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Design and Implementation of a Geospatial Portal

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ABSTRACT

Geospatial portals use Web Services to publish available geospatial data and processing services, help applications find them and invoke services or retrieve data. OGC has developed Geospatial Portal Reference Architecture to assist to implement a standards-based geospatially enabled portal application. The Geospatial Portal Reference Architecture is a major for E-Government, National Spatial Data Infrastructures, enterprises and Information Communities. It enables geoprocessing interoperability that makes it possible to exchange heterogeneous geographic information content and share a wide variety of geospatial services over the World Wide Web. In this article, we study the Geospatial Portal Reference Architecture. On the basis of this reference, we design and implement a geospatial portal. This article describes the architecture of this portal, development and deployment of this portal.

Keywords: geospatial portal; Spatial Data Infrastructure; interoperability; service-oriented architecture; Web Services

1. INTRODUCTION

Geospatial metadata, data, and services have been widely collected, developed and deployed in recent years. Most geospatial resources are separately collected, archived, managed, analyzed, and presented to suit different objectives at geographically dispersed locations and computers. Isolated, application-specific systems could impede the sharing of geospatial resources. Traditional methods of application development through tightly coupled components would no long meet increased demands and urgently needed geospatial application [1]. An important way is a spatial data infrastructure.

A Spatial Data Infrastructure (SDI) can facilitate harnessing and sharing heterogeneous GIS resources more effectively. SDI includes technologies, policies and institutional arrangements that facilitate the availability of and access to spatial data. The SDI provides a basis for spatial data discovery, evaluation, and application for users and providers within all levels of government, the commercial sector, the non-profit sector, and academia and by citizens in general[2][10]. For over a decade, organizations such as U.S Federal Geographic Data Committee (FGDC), the Open Geospatial Consortium (OGC), and the International Organization (ISO)/Technical Committee 211 (TC211) have contributed to building such an infrastructure. ISO/TC211 defines information contents and component behavior, whereas OGC develops technical specifications for building geoprocessing software and services [3]. FGDC works with U.S Cabinet-level agencies to build the U.S. National SDI (NSDI) through guidance, seed funding, and coordination. As an international counterpart to FGDC, the Global SDI Association is working to build such an infrastructure globally.

An SDI framework—whether conceived for narrow use at a local level or for broader use at a national or global level—is rooted in a requisite organizational or political will to support the sharing of spatial information. Information-sharing permissions, charters, agreements, standards, and architectures are required to confirm and formalize that will. Finally, technical mechanisms are required to enable participating parties to undertake the kind of exchange of information with one another that is intended [6].

Geospatial portal building Spatial Data Infrastructure was introduced in 2002 as an OGC Geospatial One Stop portal initiative [4] [8]. Following the initiative, OGC worked on a geospatial portal architecture to leverage GIS components and OGC spatial web services including a set of clients, data services, catalog services, and portrayal services [5].

The Geospatial Portal Reference Architecture has been developed by the members of the Open Geospatial Consortium, to assist the global geospatial technology community in implementing standards-based geospatial portal solutions that are compatible with Spatial Data Infrastructures in every nation. The reference architecture provides the guide for rapid development and informed acquisition of portals and portal-exploiting applications that can plug and play with geospatial data and services in your organization and other organizations in your community and around the world [5].

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With the wide upspring of “Digital City”, “Digital Wuhan” project was put forward by Wuhan city, Hubei province. In 2000, Wuhan Bureau of Urban Planning and Land Resources Administration began to build “Digital Wuhan-Spatial Data Infrastructure” as the first step of “Digital Wuhan” Project. After six years of building, “Digital Wuhan-Spatial Data Infrastructure” has been finished. Information level of Wuhan has reached to the advanced degree. “Digital Wuhan-Spatial Data Infrastructure” project built spatial databases including base map data, urban total planning data, land utility planning data, traffic survey data, road planning data, and construction data and so on. On the basis of “Digital Wuhan-Spatial Data Infrastructure”, many geospatial information platforms have been developed. These systems connect the central-database through the Intranet. Data update must transport to central-database which increases some loads to central-database server. The integration and sharing of geospatial asset at different levels of abstraction and detail, or the aggregation of geospatial and other information asserts is very difficult.

To meet these challenges, we design and implement this geospatial portal in terms of Geospatial Portal Reference Architecture and user requirement. Geospatial information is independently stored in each organizations database. The integration and sharing of geospatial information is base on Geospatial Web Services. The geospatial portal has been designed using SOA[9] couple with some benefits: easier extension of legacy logic to work with new business functionality, greater flexibility to change without the need to constantly re-architect for growth, and cost savings by providing straight-forward integration.

Section 2 describes the Geospatial Portal Reference Architecture addressed by OGC. Section 3 describes the design of the architecture of the portal. Section 4 describes the implementation of this portal. We describe the implementing standards of this system. We also introduce the development and deployment of the geospatial portal. We detail the system workflow and functions. The final section draws some conclusions and future work for this portal.

2. THE GEOSPATIAL PORTAL REFERENCE ARCHITECTURE

The Geospatial Portal Reference Architecture documents a “core” set of interoperability agreements that provide instructions for bridging the gaps between different organizations and communities that have heretofore shared geospatial information only with great difficulty. The portal addresses technical interoperability between diverse systems and it also helps address "information interoperability" between groups whose content has been created with different data models and metadata schemas [5].

The overall goal for Geospatial Portal Reference Architecture is to make it easier, faster, and less expensive for any organization wishing to implement a standards based geospatially enabled portal application. A primary objective of the reference architecture is to define the requirements of an architectural framework that can be used as a guide to the implementation of an operational portal that provides access to geospatial content, maps, and metadata. This reference architecture specifies the scope, objectives and behavior of a portal and identifies its functional components [5].

The Geospatial Portal Reference Architecture is shown in Figure 1. The Geospatial Portal Reference Architecture is founded on the tenants of a Service Oriented Architecture (SOA) [9]. The Geospatial Portal Reference Architecture specifies four service classes that are needed to procure a comprehensive geospatial portal implementation and it identifies the OpenGIS Interoperability Standards that are applicable to the services. The four service classes are Portal Services, Catalog Service, Portrayal Services and Data Services. Portal Services provides the single point access to the geospatial information on the portal. In addition, these services provide the management and administration of the portal. Catalog Services used to locate geospatial services and information wherever it is located and provide information on the services and information if finds to the user. Portrayal Services used to process the geospatial information and prepare it for presentation to the user. Data Services used to provide geospatial content and data processing.

The Portal Services and any required Infrastructure Services are the only ones that need to be resident on the platform on which the portal is operating. All of the other services can be distributed across the Internet and can be dynamically registered and executed.

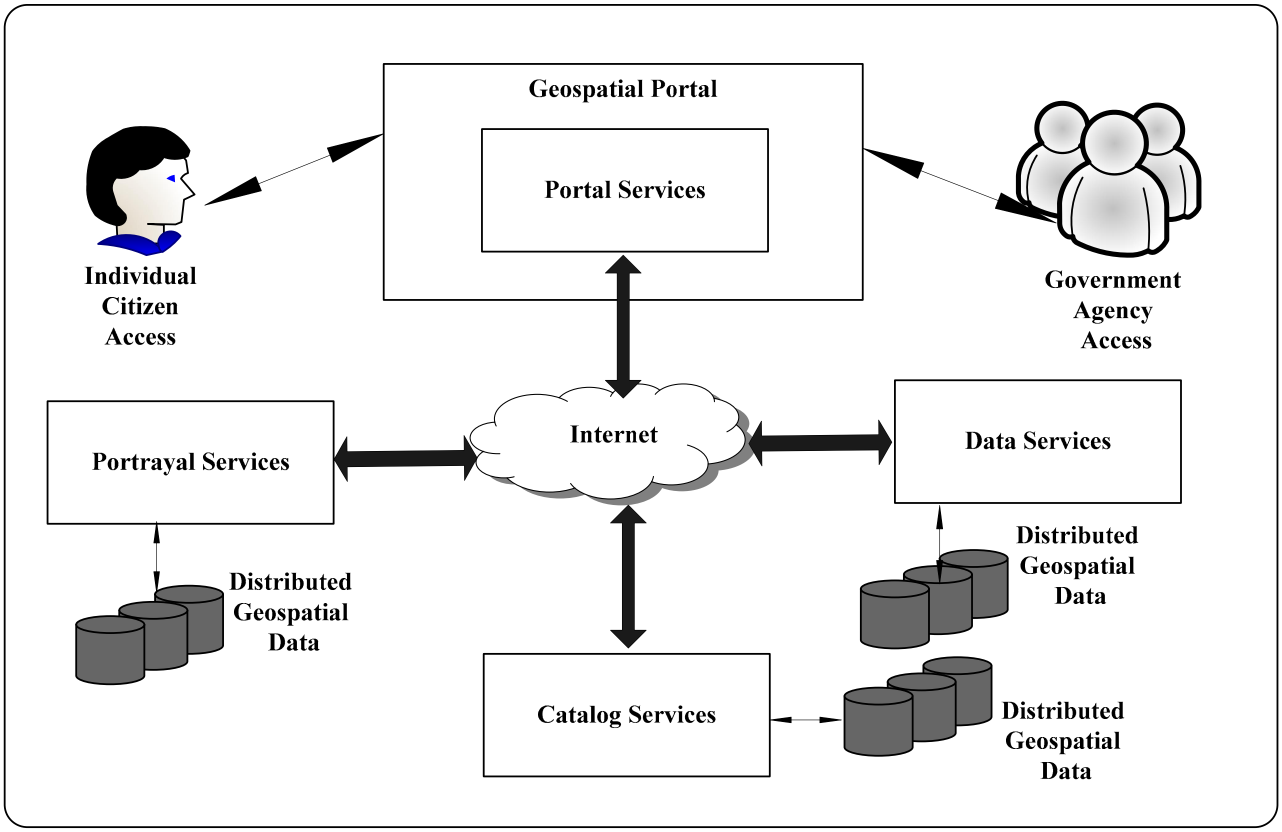

Fig.1. Geospatial Portal Reference Architecture

3. ARCHITECTURE OF THE GEOSPATIAL PORTAL

Leveraging the geospatial interoperability and web portal achievements, we developed a conceptual architecture (Figure 2) to share geospatial components. This portal consists of Client, Catalog Services, and Metadata Database. The architecture is a service-oriented architecture based Web Services. Catalog Services acts as the registry and index of the services. Client can discover needed metadata of the services from the catalog and bind them to form applications.

Data Services box provides data or information services via WMS [12], WFS [13], and WCS [14]. Data services are not resident on the portal but reside on geographically dispersed locations and computer. Metadata of geospatial data and web services store in Metadata Database.

Catalog Services box is populated with service metadata of data services. It plays the role of service broker in Web Service Architecture. This means that the catalog service is the centre to register services. Metadata records are designed to store in the databases. The Catalog can also connect to other catalogs through Z39.50 [15], CSW [16] and OAI (Open Archives Initiative) [17] to share metadata registered in other remote catalogs.

The Clients, which are Web-based applications that will be loaded to a Web Brower when being accessed, provide visualization, searching, publishing, administration. They find the service description from catalog services, then bind Data services and invoke the service.

Other remote clients complied with Z39.50, CSW, and OAI can access Catalog Services. Of course, these remote clients can be other remote catalogs.

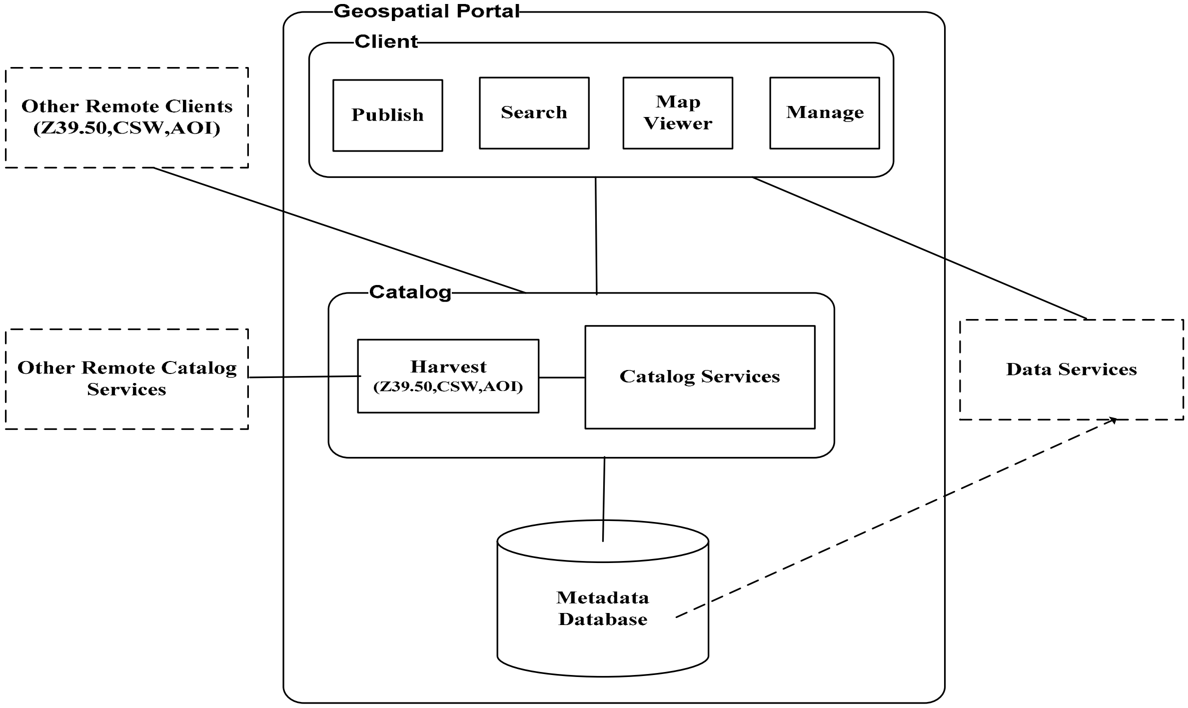

Fig.2. Architecture of the Geospatial Portal

4. IMPLEMENTATION OF THE GEOSPATIAL PORTAL

Based on the user requirements and geospatial portal characteristics, the geospatial portal was implemented with the architectures. The geospatial portal provides local and distributed search and harvest; visualization of remote data via Web Services; publishing of data and services; and user management; all linked and enabled by a flexible relational database.

4.1 Standards

All of the portal functions – local search, visualization, distributed search and harvest, publishing, and collaboration – rely on the use of open, well-defined standards, rather than proprietary or ad-hoc data models or interfaces. This enables the portal to draw on a variety of remote data and processing services, and to make its registry of data and services accessible to other software tools.

1) Metadata

The metadata profile used by this portal to describe the geographic data and services is based on Federal Geographic Data Committee (FGDC) [18], ISO 19115[19], and ISO 19139. FGDC establishes the names of data elements and compound elements [18]. The standard was developed from the perspective of defining the information required by a prospective user to determine the availability of a set of geospatial data, the fitness the set of geospatial data for an intended use, and the means of accessing the set of geospatial data, and to successfully transfer the set of geospatial data. ISO 19115 defines the schema required for describing geographic information and services. It provides information about the identification, the extent, the quality, the spatial and temporal schema, spatial reference, and distribution of digital geographic data [19]. This implementation specification is applicable to digital geographic datasets and can be used to describe many other forms of geographic data such as maps, charts, and textual documents. It provides information about the identification, the extent, the quality, the spatial and temporal reference, and the distribution of digital geographic data. More specifically, this specification provides an implementation UML model based on the ISO 19115 abstract UML model and defines an XML schema derived from the implementation UML model.

2) Geospatial Web Services

Currently, the portal is designed to access services compliant with three established OGC specifications namely the Web Map Service (WMS), the Web Feature Service (WFS), the Web Coverage Service (WCS). WMS supports the networked interchange of geospatial data as "map" which is generally rendered in a spatially referenced pictorial image, such as PNG, GIF or JPEG, dynamically from real geographical data [12]. WFS allows a client to retrieve and update geospatial data encoded in Geography Markup Language (GML) from multiple Web Feature Services. WFS defines interfaces for data access and manipulation operations on geographic features, using HTTP as the distributed computing platform [13]. WCS supports the networked access to multi-dimensional and multi-temporal geospatial data as "coverage" through "getCapabilities", "describeCoverage" and "getCoverage" interfaces. WCS provides intact geospatial data products encoded in HDF-EOS, NITF and GeoTIFF to meet the requirements of client-side rendering, multi-source integration and analysis, and inputs to scientific models and other clients beyond simple viewers [14].

3) Catalog Services

Catalog Services are compliable with Z39.50, CSW, AOI protocols. The Z39.50 protocol normally named Information Retrieval formalizes rules for querying, retrieving records, and asking for those records in a particular format [15]. This standard is used by the FGDC Geospatial Data Clearinghouse, which is part of the National Spatial Data Infrastructure. Documents available from Catalog Services can be searched by any Z39.50 client application.

CSW protocol supports the registry and discovery of geospatial information resources. It plays a directory role in the open, distributed Web Service environment [16]. Data and services providers register their capabilities using metadata, and users can then query the metadata to discover interesting information. Compiled with CSW, Catalog Services can be access by any CSW client application. Catalog Services can be accessed by remoter other catalog.

The OAI-Protocol for Metadata Harvesting (OAI-PMH) defines a mechanism for harvesting records containing metadata from repositories [17]. The OAI-PMH gives a simple technical option for data providers to make their metadata available to services, based on the open standards HTTP and XML. The metadata that is harvested may be in any format that is agreed by a community (or by any discrete set of data and service providers), although unqualified Dublin Core is specified to provide a basic level of interoperability. Thus, metadata from many sources can be gathered together in one database, and services can be provided based on this centrally harvested or "aggregated" data.

4) Harvest

There has been the need to share metadata among several other Catalog services. The harvesting is the process of collecting remote metadata and storing them locally for a faster access. This is a periodic process to do. The Harvesting Tool harvests from catalogs that meet Z39.50, CSW, and AOI protocols.

4.2 Development and Deployment

Figure 3 illustrates how the various components are implemented and deployed across different servers. The geospatial portal has been deployed in three high performance servers. Required software of this portal is Windows Server 2003, Oracle 10g, ArcSDE 9.2 SP4, IIS6, J2SDK 1.5.0_06, Tomcat 5.5.17, ArcIMS 9.2 SP4, ArcGIS 9.2 SP4, and Visual Studio 2005.

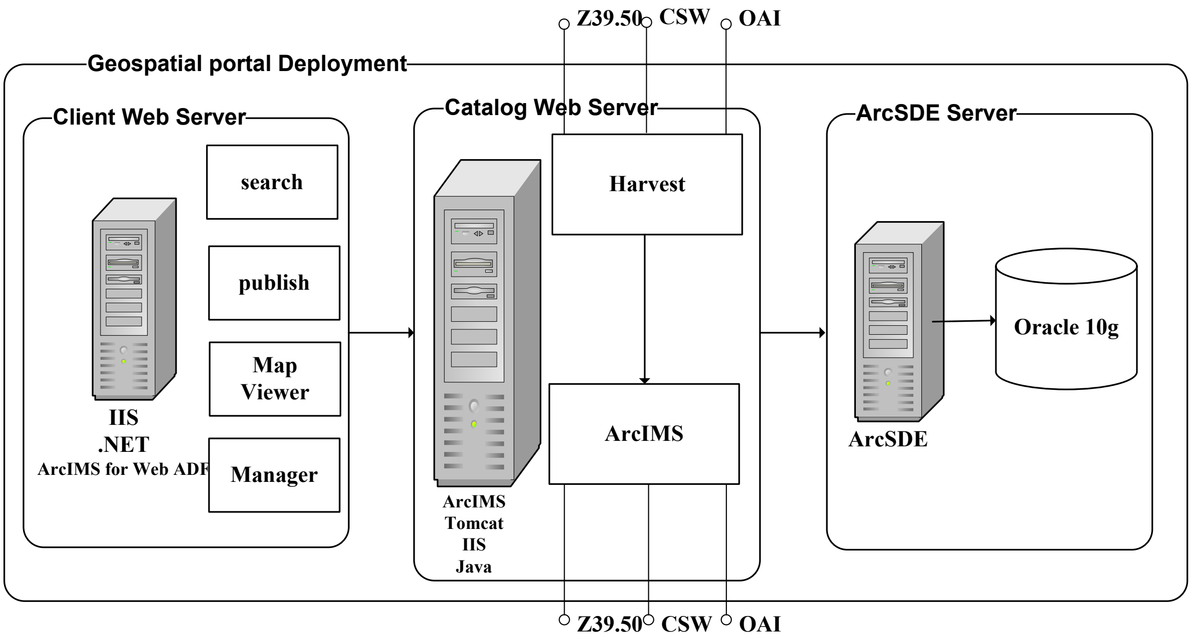

Fig.3. Development and Deployment of the Geospatial Portal

Client server' OS is Windows Server 2003 with IIS6. We must install .NET 2.0 and ArcIMS for Web ADF. Client application is Web-based application. We use ASP.NET and Web ADF tools to develop this client application. Development language is C# language.

Catalog server' OS is also Windows Server 2003 with IIS6. We install J2SDK, Tomcat, and ArcIMS. Database Server consists of ArcSDE and Oracle 10g. ArcIMS, ArcSDE, and Oracle 10g implement Catalog Services. ArcIMS provides the mechanism for hosting a Metadata Service, allowing clients to publish to the service as well as search its contents. ArcIMS uses ArcSDE and Oracle 10g with which it's configured to store, index, and search the published metadata documents. When a Metadata Service is created, several tables are created in the database to store and index the documents. Each time a client publishes a metadata document to the service and new records are added to the database tables. Metadata documents are indexed to optimize search and retrieval performance.

Catalog Services provides the Z39.50 Connector and the CSW Connector. Catalog Services can make metadata services available to clients that following the Z39.50 specification and the CSW specification.

Catalog Services also provide the OAI-PMH Connector. Catalog Services can make metadata services available to clients that harvest metadata catalogs into other catalogs.

The harvest tool can harvest metadata other catalogs into Catalog Services through Z39.50, CSW, and OAI-PMH Harvester.

4.3 System Workflow and Functions

Figure 4 depicted the system workflow and functional modules. Data Services have been described metadata format. Publish module publishes the metadata to the catalog. Search module can search the catalog. The result of the research can be input Map Viewer module. Map Viewer module binds to the data services referred by the metadata. Publish module can also publish data to the catalog through Harvest module which harvest metadata from other remote catalogs.

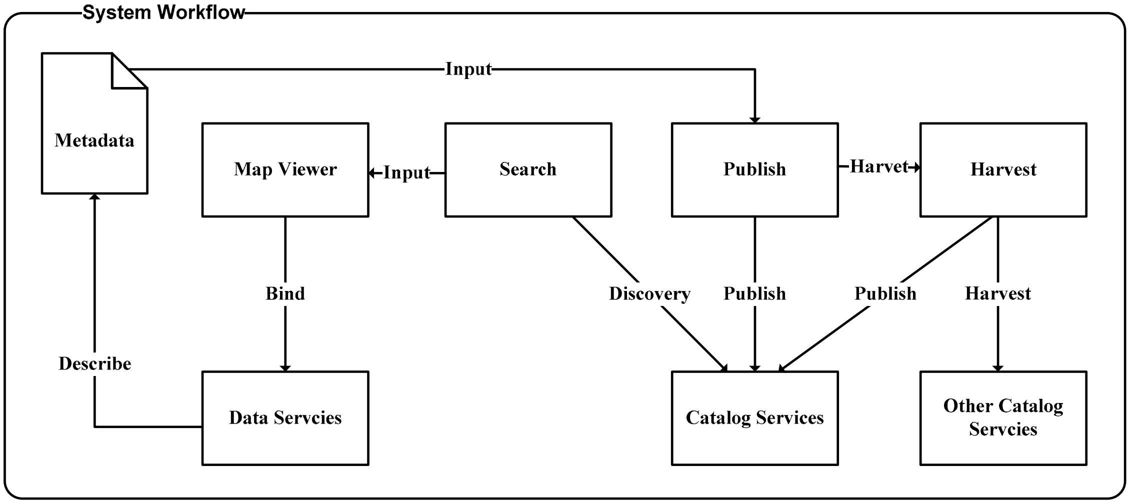

Fig.4. System Workflow

1) Publish

To publish metadata, you must first register as the geospatial portal user and be granted privilege by the portal administrator. Publish' users have three basic options for posting their metadata. They can create their metadata using an independent XML editor and upload the records to Catalog services of the portal. They can also create their metadata and post it using online metadata editor form, or make their metadata available on a Web server and register for harvesting using a metadata harvesting tool. The publishing supports the geographic content standards (FGDC, ISO 19115, and ISO 19139). The portal provides functionality that can be engaged to automatically validate submitted metadata records against applicable metadata standards. Users are informed of metadata records that fail this automatic validation before final posting to the portal.

2) Search and Discover

There are different ways to search the database for maps and other geographic data. The simple search allows users to search text within the entire record, such as keywords of the metadata. The advanced search option works similar to the simple search, however, you can be more specific in your search criteria. Here you can also search directly in the title or abstract fields and add more keywords to customize your search further. The results of the search are displayed as summary statements derived from the metadata records citing each found information item. For each metadata the result page shows the title, a hint of the abstract, keywords and so on. The user can then elect to display more detailed descriptions of each information item or the full metadata record itself. We can view the map described by the metadata record through Map Viewer.

3) Map Viewer

Map Viewer is a Web-based GIS application that can view and interact with live map services. The Map Viewer can connect to OGC WMS, WFS, and WCS services. When a user elects to view mapped data described by a search result (summarized metadata), Map Viewer window automatically pops up and the requested data is loaded atop a default map. The Map Viewer provides controls to zoom and pan; identify data values behind the view. The Map Viewer enables users to combine mapped data from different live map sources, transform them to a single map projection and extent, and overlay them on a single base map. Map layers included in a live map that is added to a Map Viewer map are listed in the Map Viewer legend, and the user can select which layer to include or omit on the map display.

4) Harvest

Harvester allows users to harvest from the following metadata repository protocols: Z39.50, CSW, and OAI-PMH. For harvesting, we must register new catalog. We can select a protocol from Z39.50, CSW, and OAI-PMH to harvest metadata. Different protocol needs different arguments. For example, for CSW protocol, we must know the URL to the CSW GetCapabilities request and CSW type. If CSW service is protected, we must know user name and password. We can set the harvesting frequency. We can view harvesting history.

5) Management

Management includes User Management, Group Management, and Category Management.

A group is a container for a set of users with common privileges regarding a metadata. Groups are created by users with the Administrator profile. Each user can belong to several groups. Each user has a profile which identifies the services he can access. If a user does not log in, the Guest profile is used. There are five profiles: administrator, user administrator, editor, registered user and guest. Each profile consists of a set of services. Profiles are combined hierarchically (higher profiles includes services of the lower ones).

Privileges of a metadata are View, Edit, Download, and Dynamic. View means the metadata can be viewed. Edit means the metadata can be modified and deleted. Download means if a metadata has maps, they can be downloaded. Dynamic allows access to Map View. What can be done with a metadata depends on the metadata itself, the group and the privilege set.

Metadata can be classified many category. Category can facilitate to search metadata. Category Management provides functionalities to increase, delete, and modify the category.

5. CONCLUSION AND FUTURE WORK

This paper introduces a geospatial portal designed and developed to leverage the advantages of interoperability, SOA, and OGC Web Services. The portal based on interoperable components using standard interface and protocols is highly flexible and agile.

As new standards and specifications are approved in OGC and implemented in products, we will integrate new services into the Portal infrastructure. We are developing application system in terms of this geospatial portal. This application system is a web application replacing old C/S information platform.

The search functionality of this portal is limited to the direct match of keywords from metadata without fully utilizing the semantic information implicitly embedded in the metadata, such as hierarchical relationships among metadata entities. Semantic augmentations can improve the discovery ability of data and services. Web Ontology Language (OWL) provides a mechanism to enable the use of semantics. OWL-S uses OWL to describe the semantics for Web service. We will enhance the semantic representation of geospatial data and services to enable the semantic search function [20].

System performance within Web Services environment may be a significant issue. This portal's reliance on distributed, independently managed services makes it hard to control its performance. It is also difficult to ensure the Quality of Service that may be required by the reliability of the services. Also, the burden of the interoperability put on computing system and network bandwidth is significant when big volume of data is accessed[7][11][21]. These are all areas needing further investigation.

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