

## Organizing and Managing of Distributed Geographical Information

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**ABSTRACT** The development of Internet provide convenient environment for information searching and browsing. It also offers a new platform for geographic information processing and analysis. This paper discusses organization and processing approach to Internet geographic information, and provides a new method to cross-platform and distributed geographic information and its software implementation. The example is used to show the practicality and superiority of this method.

**KEY WORDS** GIS;distributed;Internet

### 1. Introduction

With the development of Internet, especially the development of Wide World Web (WWW) technology, the distribution, searching and browsing of information has had a revolutionary change, no matter with which format or by which means, which has brought great convenience for human beings. Various industries related to information have managed to run their corresponding information system on WWW (Badget, 1995; Strand, 1996b). After years of efforts and reconstruction, relational database management system is gradually adapting to the requirements of the development of Internet technology. At present, most commercial relational database management systems can run on the Internet (Zhuang, 1997; Oracle, 1997). Web GIS or Internet GIS is an important orientation for the development of the current GIS (Coleman, 1997; Evans, 1996; Peng, 1997&1998). There are several directions for the development of GIS, in which the open system based on Internet, that is, Internet GIS, is the most important one (Korte, 1997).

WWW has got three remarkable advantages (Lennon, 1997; Hall, 1996). One is the friendly interface. The current popular WWW browsers, either Netscape Communicator or Microsoft Internet Explorer, are not only of high visibility, but also easy to learn and operate. The second is the multi-platforms and their easy linking. On the WWW, you may browse information from different types of computers or different operating systems. When people are browsing the information, what they care for is just the address of the website. They need not care about that which platform or operating system the information comes from. Moreover, it is quite easy to link different platforms. Third, the most remarkable advantage is the hyperlink. When people are distributing information and making Homepages, they just need to link the website to the corresponding hypertext markup word according to the Hypertext Markup Language (HTML) grammar (Berners, 1994). When users are

browsing the homepages, they can go to another homepage by clicking mouse to activate the hypertext markup word. The other homepage may be from a different place, even from a different country. This is a prominent characteristic of distributive information.

In recent years, software manufacturers of GIS are accelerating the development of GIS based on WWW. They promote their productions one after another. For example, MapGuide of Autodesk Company, MapObjects IMS (Internet Map Server) and ArcView IMS of ESRI Company, GeoMedia Web Map of Intergraph Company, Proserver of MapInfo and so on (Limp, 1997). According to the technology foundation and developing orientation of each company, some have adopted Common Gateway Interface (CGI), such as MapObjects IMS, ArcView IMS, MapInfo and Proserver. Some have adopted Plug-in mode, such as MapGuide, Geomedia Web Map. They can all run on the WWW browsers. However, they have not adopted hyperlink technology. Thus, they are restricted in organizing and managing of the distributed geographical information.

This article first introduces the conception of organizing and managing of distributed geographical information. Then it discusses the implementation method of multi-platforms and distributive GIS. At last, Internet GIS- GeoSurf developed on the basis of this idea and its application instances are to be illustrated.

### 2. The Conception of Organizing and Managing the Distributed Geographical Information

Distributed Geographical Information (DGI) means the geographical information distributed by means of various formats on the Internet with the WWW technology, such as, maps, images, data set, analytical operation and reports and so on (Plewe, 1997b & 1996). The current application modes of DGI include downloading the original data,

browsing the static images and dynamic images, browsing the metadata index, the query and analysis of geographical information based on WWW and intelligent network GIS. DGI now is still in the phase of developing (Plewe, 1997a).

Geographical information possesses the characteristic of regional distribution, so the occurrence of distributed organizing and managing of geographical information is very natural. Geographical information relates to two aspects of distribution. One is the plate distribution, which is something like the two-dimensional distribution of maps. For example, a Chinese map involves provinces and municipalities. According to the concept of WWW, if the Chinese map is the homepage, it involves the essential fundamental information of the country and provinces. Make each province of the map the Hypertext markup words. Link the markup words to the webpages of those provinces by means of the relevant web addresses. Thus users can query the information of the sub web addresses of the map. Searching in this way, users can get the information of a certain county or town. By means of the hyperlink, users can index and query information of different places and layers from wide to narrow on the map.

The other is the vertical distribution. A map based on the same scale may have geographical information at different layers. For instance, a city GIS includes multi-layers of geographical information of real estate management and pipelines under ground. Geographical information at different levels may be collected and maintained by different departments. Therefore, the database servers may be distributed in different departments with different web site.

Out of question, these two kinds of distributions

both relate to the problem of distributed organizing and managing of geographical information. Each department of each region establishes and maintains their own systems. These systems are linked by hyperlink for users to cruise and navigate, index and query relevant geographical information among different systems. There is off-the-peg technology to establish GIS of various regions and departments. At present, the key problem is how to establish a navigational hyperlink that can directly enter another system by means of markup words or figures.

In addition, there are other problems to be settled. One is the expression and relating of multi-scaled map. The scales of GIS for a country and for a city are obviously different. How to coordinate is a problem to be studied and settled. The second is that information of different layers may be integrated for browsing. This is not as same as the browsing of a common homepage. In the process of browsing homepages designed by HTML language, when entering the next webpage, the previous webpage has been turned over. However, the integration of geographical information of different layers needs to display geographical information acquired from different web sites in the same window interface of the same webpage. The third is multi-platforms. The establishment and maintenance of GIS generally adopts the ready-made software. These systems may use different platforms such as image workstations or PCs, different operating systems as Windows, Macintosh or UNIX packages and different software packages as Arc/ Info, MapInfo and GeoStar. How to work harmoniously on the Internet is a big difficult problem. This is in fact a problem of information management of multi-platforms. The next section

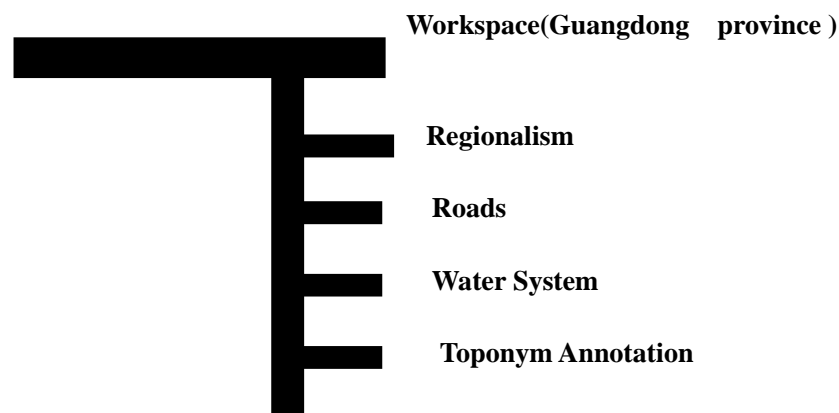


Figure 1 The Tree Structure of Workspace and Layers Information of GeoStar

will discuss the implementation method of distributed organizing and managing of multi-platforms geographical information in detail.

### 3. Organizing of Distributed Geographical Information

The organizing of DGI is the same as the common geographical information, according to a website. The supporter and maintenance man of the geographical information data may establish a project or a workspace on the database server. These data are organized according to their own software. Take GeoStar as an example to introduce the spatial data organizing of a workspace. Suppose that Guangzhou Geography Institute is a network node. Its database server has installed the district map of 'Guangdong Province' which includes important feature class layers as regionalism, roads, water system, toponym annotations. Figure 1 shows the tree structure of GeoStar's workspaces and layers information.

This figure is completely accordant to the conceptions of workspaces, projects and feature class layers of GeoStar. In fact, the basic data structure of Internet GIS-GeoSurf of GeoStar package is the data structure of GeoStar NT. Thus, we can establish our own workspaces in Fushan,

Dongwang, Shenzhen and so on. The key problem is how to join the GIS Spatial Databases established in different places and with different software packages.

It is required that Spatial Data Service Directing Department of each region provides the domain name addresses, the software to establish the database, the map range and projection information of the server for the spatial database. According to the workspace at provincial level, the geographical information workspaces of each region are considered as the sub objects. A kind of hyperlink is established by establishing a relational table. Generally speaking, the range and name of cities in each province and territory are presented in the provincial map. Thus, the name or polygon of cities can be taken as the node of the hyperlink. A relational table of the hyperlink is established, as Table 1 shows:

If double click the position of Shenzhen on the provincial map, the system will contact the domain address and data structure of spatial data of its sub node. Then the system will start up the corresponding data acquiring software or component to pursue more detailed information about Shenzhen. However, sometimes users do

Table 1 Hyperlink of Distributed Geographical Information

| Object ID | Description | Geographical Range | Super Object Domain Ad. | Data Acquiring Software/Component | Sub Object Domain Ad. | Data Acquiring Software/Component |
|-----------|-------------|--------------------|-------------------------|-----------------------------------|-----------------------|-----------------------------------|
| 12        | Fushan      | (x1,x2,y1,y2)      |                         |                                   | Xx.xx.xx.xx           | ArclInfo                          |
| 13        | Shenzhen    | (x1,x2,y1,y2)      |                         |                                   | Xx.xx.xx.xx           | GeoStar                           |
| 14        | Dongwang    | (x1,x2,y1,y2)      |                         |                                   | Xx.xx.xx.xx           | MapInfo                           |
| 15        | Zhanjiang   | (x1,x2,y1,y2)      |                         |                                   | Xx.xx.xx.xx           | GeoStar                           |
| ...       | ...         | ...                | ...                     | ...                               | ...                   | ...                               |

Table 2 Sub Hyperlink of Distributed Geographical Information

| Object ID | Description | Geographical Range | Super Object Domain Ad. | Data Acquiring Software/Component | Sub Object Domain Ad. | Data Acquiring Software/Component |
|-----------|-------------|--------------------|-------------------------|-----------------------------------|-----------------------|-----------------------------------|
| 201       | Fu Tian     | (x1,x2,y1,y2)      | xx.xx.xx.xx             | GeoStar                           | Xx.xx.xx.xx           | ArclInfo                          |
| 202       | Luo Hu      | (x1,x2,y1,y2)      | xx.xx.xx.xx             | GeoStar                           | Xx.xx.xx.xx           | GeoStar                           |
| 202       | Bao An      | (x1,x2,y1,y2)      | xx.xx.xx.xx             | GeoStar                           | Xx.xx.xx.xx           | MapInfo                           |

not think that the city map is detailed enough. They want to get information of towns or counties and even administrative regions. A sub spatial database can be established at the time. Then a hyperlink at the county level can be built on the city map. As Table 2 shows, it is a sub map related to the city map of Shenzhen. We may search for more detailed information step by step with this hyperlink.

**4.Implementation of Distributed Geographical Information**

It should be said that the technology to establish distributed geographical information system (DGIS) on the Internet is mature. It is easy to realize the navigational query among any homepages similar to the hyperlink, if a unitive GIS software is adopted and a hyperlink between nodes and sub maps is established.

However, GIS and hyperlink is different. Hyperlink has restricted regulations and adopts HTML language. Homepages established according to the regulations and HTML language is easy to achieve navigational query with the hyperlink. However, there are no unitive regulations for GIS. Even the data structures differ from each other. As a result, the problem to establish DGIS is the mutual linking among data of different structures (Wilson, 1998). So as to settle the problem, the GIS software industries in U. S. A. and Europe are discussing and drafting "Open Geodata Interoperability Sophistication" (Buehler, 1996; OGC, 1997). According to the distributed component principles, it

has drafted a set of protocols and functionstandards of spatial data interoperations. If this set of protocols and functions is implemented, geographical information data stored by different software can be manipulated. However, this set of protocols is quite complicated, which still has a long way to go.

Another scheme to manipulate the spatial data of different structures is to redact functions, COM or components that can directly read the spatial data structure. There is no external data structure for the Internet GIS. However, the Internet GIS can read and input spatial data stored by various GIS software packages into its own memory so as to carry out operations as displaying, query and cartography. It is required to learn about the data structure and data organizing mode of various GIS software. Moreover, it is required to acquire the legal permission to read the data structure. In addition, when organizing the data structure memory, a strong compatibility is needed. It is necessary to take data with both topological and non-topological relations into consideration.

When writing software and creating software components, it is promoted to redact software with distributed components, especially the component that can read and write spatial data. In the organizing of DGIS, according to the Internet GIS, the software of spatial database is different only means that the spatial data structure is different. That is to say only the software to read and write this data structure is different, while memory

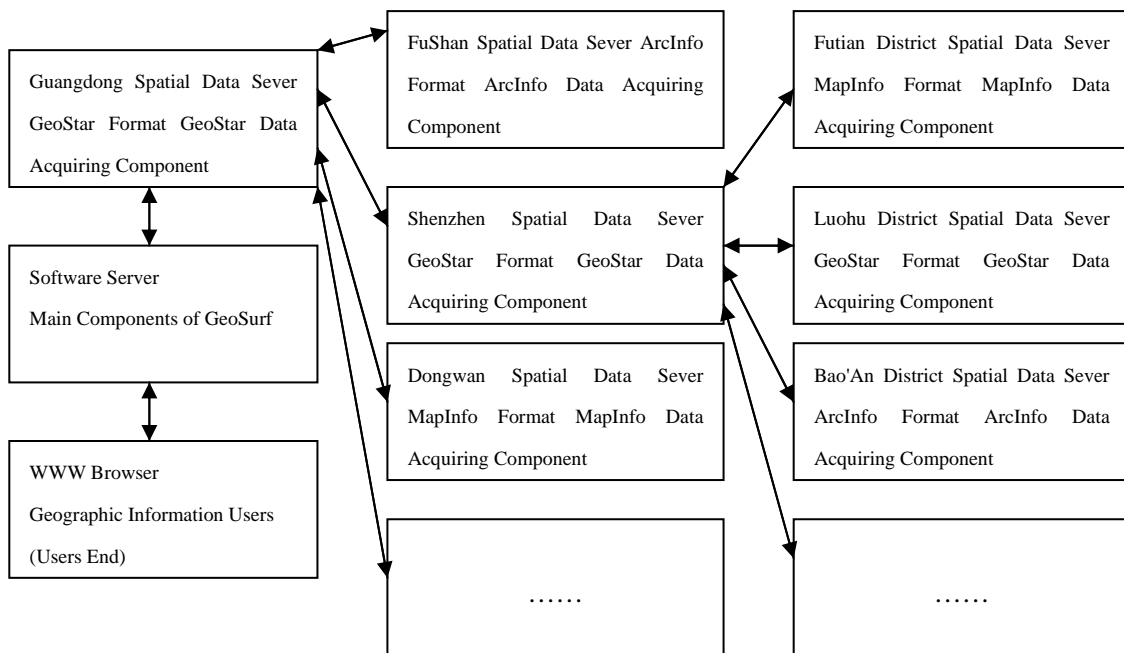


Figure 2 The Distributed Information and Organizing Structure of the Distributed Components

management, graph displaying, spatial query and special cartography are the same. At this moment, the software that reads and writes spatial data is designed to be the distributed software. And the software is even stored with the relevant spatial data. If it is required to use the data, start up the component to read the spatial data and transmit the result to the users' end. It is obvious that the distributed component has decreased the transmission pressure of the network, and the burden of users' computers to acquire spatial data of various formats as well. Figure 2 is a sketch map of DGI and organizing structure of the distributed components.

### 5. Instances and Conclusion

In the light of the above ideas, we have developed an Internet GIS software of multi-platforms distributed geographical information named GeoSurf. This software is written in Java language. It can be operated in platforms of different operating systems and GIS software. It adopts the distributed component object model (DCOM) to read data of various GIS software. It adopts the organizing mode of DGI to link maps of different scales and carry out navigational spatial query, cruising and cartography. Figure 3 is a world map. Double click China on the world map, the Chinese map will be displayed (Figure 4). Double click the Three Gorges Area on the Chinese map, the map of Three Gorges Area will be displayed (Figure 5). Each map can carry out query and special cartography respectively. Certainly, if the projection system is accordant to the coordinate system, they can be overlapped to display and query.

Since the current speed of Internet is rather slow, different users can acquire information of different levels if they adopt the DGI management. Moreover, this kind of navigational query is much similar to the query on WWW homepages that people are accustomed to. People can roam in the DGI.

On the other hand, the organizing of DGI has turned its integrated management and maintenance of Geospatial data to the distributed management and maintenance. As a matter of fact, with the accelerating updating speed of geographical information, the integrated management is hard to adapt to the circumstance. For example, the social economy requests that the geospatial information of Comprehensive GIS of social economy change monthly. It is impossible for one department to manage and maintain the social economic information from the Central Government to a county and a town. Each department should take its own responsibilities. Each area and department take in charge of the updating and maintenance of

the data in their own database, and adopt the organizing and navigational query of DGI. Any user can find the geospatial information of the social economy in each area rapidly.

The Internet technology provides the establishment of DGIS with technical foundation and platform environment. In the practical application, the main problem to be settled is the mutual operation of data with different data structures. The Internet GIS- GeoSurf in the GeoStar family introduced in this article has had a successful attempt in the organizing and managing of DGI and has presented a favourable application prospect.

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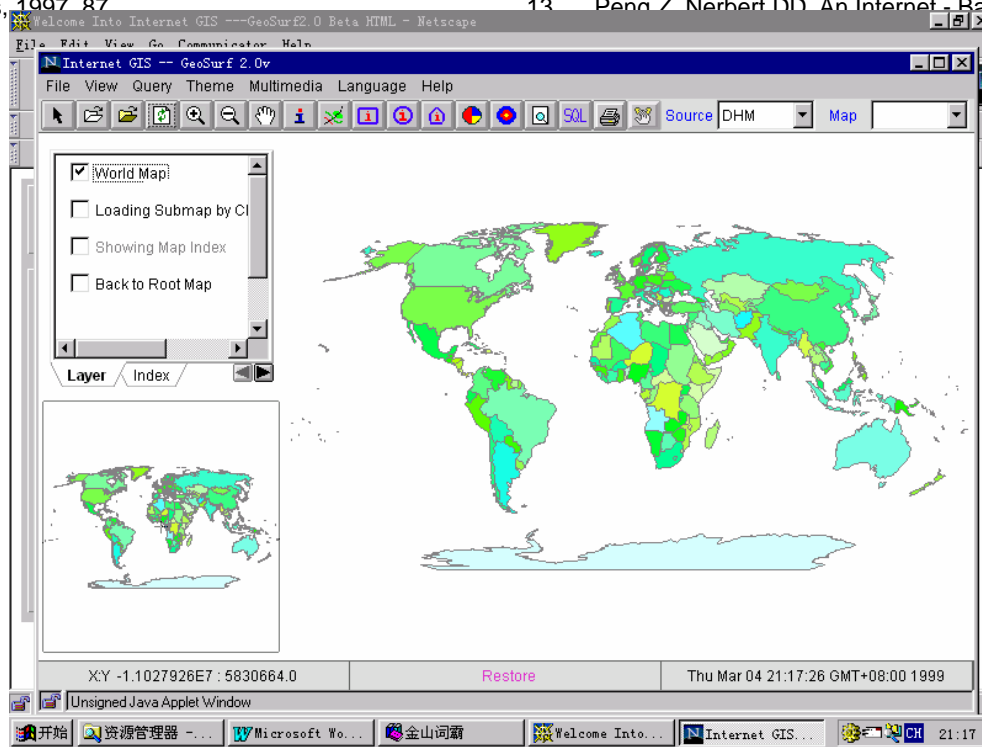


Fig.3 Map of World

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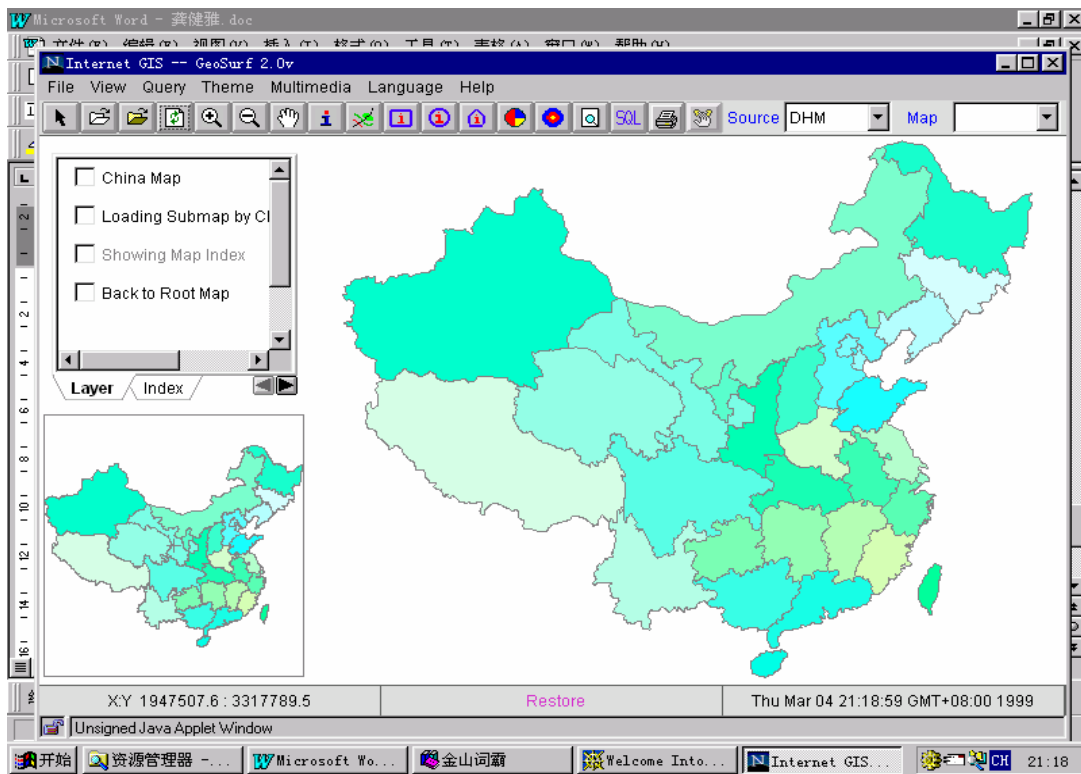


Fig.4 Map of China

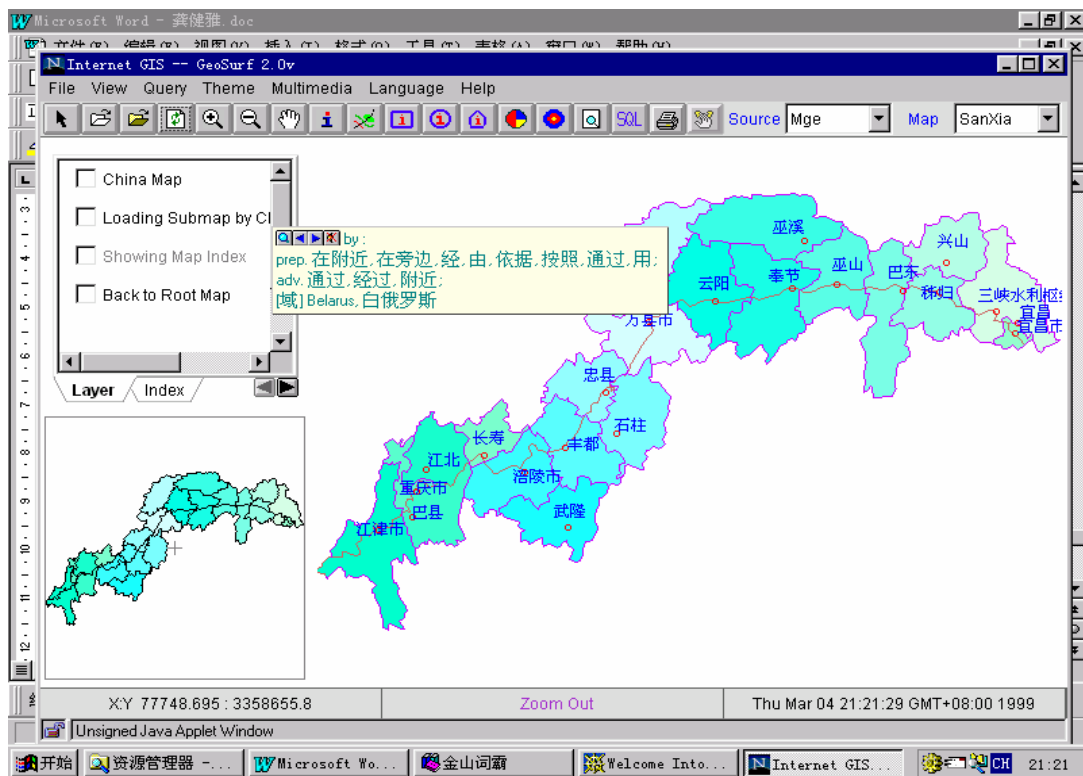


Fig.5 Map of Three-Gorges