

THE STUDY AND DESIGN OF GEO-SPATIAL METADATA MANAGING SYSTEM BASED ON USDI

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ABSTRACT:

Firstly, the paper presents the concepts of USDI and spatial metadata. Then after analyzing the existing spatial metadata managing systems, a mode of building distributed spatial metadata system is described and proposed according to the requirements of construction of USDI and our engineering practices. The system adopts XML as descriptions of metadata standard and three-layer B/S structure as basic framework to provide a more flexible and efficient query mechanism for distributed metadata repositories. Finally, the paper presents the design and realization of the spatial metadata managing system which introduces the total system design scheme and confirms its feasibility in the construction of USDI sharing and changing platform of "Digital Hefei".

1. INTRODUCTION

Along with the increasing volume of vast resources of geo-spatial data, GIS users need a mechanism to efficiently search for available geographic information and to openly share this information. The NSDI, or National Spatial Data Infrastructure, is proposed. The NSDI aims to promote and establish an infrastructure at the national level for the availability of organized spatial (and non-spatial) data and multi-level information networking to contribute to local, national and global needs of sustained economic growth, environmental quality and stability and social progress. The USDI, or Urban Spatial Data Infrastructure can be seen as the implementation of NSDI on the scale of city.

In the USDI framework system, metadata is the precondition and basic guarantee of realizing sharing of geo-spatial information and becomes an important component of USDI already. Metadata is the data about the data. It is the resume of geo-spatial data, describing such information as availability, accessibility and transferability of any geo-spatial data (Tschanho John Kim, 1999). It allows a producer to fully describe a dataset, so users can understand the assumptions and limitations and evaluate the dataset's applicability for their intended use. At present, spatial metadata becomes the key to bridge the heterogeneous environments of distributed GIS databases and services and to provide users with the semantics and syntactic of GIS databases.

Along with extensive and effective uses of spatial metadata, more and more institutions and organizations home or abroad have formulated spatial metadata standard. The objective of spatial metadata standard is to provide a common set of terminology and definitions for the documentation of digital geo-spatial data. Nowadays, a number of metadata standards are being used or are being proposed world widely (Tschanho John Kim, 1999). Each has been developed for a specific purpose and has certain common as well as unique elements. Federal Geographic Data Committee (FGDC) and International Organization for Standardization (ISO) Technical Committee 211 (ISO/TC211) are two most common and famous metadata

standards in the world. Besides, there are Dublin standard and International Institute of Electrical and Electronics Engineers (IEEE) standard.

As we know, metadata just describes the contents of data. With the advent of computers and our incessant needs for data (Arun Sen, 2004), a mechanism which can organize and manage metadata is necessary. We call it metadata managing systems, which are built for searching, indexing, and retrieving metadata. After analysis of the existing metadata managing systems, however, we found that they are not suitable for the construction of USDI. This objective of this paper is to study this field, analyze existing metadata managing systems and put forward a new metadata managing system with its practical application in construction of USDI in "Digital Hefei".

The paper is composed of 4 chapters. Firstly, the paper presents the concepts of USDI and metadata. Then it analyzes the existing metadata managing systems. Second, according to the requirement of construction of USDI, a mode of building distributed spatial metadata managing system, which adopts XML as descriptions of metadata standard and B/S as basic framework is described and proposed. The third section is the design and realization of the system that introduces the total design scheme. Finally, we conclude the paper in section 4.

2. KEY TECHNIQUES

2.1 Metadata Standard based on XML

After examining of the present managing systems, we found that most of them only support several special metadata standards. For instance, users can search and obtain metadata whose standard is FGDC by Clearinghouse. ArcGIS systems also only support FGDC and ISO standards. However, these standards don't suit the construction of USDI (Chang Yuan-fei, Wang Wei, Sun Jin-yue, 2003). It is known that spatial metadata commonly have a great many items and complex interior relationship. As a result, it is impossible to formulate a unified spatial metadata standard, which can sufficiently satisfy various

geographic information industries (Gu Wei, Chen Tian-zi, 2003). At the same time, a great number of city departments always formulate their own metadata standards due to various application needs. As a result, the metadata managing system is supposed to support different metadata formats, including common metadata standards and formats defined by users. Accordingly, XML is proposed to describe metadata standard to ensure the system's flexible configuration.

XML is the Extensible Mark-up Language. It is designed to improve the functionality of web by providing more flexible and adaptable information identification. It is a powerful tool for data representation, storage, modelling, and interoperation. XML provides a format of describing structured data, allows users to establish their own tags and endow them with different semantics. This trait enables users to use existing metadata standards directly without different meanings (Gu Wei, Chen Tian-zi, 2003). Moreover, users can define their own metadata standards and don't have to worry confusion between users' tags and others'. Since the name, meaning and content of each tag are related; it's easy to understand the meaning of XML file through descriptions of tags.

Establishing an XML file is very easy. It is usually composed of declaration, elements, notation, character citation and processing explanation. Below is a part of an XML file describing FGDC standard. Figure 1 illustrates its structure.

```
<?xml version="1.0" encoding="UTF-8"?>
<metadata desc="metadata">
  <idinfo desc="identification information">
    <citation desc="introduction">
      <citeauthor desc="author"></citeauthor>
      <resdesc desc="data source description"></resdesc>
      <citedate desc="publication date"></citedate>
      <citetitle desc="title"></citetitle>
    </citation>
    <descript desc="description">
      <abstract desc="abstract"> </abstract>
      <purpose desc="purpose"></purpose>
    </descript>
  </idinfo>
</metadata>
```

The first row of that file is the declaration, which must be at the beginning of file. The parser of XML will read this row and acquire the method of coding. Below the first row is a structure of FGDC standard. These tags have beginnings and ends, like (<tag></tag>) (Sun Xiao-li, Zhao Li, 2001). We call this file well-formed XML.

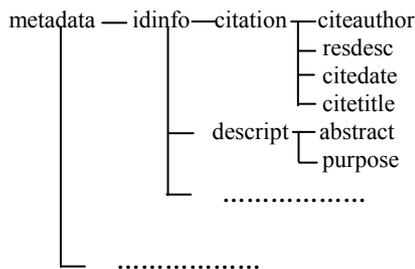


Figure 1. The structure tree of FGDC metadata standard

To handle XML file, XML parser is indispensable. We adopt DOM (Document Object Model). DOM is programming interface criterion of HTML and XML document, which offers methods of accessing, keeping and getting XML document. Making use of DOM, we can break down XML document to the distinguishable elements, lay out them as tree structure, and achieve the addition, deletion and motion of them. Consequently, we can change metadata standard randomly by changing the elements of XML document. Figure 2 is the display of FGDC standard in JSP web page.



Figure 2. Display of FGDC metadata standard

Making use of XML as descriptions of metadata standard, we can achieve flexible configuration of the metadata managing system. But in the practical applications, the storage and management of mass data usually depends on relational database management systems (YU Hai-yan, ZHOU Shun-ping, 2002). Therefore, we still storage, manage and maintain spatial metadata by using well-rounded structured relational database management system. We build reasonable mapping between XML and relational database by setting up suitable database structure. The database structure of metadata standard and metadata document is designed like this:

FIELD NAME	VALUE TYPE	MEANINGS
TAGID	NUMBER	Tag identification, primary key, e.g. citeauthor's tagid is 4
TAGNAME	VARCHAR	Tag name ,e.g. citeauthor
PARENTTAGID	NUMBER	Parent tag identification, e.g. citeauthor's parent tag is citation, whose parent tagid is citation's tagid
TAGTYPE	VARCHAR	Tag type, e.g. string, data etc.
TAGDEPTH	NUMBER	Tag depth
⋮	⋮	⋮

Table 1. Standardtags-Metadata Standard Tag Table

FIELD NAME	VALUE TYPE	MEANINGS
DOCUMENTID	NUMBER	Metadata document identification, primary key
TAGID	NUMBER	Tag identification
TAGVALUE	VARCHAR	Tag value,

Table 2. Metadatacontent-Metadata Document Table

At table 1 Standardtags, we build up tags' hierarchy by tagid and parent-tagid. By altering the value of each field in table 1, we can randomly alter metadata standard information. Table 2 is a metadata document table, which is associated with table 1 by tagid. It stores each tag's value, for example, citeauthor's tagvalue stores the author information of metadata document and citedate's tagvalue stores the publishing date information.

In a word, we adopt XML as description of metadata standard to achieve the flexible configuration and well-rounded structured relational database to storage metadata, realizing the efficient management of spatial metadata.

2.2 Distributed Metadata Management

Another problem with existing metadata managing systems is the poor management of distributed metadata. Along with the widespread applications of terrestrial geodesy, photogrammetry and satellite remote sensing, the various departments in cities have accumulated a large amount of spatial data chronically. However, these data are dispersed in different departments so that they lack unified and centralized management. On the other hand, the construction of USDI of digital city is related to a great deal of different sub-systems, whose database has its own metadata. As a result, it is impossible for the collection、modification in single machine. Hence, how to manage distributed spatial metadata is a problem which urgently requires solving. Meanwhile, the information sharing based on Internet does not set apart providers and users. Any user in Internet can submit his data to the special server on the basis of prescribed format, share them commonly, and establish his own metadata database after acquiring relevant purviews. Thus, the management of metadata is not aimed at fixed groups, but is a dynamic, network oriented and open management pattern (WU Hong-qiao, HE Jian-bang, CHI Tian-he, 2003).

Based on above analysis, B/S structure, one of widely applied ways in web development, made up of three layers: Browse/Server/Database is proposed. Currently, one calculation pattern of B/S structure is based on JAVA and J2EE.Compared to C/S structure, B/S structure has many advantages such as friendly user interface, direct operation, convenient protection and updating, fine extensibility and supporting different databases. It's noticeable that B/S is based on the network service through Internet or Intranet. As a consequence, the security of data becomes especially important. The use of fundamental geography data has certain restrictions and their metadata are sometimes secret. So establishing effective limits of authentication is a good solution. We divide the limits four levels: metadata browsing, publishing, managing and system managing. Certain limit level corresponds to certain service and

any manipulation should be validated to maintain the security and reliability of system.

3. DESIGN AND DEVELOPMENT OF THE METADATA MANAGING SYSTEM

3.1 Structures

Based on our theory research and engineering practices, we constructed the sharing and changing platform of distributed spatial information in Hefei city based on USDI. The platform takes spatial metadata as its core, supports registration of distributed spatial information resource, search and retrieve of metadata, preview, download and service of data resource. The whole framework of platform adopts B/S structure. Fig.3 illustrates the whole framework of system.

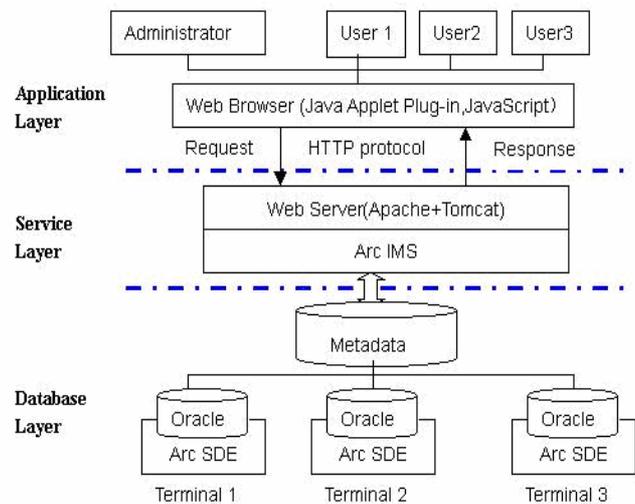


Figure 3. Framework of System

In database layer, we use Oracle9i as database to storage and manage data and ArcSDE to manage spatial data. ArcSDE can be seemed as the access between GIS and relational database. Not only can ArcSDE integrate with DBMS which has the ability to manage spatial data, but also it supports all functions of these DBMS. By taking advantage of Application Programme Interfaces (API) ArcSDE provides, we can integrate the functions of spatial data such as searching, analysis and etc.

In service layer, Apache & Tomcat is adopted as Web server. Apache serves as Web server and Tomcat serves as special JSP engine. This configuration may be a little complex, but it is capable of integrating Apache and Tomcat perfectly, achieving powerful functions. Moreover, we publish map services by virtue of ArcIMS which is taken as map server. ArcIMS is GIS based on Internet. It grants the large-scale GIS map establishment, data and applications to users and offer users results in Internet.

In application layer, the client is composed of Java Server Page (JSP). The client validation is realized by browsers script language - JavaScript. JSP is a dynamic web page technique based on Java, which is easy to develop complex Web application program. JavaScript is a script language based on object and event-driven. Making use of JavaScript, the system

can validate the user's input and display users' mistake in time. This trait improves the real time response ability and lightens the burden of Web server.

3.2 Functions

The system has four major functions: Browse, Search, Publish and Management. Fig.4 illustrates the detailed functions of system.

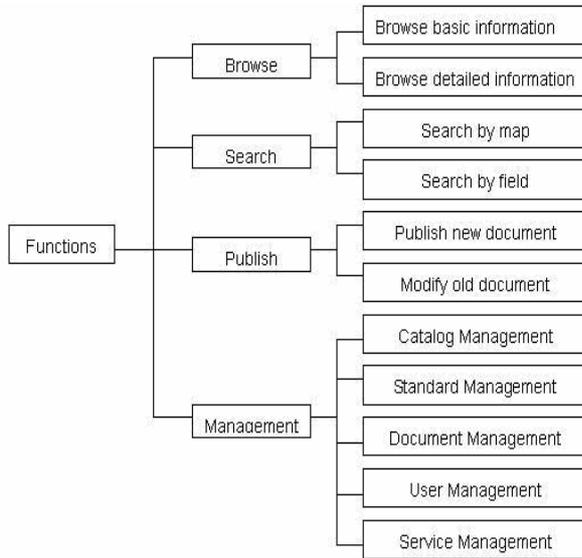


Figure 4. Functions of System

3.3 Characters

Compared to traditional metadata managing systems, the system has characters below:

3.3.1 Configuration of Metadata Standard: The system adopts XML as descriptions of metadata standard to realize the fine ability of expand and transplant. It supports universal metadata standards like FGDC and ISO standard as well as allows users to formulate their own metadata standard. Therefore, it accords with the requirement of constructing USDI.

3.3.2 Distributed Metadata Management: By the means of B/S structure, users can browse, search and publish metadata as long as they can surf in Internet. In a word, the system supports metadata management of various departments in distinct places of city, improving the working efficiency.

3.3.3 Visible Operation Interface: Thin client technique is employed. Consequently, it's unnecessary to install any control or plug-in in the client browser. The operation of users is aimed at pages, so the interface is friendly and manipulation is intuitionistic.

3.4 Significance and Realization

The system has been successfully built and applied in building the USDI sharing and exchanging system of "Digital Hefei". By acquiring information through the metadata system, users are able to find out the kinds of basic geographic information, the covered geography bound, the format of special data, the methods of using data and the approach to obtaining data. Furthermore, it alters the separation and uncertainty of data,

avoids the repeated data building among various city departments and exerts the effect of basic geographic information on city construction, land management and environment protection greatly (LI Sheng, CHEN Lian, 2002). It can be safely concluded that the metadata managing system has solved certain problems of construction of USDI, such as data sharing and exchanging, system managing, maintaining, exercising and serving. On the other hand, it promotes the construction of "Digital Hefei" and it is practically meaningful for urban information. Fig.5, Fig.6 and Fig.7 are the operational user interfaces of the system.



Figure 5. Browse and search



Figure 6. Metadata document publishment

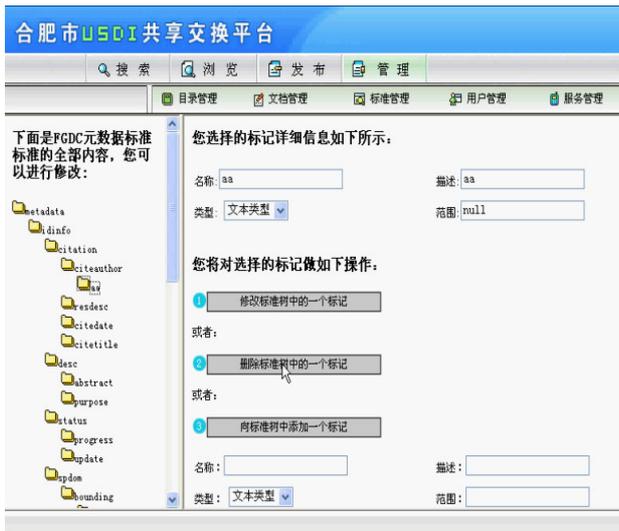


Figure 7. Metadata standard management

4. CONCLUSIONS

The paper analyzes the existing metadata managing systems, proposes a new mode of metadata managing systems and realizes it in "Digital Hefei" project. Compared to traditional metadata managing systems, the system adopts XML as descriptions of metadata standard and B/S as basic framework. Therefore, it provides a more flexible and efficient query mechanism for distributed metadata repositories which have multiple metadata standards and offers opportunities for users to formulate their own metadata standard. In the future, we hope to support distributed heterogeneous spatial metadata database and the search of Z39.50 client.

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