maps into any desktop application and web application. The system presented in this paper allows the presentation of whole map of the world or any region based on spatial query. The system is capable of scaling a map and identifies a particular region. It allows the recognition of Global Positioning System (GPS) data and their conversion into system's own data format. The converted data eventually is used in handheld devices such as PDA, Pocket map. The system provides persistent facilities and can address interoperability issues which are the main contributions of this paper.**

Keywords: Map visualization, GIS, GPS, Mapviewer, Shape file, Persistency, Interoperability.

I INTRODUCTION

The use of Geographic Information Systems (GIS) [2], [13] with spatial data is becoming more and more popular nowadays. The availability and usage of remotely sensed data augmented radically that necessitate advanced technologies in computer science and related areas. Location, shape, size, and orientation are included by spatial data. The attributes of spatial data are formally expressed by means of the geometric features of points, lines or polygons in a plane. Computer based geographical data services involve management spatial and non-spatial data. GIS has come to be an indispensable tool for analyzing and managing these spatial data. The development of a computer system by integrating GIS would serve the following two crucial purposes:
(1) It should allow the user to operate the system without having to struggle with the underlying workings of GIS technology.
(2) It should allow the sharing of information and technical expertise among all level of users.

A growing amount of freely available GIS data on the Internet has motivated recent research into Geographic Information Retrieval (GIR) [14]. Generally GIR deals with the problem of retrieving meaningful GIS datasets. These GIS datasets largely contribute to the analysis of various GIS application tasks. One of the widely used applications is the map creation from the retrieved data. The performance of the GIS data analysis and map creation is largely influenced by some factors. Such as, to fully realize the capability and advantages of geographic information and the technology of GIS, sharing of spatial data needs to be made and the concerning systems need to be interoperable. This paper pays particular attention to handle the interoperability problem and provide persistence facilities which in turn improves the performance of correct map creation.

The paper provides the framework for a shared spatial data infrastructure and a distributed architecture. Our proposed system uses shapefile (.shp) spatial data format. That is available in Environmental Systems Research Institute, Inc. (ESRI) [21]. This is used for creating shapefiles directly or converting data into shapefiles from other formats. The products of ESRI are developed based on open standards in order to ensure a high level of interoperability across databases, development languages, platforms, and applications. A shapefile whose purpose is to store the nontopological geometry, also store the attribute information for the spatial features in a data set. The geometry for the features is stored as a shape which comprise of a set of vector coordinates.

For the purpose of map creation, our proposed system uses spatial data as input and by using this data the system can visualize map. A map is a geo-referenced data. This is not the data itself rather it is defined as a visual representation of geo-data. This data is very significant in various application fields that need to be managed and processed.

The aim of the proposed work is to develop a system that work as Web GIS and we called this MapEngine as MapViewer [12]. This system will help us to analyze GIS data. Here we analyze spatial data that include point, line and polygon. User can easily access this data and their attribute. MapEngine can easily generate map. It offers customizable options for more advanced users and during this process, it provides tools that hide the complexity of spatial data queries and cartographic rendering. These tools are designed in such a way so as to integrate with map-rendering application and thus can be used in a platform-independent manner. MapViewer includes a rendering engine that provides cartographic rendering capabilities. MapViewer can be applied to [3]:

• Create customized maps that show geographic features such as roads, city areas, waterways and other transport networks.
• Display the map themes in terms of local, state and national boundaries.

With MapViewer the client requests a map. For generating a map, the client passes some useful information like the map name, data source, center location, map size and other optional data that are to be plotted on top of a map. The server returns the map image (or a URL for the image) and the minimum bounding rectangle (MBR) of the map, and the status of the request.

We will now set the objectives of this paper that include:
(1) Analysis of GIS data, (2) Understanding the ShapeFile data format, (3) Developing a ShapeFile reader efficiently, (4) Developing a MapEngine to draw a map, (5) labeling and coloring of output map and pane the map, (6) **I**mplement the GPS data to display map.

The rest of the paper is organized as follows. Section II covers some background concepts related to spatial database. Existing works on map creation and GIS data analysis are discussed in section III. Section IV explains our proposed framework with details of each and every step. Section V illustrates the experimental results following our implementation. Finally, the paper concludes with section VI with an indication of our future research.

II SPATIAL DATABASE

In various fields, it is needed to manage geometric, geographic, or spatial data, which means data related to space. Modeling spatial database [4] is concerned with set of objects in space. It does not give full emphasis on images or pictures of a space. An increasing amount of available GIS data on the Internet has made it an outstanding research area in spatial database system. To give it a semantic view, modeling is necessary to a greater extent. An important alternative can be considered as arranged distinct entities in space. Another suggestion may be to explain the space itself because it describes each and every point in space. The first option gives a way to model cities, forests or rivers. The next one is the one of describing thematic maps, for example, usage of land or the grouping of a country into districts. We can reconcile this view by offering concepts for single objects and spatially related collections of objects modeling. The fundamental abstractions are point, line, and region for modeling single objects [5]. Figure 2-1 shows the three basic abstractions for single objects.

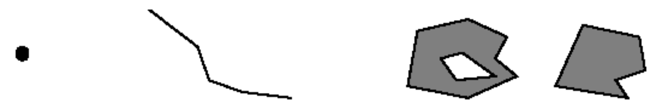

Fig.1. The three basic abstractions point, line, and region

Systems of spatial data types, or spatial algebras, can capture the fundamental abstractions for point, line and region. Spatial relationships are the most important ones among the operations offered by spatial algebras [9]. A graphical representation of results, along with a graphical input of queries or SDT values used in queries is required by the spatial data. It is consider from an algebraic point of view operations for manipulating sets of database objects with spatial attributes. They can be classified as spatial selection, spatial join [22] spatial function application, and other set operations [3].

2.1 Spatial Data in Map Creation

Map visualization is generally considered as a layered concept. The underlying principle of GIS data organization is the grouping of spatial data into themes or we can say this as spatial data layers. Each of the concerning theme has an associated dataset of which it is made of and Meta data. These spatial layers are generally placed one on top of each other in the visualizations interface. The use of spatial data facilitates the performance of map generation in terms of categorizing data into themes which can increase the efficiency while data querying. It will allow the easy addition of new data by simply placing on top a new theme layer [19].

Spatial information, as mentioned in the previous section consist of sets of polygons like our sales region, line strings like roads or rivers, and some points like store locations. One of the most commonly used map type for analyzing business data is called choropleth, a thematic map [2] in which the areas are shaded in proportion to the statistical variable that we would like to analyze.

III RELATED WORKS

In [15], the author produced a fire-risk map and made detail analysis of it. They particularly paid attention to reduce the risk of fires by properly analyzing fire-risk maps. In [16], the work intended to analyze sketch maps by GIS utilization. The concerned authors showed that buffer operation was much effecting for sketch map analysis than other existing techniques. In [17], the author produced thematic maps by using Quasi GIS analysis and successfully generated maps of regions of risk areas along a street, places of environmental quality and also optimal position areas for micro-hydro power plant along a river. In [18], the author showed the effect of GIS in geographic profiling and crime analysis.

By studying these related works, we were greatly motivated to perform GIS data analysis to a greater extent with special interest in bringing persistency and dealing with interoperability problem for map creation.

IV MAP ENGINE

The main task of map engine is the visual representation of geographical data. Before geographic data can be used in a map engine, the data must be converted into a suitable digital format. Digitizing is the process of converting data from paper maps into computer files. Now-a-days many different types of geographic data exist in GIS-compatible formats. Data types required for a particular system will need to be transformed or manipulated. To store geographic information it is often best to use a database management system (DBMS) which can be used to store, organize, and manage the data. There are of several types of map engine called ArcView, ArcExplorer, ArcReader and ArcEditor GIS [10].

Arc View works with geographic data in interactive maps. It also work with image data, tabular data [7]. But in ArcView, we can't generalize the spatial data itself. ArcExplorer can be used to view and query geographic data stored on computer. It Creates map using classifications, symbols, and labeling. Arc Reader work with .pmf file. ArcReader's published map do not store data actually that show on the map. But maximum map engine that we discuss here are desktop based. In our proposed Map engine we tried to create a web based system. In our system we use shape file to store spatial data. In Map Engine the relational design are the most useful. Map Engine provides both simple point-and-click query capabilities and sophisticated analysis tools to provide timely information.

V METHODOLOGY

This section focuses completely on the process and working several techniques to visualize maps. Mapviewer provides cartographic rendering capabilities [11].

For a map request:

1. The client requests a map, passing in the map name, data source, center location, map size, and, optionally, other data to be plotted on top of a map.
2. The server returns the map image (or a URL for the image) and the minimum bounding rectangle (MBR) of the map, and the status of the request.

For a MapViewer administrative request:

1. The client requests a MapViewer administrative action, passing in the specific type of request and appropriate input values.
2. The server returns the status of the request and the requested information.

Figure 2 shows the general framework of the system.

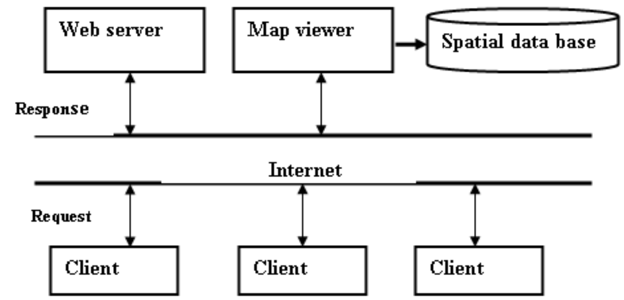

Fig. 2. Framework of the system

5.1 Map Drawing Technique

First of all to draw a map a ShapeFile generator is needed. This system also supplied a ShapeFile creator with the Software. Then we can create ShapeFile of desired location. There are following ways for data collection.

A Onscreen Digitization

For onscreen digitization required the either satellite image, aerial photography or scanned map. If an image is present then use special GIS software to draw a map of that location. Invoke the image file as layer or theme. Use digitizing tools to digitize [22].

B Drawing Board Digitization

For drawing board digitization should need a drawing board device then configure that device with the software. Then the drawing board cursor will activate like mouse with number button facilities. Attached the hard copy map to board and then need to follow the general procedure to create shape file of that map.

C Proposed Technique

Apply our own Developed technique to make ShapeFile using GPS data. . The entire procedure functions considering the idea of Map Engine are presented with the following prime steps:

1. The Shape writer creates and writes feature data to shapefiles in the directory specified by the DATASET keyword.
2. Then the Shape reader scans the directory given for the shapefiles which have been defined in the mapping file. The Shape reader extracts features one at a time from the file. When the file is exhausted, the Shape reader starts on the next file in the directory.
3. By using this data Map Engine generate map.
4. After that we can see a map as a visual representation of geographical data and can take help of various attribute from the feature.

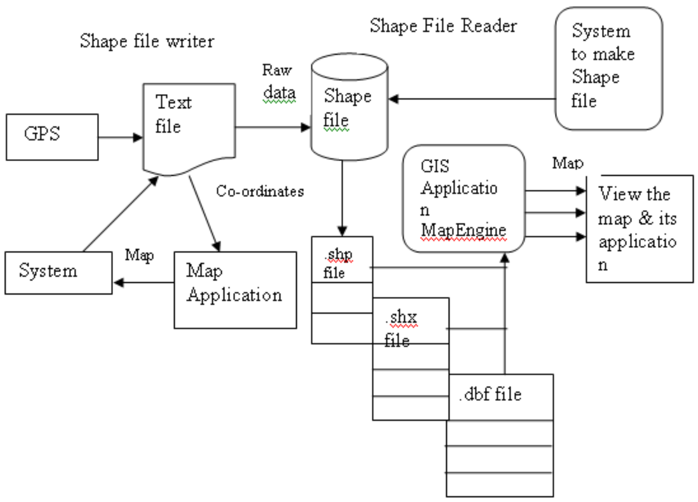

Fig.3. Model of the information flow for the system

Figure above show the model of the information flow for this system. Where we see several parts : such as shape file writer, shape file reader and map viewer. At first GIS data write by shape file writer. Then this raw data is stored in shape file. From this we read this raw data by using shape file reader. Then user can visualize the map.

5.2 ShapeFile Writing Technique

This paper used three types of ShapeFiles. Those are Point, PolyLine and PolyGon layers. Here Point type layer are used for indication of point. By using PolyGon layer it can show the bounded region and PolyLine layer map can show the any other way like highway, railway, and airway and so on. Point type shape is just geometric point, X- coordinate and Y-Coordinate (Latitude and Longitude) values. ShapeFile is a byte code file. Its internal data have written in byte code. Every ShapeFile the first 100 bytes are its header file. To write header file the main problem is converting BigEndian format byte order. And another problem is declaring the bounding box values. File length calculation is also a mathematical process [8].

For the point type shape file we used the following formula to calculate the total file length.

File Length = (100+4+ Number of Record*16+ Number of Record *12)/2;

For the PolyLine abd PolyGon type shape file we used the following formula to calculate the total file length.

File Length = (100+ (8+44+4*Number of Parts)*Record Number)/2;

5.3 Data Collection

For Point type Shape data, the first value of the file will be the shape type and must be an integer value. Then the X and Y Co-ordinate value correspondingly. For PolyLine type shape, first value is Shape Type and then the Record value. For each record the format is -1st value is Record number. 2nd value is Shape Type, 3rd value is number of parts, 4th value is Number of Points with in this Records. For PolyGon type shape, it is like PolyLine and same data format. That is the First value is Shape Type and then the record value. For each record the format is - first value is Record number. second value is Shape type, third value is number of parts, fourth value is Number of Points with in this Records.

5.4 ShapeFile Reading Technique

Actually shape file reading technique is very important to show a map. This should be followed in easy and efficient way. The shapefile can be read in some steps-

1. Reading file header
2. Reading point type record content
3. Reading polyline type record content
4. Reading polygon type record content

5.5 Client/server Interoperability and Persistence

Interoperability problem arises when different heterogeneous nature of geo-data posses disagreement amongst information sharing. The heterogeneous nature grows because different information systems have tendencies to store their data in different structures. Our proposed system support ESRI. For this data can be easily accessed by other technologies and applications. With this interoperable Web mapping, each map server implements a common interface. Interoperability includes intercommunication at hardware, software, communication level protocol, and data compatibility layers. In case of persistence any spatial object such as point, line and area may persist for as long, or as short, a period as that object is required, and also may be manipulated in the same manner regardless of this longevity.

Our proposed system follows a non-proprietary approach that support interoperability program. For this interoperability, data can be easily accessed by other applications and technologies. Interoperability [19] point to the ability for a system or components of a system to provide information portability and interapplication as well as mutual process control.

This enables users to immediately overlay and operate on views of digital thematic map data from different online sources.

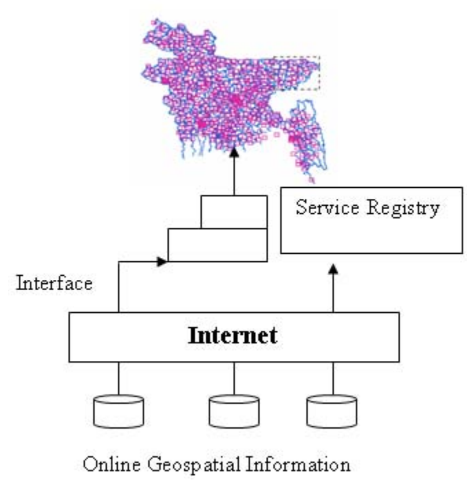

Fig. 4. Interoperable map overlay

These type of interface address basic Web computing, image access, display, manipulation and coordinate transformation capabilities. That is, they specify the request and response protocols for open Web-based client/map server interactions [20].

The model of interoperable, scattered mapping systems is shown in figure-5 below.

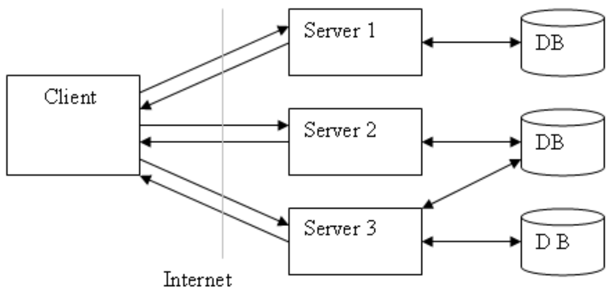

Fig. 5. Client/server Interoperability

This approach allows the user to run a single client that accesses all the capabilities of each server.

5.6 Persistency

GIS software packages are considered as either vector-based or raster-based because of different processes required by the vector and raster data. But, actually neither system can meet all the required GIS applications. It has often been discussed that the incorporation of raster into vector functions into a single system would have much more things to offer. In this regard, the introductions of persistent programming languages solve this problem. Because, this language allows both data and program to be placed in a persistent store. The programming language execution and the database query activities take place in the application program environment and share the same data workspace and type system. Persistent programming languages [1] provide a single working environment that can meet the fundamental requirement of developing a truly integrated GIS. For this reason, our paper proposes a new approach to the development of a web based integrated GIS that employs a persistent programming language.

For ensuring persistency, our system provides the following principal features that are extremely suitable for the development of an integrated GIS:

-In addition to base types, it also provides the type constructors. It means that we can create any new type from other predefined types.

-For line drawings and bitmap operations, it provides graphical facilities. It results in both vector (picture) and raster (image) types of data can be stored in and subsequently retrieved from the persistent store. This special feature allows both the raster and vector types of geographical data to be organized and also manipulated within the same database environment.

-It provides abstract data types and higher-order procedures. This feature is suitable for constructing the object-oriented organization of geographical features.

-It uses a uniform model for all aspects of binding and also supports incremental software construction. The program modules are frequently fully type checked and also are incrementally bound to the persistent environment. This strong feature helps us to efficiently construct and maintain GIS software.

VI RESULTS

For the experimental purposes, we used Java as our programming language to implement the map engine. We used JDK 1.6 version. We particularly used Java for the following reasons relating our concerning problem-

(1) ShapeFile Reading was supposed to be efficient in order to visualize the final map.
(2) In case of GIS-based applications, there are always some function overheads.
(3) Image transformations such as scaling, rotations are difficult to handle with other programming languages because of less simplicity nature.
(4) Error handling regarding GIS applications are always obtrusive.

After we implemented using Java, the above mentioned problems became easy to handle with. Moreover, the modular nature of the language Java enabled us to group the whole problem into small modules for taking care of the concerned sub problems. And the codes were efficient and easily changeable without putting much effect on other modules.

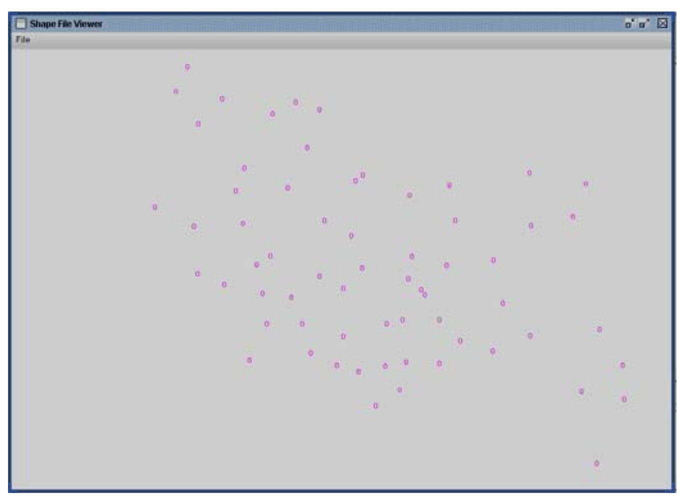

Fig. 6. Interface shows a point shape based on district head quarter

This interface showed the shape of point type. To see this we use .shp file of district head quarter. Here we see the district head quarter of sixty four district in Bangladesh. For the shape type point we use the value 1.

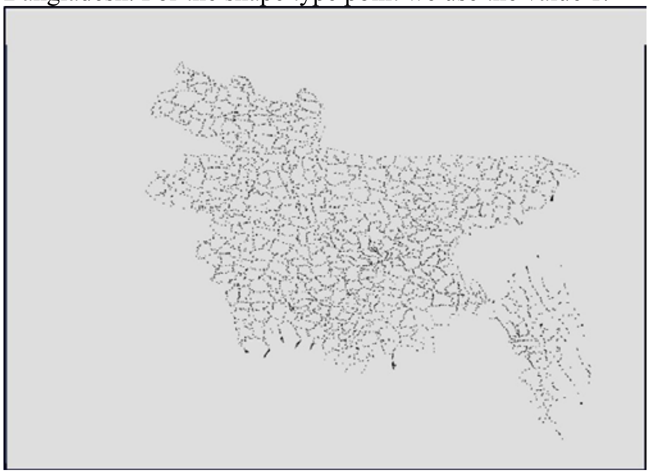

Fig. 7. Poly line shape based on boundary line

Figure-7 shows the shape of polyline type. For the shape type polyline we use the value 3. Here we see boundary line shape. Polyline files include linear features or collectives of linear features, which have single attribute entry.

Table 1: Attribute of specific co-ordinate based on district head quarter

World Co-ordinate	Dist. name	Dist. code	Disthqp_id	Div. name	Div. code
X: 91.83868473238 Y: 22.33309190622138	Chittagong	15	56	Chittagong	2
X: 1.408385110324 Y: 23.01770296708212	Feni	30	49	Chittagong	2
X: 0.828523025683 Y: 22.95517437602178	Lakshmipur	51	51	Chittagong	2
X: 90.42454216606613 Y: 23.99476077104221	Gazipur	33	52	Dhaka	3
X: 88.64414938932607 Y: 25.62681865251953	Dinajpur	27	57	Rajshahi	5

Table-1 shows some attribute of district headquarter based on world co-ordinate. Here we present only five co-ordinates as a sample.
Here we see the district head quarter of sixty four district in Bangladesh. For the shape type point we use the value 1.

VII CONCLUSION AND FUTURE WORKS

By analyzing the application of the system we can measure its achievement. With this system shape file can be read and user can easily get the idea about point type, poly line type and polygon type data and can observe the map. This system is capable to show the attribute of the shape file. Here we tried to make the system web based. As a result client can request any data to the browser and server can response this request. Main achievement of this system is to solve interoperability problem and to get persistent facilities.
There are some scopes for future research work, Measuring the shortest path and distance for two different points. If there has roads and railway line shape main file then applying different shortest path graphical algorithm can measure the shortest path. Mainly for Bangladesh, collecting data by using GPS can show the different Gas fields, Tea gardens, Mineral resources and other historical and memorable position. Interface this MapEngine to GPS devices, and apply it with pocket PC.

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