An Exploration of WebGIS Based Building Information System

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Abstract: - Geographic Information System (GIS) has developed rapidly since it came into being in the 1960s [1]. In recent years, the geographic industry has seen an increasing interest and activity in the deployment of web sites that provide access to geographic content. In this paper, we model a Building Information System (BIS) based on WEBGIS to help the people to manage the buildings. The BIS collects graphic and non-graphic data related to buildings and then transforms this data to a computer platform, stores, queries, analyzes and presents this data to the user with various formats including texts, maps, and web-based views with the aim of increasing the efficiency and progress of building management. SQL Server2000 DataBase is employed in the system.

Key-Words: - GIS, BIS, WebGIS, Building, Internet.

1 Introduction

In recent years, with the booming of the China economy, more and more multi-storied buildings have emerged in China, especially in the urban areas. Traditionally, to manage a building effectively is a kind of challenging work because the data of the building is complex and tremendous. The typical data of a building includes electricity supply line and equipments, water supply pipe and switches, heating system pipes and switches, etc.

For the maintenance men of a building, in order to ensure the building running normally, they need to know the details of the building like deployment of the equipments and facilities and the routes of the all kinds of lines. Furthermore, if the serious situation happens accidentally, for example, fire or water pipe broken, the quick response of rescue and evacuation is needed in case of emergencies.

In conventional way, these kinds of data are stored in the static files. The typical application is to use AUTOCAD file to keep the data. Undoubtedly, there are many limitations in this way. First and foremost, it is restricted to a location or specific locations and cannot present over the network. If the accident happening, they have to wait the person which holds the documents to find the obstacles; Second, for the maintenance men, they have to learn the relevant software like AUTOCAD and it is a burden for them because of the limitation of knowledge; Finally, to update the document of blueprint is complex and also error-prone because the maintenance men have to synchronize all copies to ensure these files are the same.

For the purpose of solving the above problem, a BIS model is proposed. This paper reviews the related concepts of the BIS, investigates the realization of the BIS and demonstrates the scenario of the BIS.

2 WebGIS Background

2.1 Internet Review

Over the past decades, one of the most significant trends has been taken is that the evolution from individual stand-alone computers to the highly interconnected network environment of today. At the beginning, computers within organizations were connected via Local Area Networks (LANs), allowing teams and workgroups to share information more easily. Then, organizations began to connect their networks in Wide Area Networks (WANs) to facilitate sharing of information across organizational boundaries. Finally, the Internet and WWW created an environment with almost ubiquitous access to a world of information. [2]. Now, the Internet has become an immensely valuable information resource.

2.2 WebGIS History

Before the birth of the Internet, GIS technology, a general-purpose for handling geographic data in digital format, has been applied in various domains

including surveying and mapping, urban planning, land administration, entertainment industries and so on. The tasks of GIS include: preprocessing data into a form suitable for analysis, supporting spatial analysis and modeling directly, and post-processing results [3].

Like other software technologies, initially, GIS was limited to the domain of desktop, workstation and in limited cases, server-based computing platforms.

Eventually, with the exponential growth of the WWW, more domains are open to the GIS applications. The Internet can spread information to a multitude of users, making GIS available to a wider range of public users. The corresponding change of domain users from GIS experts to ordinary users requires the consideration of some new features and design issues for GIS. For example, we have to reconsider the system architecture for Internet usage, focusing on factors such as differing platforms across the Internet, network speed, performance, and so on. One of the major considerations is to make a GIS application accessible to the general public users who have little knowledge of the spatial data, and to allow them to interact with the system to manipulate and retrieve information they need.

2.3 WebGIS Classification

There are many different WBGIS systems on the Internet. Ahmed Shaig defines the types of WEBGIS based on the data source and web page technologies [4]. At the top level, the WEBGIS systems can be divided into two broad categories based on their data source, namely Heterogeneous source and Single source. Single source systems mean that all spatial data are stored in a single web server. In contrast to single source systems, heterogeneous source systems allow spatial data storing in multiple web server.

Furthermore, single source systems can be divided into static pages and dynamic pages according to their different types of web pages (see Figure 1). The key difference between them is that whether the page is predefined or dynamic generated. Static pages are that the browser sends the predefined request to the web server where data has already been prepared. Dynamic pages are that browser sends request to the web server and receives the content which is generated by web server dynamically. Dynamic pages adopts capabilities of procedural languages, server side scripting languages, internet standards or vendor specific GIS and graphics software to achieve it while static pages just requires image maps or vector display plug-ins.

According to whether can provide basic or advanced operation, the dynamic pages are divided into two groups. One group can provide simple operations like layer overlay, visualization, distance and location calculation. Another group of dynamic pages can provide senior operations like querying spatial data using spatial operators. Many companies migrates the advanced capabilities from their conventional GIS to WEBGIS which can provide advanced feature by using software package or middleware.
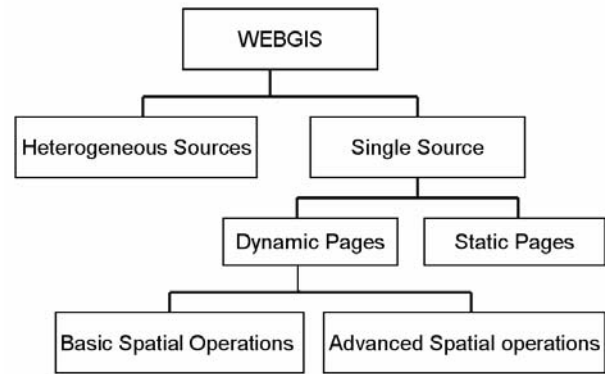

Fig 1. WEBGIS Classification

2.4 WebGIS Architecture

The general architecture of WEBGIS is illustrated in Figure 2. Web clients like IE or Netscape and server communicate across a computer network either on Internet or Intranet by means of a HTTP. A web browser is a general purpose program. The browser sends a request to the server and finally a file is transmitted from the server to the client by means of Uniform Resource Locator (URL). To transfer information between clients and server runs on an open protocol-Transmission Control Protocol/ Internet Protocol (TCP/IP) upon networks.

If the client wants to see an ordinary web page, the process is described as follows:

Firstly, a client sends a request to web server. Secondly, the web server sends a request to database server and receive the response from data server. Finally, the web server generates a page dynamically and transfers this page to client end.

Otherwise, if the client wants to see web map page, the process is described as follows:

Firstly, the browser sends the request to the web server. Secondly, web server forwards this request to the map application server, and the map application server sends a request to database server. Thirdly, the map application receives spatial data from database server and then generates a map. Finally, the web

server assembles the map with other html elements together to form a page, and transfer this page to the web client.
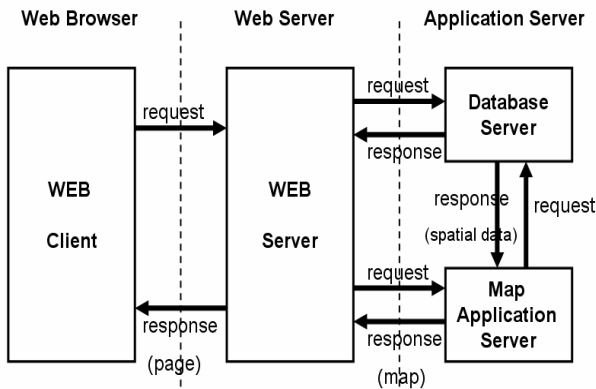

Fig2. WebGIS architecture

2.5 WebGIS Middleware

There are a number of leading WEBGIS middlewares such as ESRI's ArcView IMS(Internet Map Server for ArcView), MapObject IMS and ARC IMS, MapInfo Corporation's MapXtreme, Autodesk's MapGuide, Integraph's GeoMedia WebMap and so on. These middleware are used to manipulate and view different spatial data worldwide. Also, in recent years, China has also emerged several successful GIS venders like SuperMap, MapGIS [5]. All of these applications make use of the geographical data and the multimedia tools for animation, simulation, and visualization purposes by web browser.

Most of these middlewares are software packages provide a conceptually similar method to create a web based GIS. On the server side, a Map Server is used to perform various advanced spatial operations. The client side most of the times consists of a viewer that can be used in a web browser that will communicate with the map server and manipulate the visualization process. With the help of these packages, developers can easily implement the web-based GIS applications.

3   BIS Realization

This section will show how the BIS can be implemented by using standard internet techniques and WEBGIS packages, also introduce the modules of the BIS system.

3.1 Platform Introduction

In this project, MapXtreme2004 for NT is adopted as WEBGIS middleware on the Windows2000 Server. MapXtreme2004 for NT is an ideal WEBGIS package which is seamlessly combined with

Microsoft Visual Studio .NET environment, and it is able to develop either customized web or client-based applications within a single development toolkit (see Figure 3) [6].
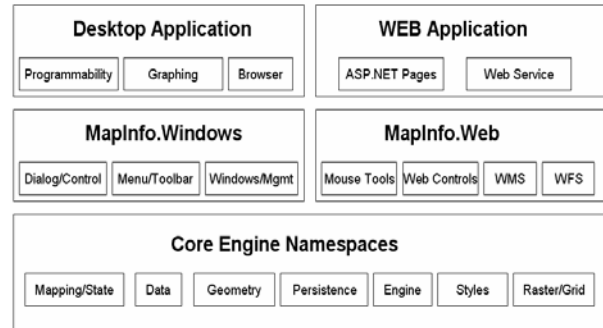

Fig3. MapXtreme2004 for NT Architecture

MapXtreme2004 also contains support for the Open GIS Consortium specifications like Web Map Service (WMS), Web Feature Service (WFS) and Geography Markup Language (GML 3). The details of the BIS system are described in Table 1.

Operating System	Windows2000 Server
Web Server	IIS 5.0
WEBGIS Middleware	MapXtreme2004 for NT
Development IDE	Visual Studio .Net
Developing Language	C#
Database	MapInfo Data Table
WEB Client	IE or Navigator

Table 1.Details of BIS Architecture

3.2 BIS Sub-Systems

According to functions, a complete BIS system consists of many sub-systems. In this project, we divided the BIS system into eight sub-systems (see Figure 4). In each sub-system, it includes equipments and pipes or lines. For example, the Lighting Sub-System includes the following properties: Lighting Switches; Lighting Equipment; Lighting Lines; Cable Channel.

In the BIS system, each sub-system will be presented as a layer, and each category of a sub-system like equipment or line will be displayed as a sub-layer. For each sub-layer, it has both spatial and non-spatial data. Spatial data is used to display the geographic information like location, distance calculation, etc. On the other hand, non-spatial data is used to represent the property of the element in the map like vender information, text introduction, installation date, etc. More details about these data are introduced in section 3.4 and 3.5.
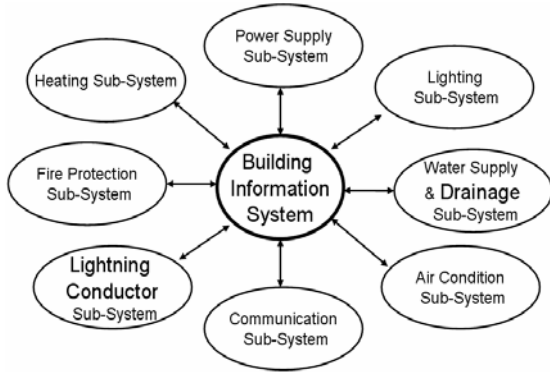
Fig4. Sub-Systems of BIS

3.3 BIS Functions

The main functions of BIS system are divided into five categories and listed bellow:

(1)Basic Operations include map scanning tools such as zoom out, zoom in, move map, and spatial measuring tools as distance, area.

(2)Layer Controlling Tree is used to control whether a layer is added to display. This tree is generated automatically corresponding to the sub-systems categories. It is easy to load the layer by select the relevant checkbox.

(3)Property Querying is used to query the non-spatial data in the map. For instance, if you want to know the vendor information of an electricity switch, just click this switch in the map and you will see the detailed information about it including vendor information. This feature is very useful for maintenance men because they want to know more about the facilities inside in the building. Furthermore, this kind of non-spatial data could be used for the use of Decision Support System (DSS) to extend the current functionality.

(4)Error Analysis is used to trace the error when the equipment runs wrong. For example, the air condition which is in Room1201 at 12th floor doesn't work. After examination, the maintenance man confirms that because of no power supply, so he wants to know where the power should be from. Then he logon the BIS system, locate the exact place of that air condition in the map, uses Upper Node Search function and finds the error place.

(5)Other Operations are general website operations such as Roles Management, Statistical Report as well.

3.4 Spatial Data

The BIS graphic data includes Heating Sub-System, Power Supply Sub-System, Lighting Sub-System, Water Supply and Drainage Sub-System, Air Condition Sub-System, Communication Sub-System, Fire Protection Sub-System as well as Lighting Conductor Sub-System.

In China, it is necessary to design the architectural drawing by Architecture Design Institute before the building project starts. These architectural drawings are always Atutocad-based files. For the purpose of reusing these data, the geographic data was transformed from Autocad DXF format files to MapInfo format files.

During the transforming process, the original layers in DXF format need to re-arrange. For example, the standard for layer classification is not well-defined in Autocad files, it is needed to delete the unnecessary layers or combine the close-relationship layer or add new layer. Finally, the geographic data is generated and stored in specific MapInfo files.

3.5 Non-Spatial Data

One of the key advantages of GIS system is that it can provide property fetching. The non-spatial data is used to represent such property of an element which is in the map.

In BIS system, they are many kinds of elements within different layer. The BIS system is divided into eight sub-systems. Each sub-system is also divided several items depending on their features. For instance, in a Heating Sub-System, there are four kinds of items which are shown in Table2.

Sub-System	Items Classification
Heating Sub-System	Horizontal Tube
	Valve
	Vertical Tube
	Radiator

Table 2.Categories of Heating Sub-System

For each item, a table is needed to store its non-geographic features. When the web server receives the requests from the client, it fetches the results from the data table, generates a gage by these results and backward this page to client. A sample table for non-spatial data is defined in Table 3.

Table name: Heating_Valve

Field	Data Type	Length
itemid	varchar	12
name	varchar	20
class	varchar	20
vendor	varchar	50
type	varchar	20
elevation	float	8
interface	varchar	20
produceno	varchar	12
producedate	varchar	8
installarea	varchar	20
picture	varchar	20
memo	varchar	100

Table3. Data type of Valve table

3.6 Layer Control

Maps are made up of layers. Layers contain map features, such as postal code boundaries, schools, or streets networks. There are over 38 layers in BIS system. These layers are grouped by sub-system (see Figure 5).

The bottommost layer is drawn first and the topmost layer drawn last [7]. In the map of each floor, the lowest layer contains the map background including basic map, room name, scale, distance number, etc. The above layer depends on what kinds of layers are chosen.
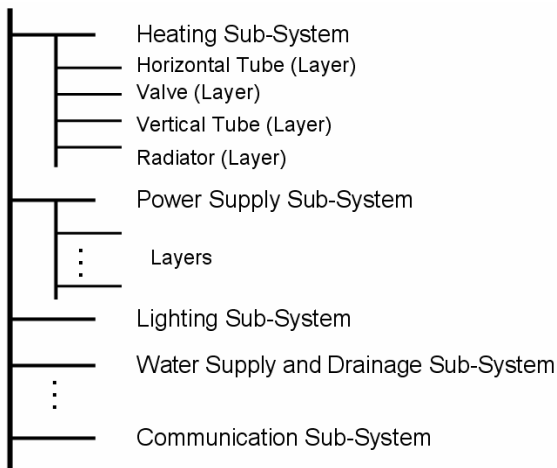

Fig5. Grouped layers of BIS

For the purpose of loading layers to a map dynamically, the following steps are needed.

Firstly, each FeatureLayer object is corresponding to a layer and its spatial data is from the .TAB table [7]. Whether this layer will be or not loaded is determined by checkbox status at navigation area. Secondly, each map is a collection of the FeatureLayers represented by the Layers class. The order in the collection is the order in which the layers are drawn. After layers are chosen, the map is generated. In the program, Add, Insert, Move, and Delete Methods are used to manipulate the map to load layers.

4   Application Scenario

This section describes some scenarios in which the BIS system could be used in order to shed some light on what the maintenance men can expect to see.

4.1 Querying Spatial Information

A maintenance man is looking for water supply pipe in the Room501, 5th floor after he received an emergency report that the room's water pipe was broken. He must find the exact beak-down place immediately and then repair the trouble.

Through BIS system, it is easily to solve above problem. Firstly, the maintenance man need login the BIS system using his account and password. The system then forwards the user to main page if the input information is valid. Secondly, in the navigation area, he clicks the 5th floor in the dropdown list and selects the Water Supply and Drainage Sub-System in the checkbox list. The map will automatically be loaded (see Figure 6). As all of the information is presented on one interactive map to the man, the decision of where to fix is easy. Therefore, the maintenance man can recover the normal state quickly.
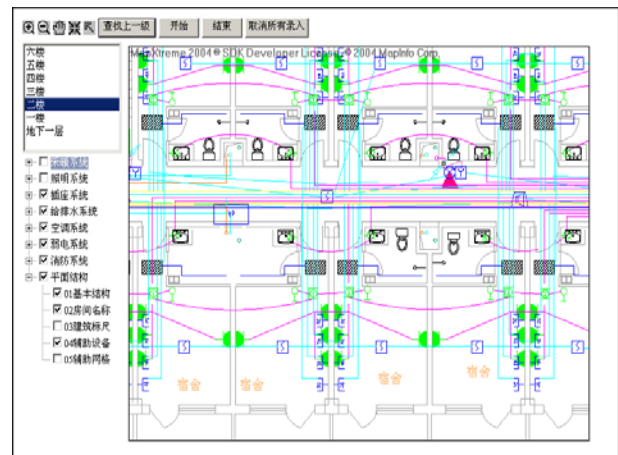

Fig6. Spatial Map with multiple layers

Obviously, the BIS system lets the maintenance men on various platforms interact with the system at

different places, exploit spatial data of their interest, and issue queries to retrieve information they need. Another benefit is that the users are without the need for extensive training with the system, thus avoiding a painful experience.

4.2 Querying Non-Spatial Information

One of important benefits of BIS is that it can provide non-spatial data operation. Non-spatial data is to represent the properties of each element in the map. For instance, if a maintenance man wants to query the installation date and the vendor information of an electricity switch. Firstly, he should follow by the steps described in section 4.1, then select the floor and sub-system options and the then map is generated. Secondly, he click the switch, the properties of this switch are shown in the property table lying in the bottom area of the page (see Figure 7).
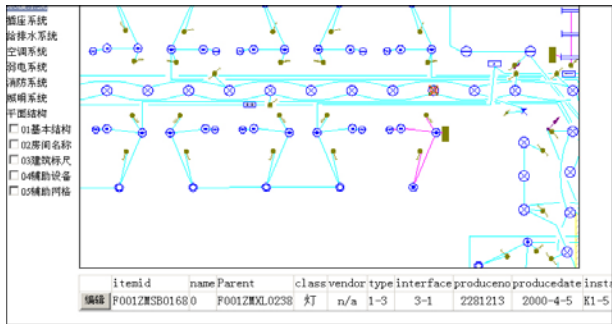

Fig7. Non-Spatial Data of an element in the map

In addition, if user wants to update the non-spatial information, he can input the latest information and submit them. The non-spatial data table will update easily.

5 Conclusions

This paper describes a work in constructing an MIS model. The first prototype has already been designed and implemented for the Overseas Student Building in China Petroleum University, Beijing. This prototype has been intensely evaluated. The second prototype will be designed and implemented by adding Spatial DSS to MIS model, and also will migrate the data from the current format to spatial database. In the second stage, we will also concentrate on solving the problems like performance and response delay resulting from the first prototype. The final version will show the success of implementing the system in different buildings.

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