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Research of Directory Service Model for Geographic Information

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Abstract

With the deepening application of geographic information web services, as a significant part, geographic information directory service sets up a service transaction platform between the service providers and the service requestors, providing one-stop registration, access and management functions of geographic information web services, so it is very important to carry out the research on geographic information directory service. According to the domestic and overseas metadata standards, the service expression-oriented metadata information model for geographic information web service is established, and the discovery mechanism dominated by geographic information service registration and active discovery is realized accordingly. After that, overall design of directory service model is made, and finally the research results are integrated into the geographic information service software NewMapServer and deployment test is made under the Google Cloud Environment Google App Engine, providing a certain reference for sharing the Smart City construction achievements.

Keywords

Directory Service, Metadata, Service Registration, Service Discovery, OGC CSW

1. Introduction

With the proceeding of digital China and smart city construction in China, the increasing demand for geospatial information sharing, and the development of information technology, the geographic information service comes on the scene instead of the geographic information system, which plays an increasingly sig-

nificant role in all the aspects relating to social construction, accompanying the emergence of a large number of available geographic information web services. Moreover, geographic information services are theoretically and practically developing and maturing. On the one hand, GIS service providers and concerned authorities begin to provide online geographic information service one after another, and international organizations such as OGC (Open Geospatial Consortium) have designed and defined the interface specifications for map data services and Geo-Computation processing services. On the other hand, users can use the simple and effective GIS functions only by making a GIS service request on the Internet according to their demands rather than buying the service. However, facing numerous and dispersed geographic information services on the Internet, how do the GIS service providers make the services that they have published to be discovered, bound and called by more users, how do they make their service products more competitive, and how do the users quickly find [1], discover and match the services meeting special requirements are problems that must be confronted with and solved in the development of GIS services.

As a significant part constituting the Service-Oriented Architecture (SOA), geographic information directory service uses the geographical information service metadata to realize the service matching and positioning rapidly, and sets up a service transaction platform between the service providers and the service requestors, providing one-stop registration, access and management functions of geographic information web services. Furthermore, geographic information directory service allows the service providers to register the geographic information services they have published to the service directory database according to certain rules, and users can quickly position the required services only by searching and matching in the service directory database according to their requirements [2] [3]. In this process, directory service works for three aspects: firstly, registration function, providing a platform for service providers to describe and display their services; secondly, discovery function, providing a platform for service requestors to search, select and access to the services; thirdly, management function, providing the directory updating, changing and deleting functions.

The recent researches of geographic information directory service are mainly focused on the registration and retrieval of metadata services. Batcheller J. K. [4] proposed an automating geospatial meta data generation method based on data management and documentation approach. Luo [5] proposed a registration and management method of data metadata based on XML, and designed the metadata system. Sun [6] proposed a database storage scheme of resource description framework for resource registration of service metadata. In combination with the OGC CSW specification, Zha [7] studied the metadata information model, attribute item mapping, and defining the result encoding format. These researches provide some good ideas on how to realize the rapid generation and metadata retrieval, but how to use these methods to realize the directory service

without enough research. The problems mainly focus on the following two aspects. Firstly, the research of geographic information directory service is not enough, and there is not very suitable technical scheme helping geographic information directory service to manage geographic information web service. Secondly, after establishing the directory service model, it is necessary to further study the registration and discovery methods of geographic information service to realize the sharing and interoperation of network geographic information services.

Aiming at these problems above, based on the existing research of metadata services, this article proposed a framework of directory service model for Geographic Information and the implementation mothods of registration and discovery of geographic information service, in order to realize the sharing and integration of geographic information resources.

The remainder of this paper is organized as follows: Section 2 analyzes related works of Metadata, Metadata standard and Web Catalog Service; Section 3 presents the Design of Web Service Metadata Model for Geographic Information, including ISO metadata model and SMMD metadata model; Section 4 designs the directory service model for geographic information, and gives the realization of the functional layer and the data layer; Section 5 demonstrates the experiments and analyzes the results obtained; Section 6 describes the conclusions.

2. Related Works

2.1. Metadata and Metadata Standard

Metadata are data to describe the data, which are used to describe the contents, coverage, quality, management mode, data provision mode, data owner and other related information about elements, data sets or data set series [8].

In the metadata standard research, the most widely available standard is the ISO metadata model which is developed by OGC. This model combining the ebRIM (ebXML Registry Information Model) Model [9] of OASIS (Organization for the Advancement of Structured Information Standards), ISO19115 geographic information metadata standard, and ISO19119/19139 geographic service metadata standard, and widely using in some directory service software, such as Arcgis. The National Geomatics Center of China has researched the metadata information model SMMD, which has referred to the methods mentioned in the special specification for ISO metadata application and defined the corresponding relationship between the query items and return item attributes [7] [10], and it has been applied in the national directory service system for surveying and mapping achievements.

2.2. Web Catalog Service

The directory service is classified into two categories, namely, the universal web service registration center and the dedicated GIS directory service.

Among them, the universal web service registration center is realized through UDDI service (Universal Description, Discovery and Integration), which defines

the methods to publish and discover the web services [11]. At the very beginning, UDDI serves the e-commerce field for establishing a universal, platform-independent and open framework for enterprises to 1) discover each other; 2) define how to interact with each other through the Internet; and 3) use a global commercial service registration center to share the information. If geographic information service registration is made only through UDDI, part of the service description information will be lost in service registration, causing problems of low precision, low recall and low efficiency in finding GIS services through UDDI.

The dedicated GIS service directory service generally refers to CSW service (Catalog Service for Web) of OGC, which provides geographic information resources, including the access interface specification for data and functional resources. Directory service provides a universal common mechanism for the classification, registration, description, searching, maintenance and access of geographic information web resources. This service allows the resource publisher to provide the description information about the type of resource and examples, and the resource requestor can not only search the information about the type of resource and examples, but also utilize or bind the geographic information provided by the resource publisher.

3. Design of Web Service Metadata Model for Geographic Information

3.1. ISO Metadata Model for Geographic Information Web Service

In order to manage various services in a centralized manner by registering them in the service center as per the ISO metadata STANDARD, and to interoperate the registered metadata information, this paper designs the service expression-based ISO metadata model for geographic information web service in the following principles.

1) Follow the frame structure of international standard ISO19139;

2) Considering that ISO19139 metadata standard is a general international standard with numerous and complex nodes, this paper deletes the nodes appropriately and only keeps the nodes relating to geographic information web service, so as to meet the special requirements;

3) Ensure that the support of multiple layer services are available;

4) Ensure that the nodes interacting with the client are included in the service;

5) Establish the mapping between the metadata information model and the general attributes.

According to the above-mentioned principles, the structure of main nodes of ISO metadata model for geographic information web service established as per the ISO metadata standard is shown in **Figure 1**, which has six modules.

3.2. SMMD Metadata Model for Geographic Information Web Service

In order to manage various services in a centralized manner by registering them

in the service center as per the SMMD metadata standard, and to interoperate the registered metadata information, this paper designs the service expression-based SMMD metadata model for geographic information web service in the following principles.

1) Follow the SMMD frame structure formulated by the National Geomatics Center of China;

2) Considering that SMMD metadata standard is established by referring to the international metadata standards and it is mainly oriented to the management of surveying and mapping achievements, this paper increases its nodes appropriately and expand it to be the SMMD standard that can be oriented to service expression;

3) Ensure that the support of multiple layer services are available;

4) Ensure that the nodes interacting with the client are included in the service;

5) Establish the mapping between the metadata information model and the general attributes.

According to the above-mentioned principles, the structure of main nodes of SMMD metadata model for geographic information web service established as per the SMMD metadata standard is shown in Figure 2, which has nine modules.

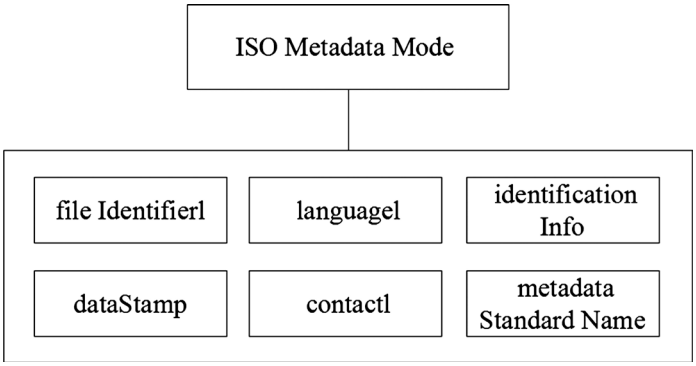


Figure 1. The design diagram of ISO metadata model.

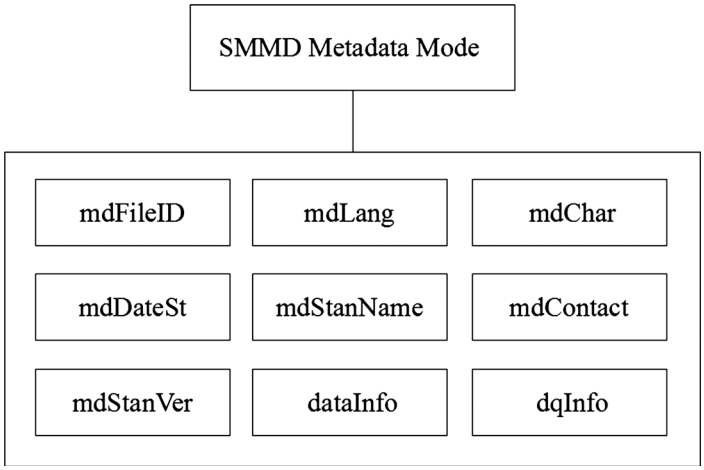


Figure 2. The design diagram of SMMD metadata model.

3.3. Comparison between ISO Metadata Model and SMMD Metadata Model

Chapter 3.1 and 3.2 provide the setting of ISO metadata model and SMMD metadata model, and it can be found that there are some differences between the two models. So Table 1 gives the comparesions the characters between the two models. Although the module name is different, but it can be found that SMMD metadata model contains all characters of ISO metadata model. Then on the basis of ISO metadata model, SMMD metadata model expends three characters, which are mdchar (the character encoding standards for metadata), mdstanname (the standard name of metadata) and dqInfo (the data quality information). The three characters can give more detailed of the metadata, and make the process of data sharing and quality evaluation easier to operate.

4. Design of Directory Service Model for Geographic Information

As a core part constituting SOA, geographic information directory service sets up an intermediate service communication platform between the service providers and the service requestors, providing one-stop registration, access and management functions of geographic information web services.

According to the contents and functions of directory service model for geographic information, and from the perspective of the interaction between the directory service, the service provider, and the service publisher, this paper establishes a system frame with high efficiency, stability and safety, and its structure is shown in Figure 3.

The overall framework of directory service model for geographic information established in this paper includes four parts, namely, the user layer, the network layer, the functional layer, and the data layer.

1) User layer: It is the service object of directory service metadata model for geographic information, including the service publisher and the service requester. By using this model, service providers can make the services that they have

Table 1. Comparison between ISO metadata model and SMMD metadata model.

ISO	SMMD	Description
File Identifier	mdFileID	The unique identifier for a metadata file
Language	mdLang	The description language of metadata
Identification Info	dataIdinfo	The data basic information
Data Stamp	mdDateSt	The date of the metadata creation
Metadata Standard Name	mdStanVer	The standard version of metadata performed
Contact	mdContact	The organization that creates and manages metadata
/	mdchar	The character encoding standards for metadata
/	mdstanname	The standard name of metadata
/	dqInfo	The data quality information

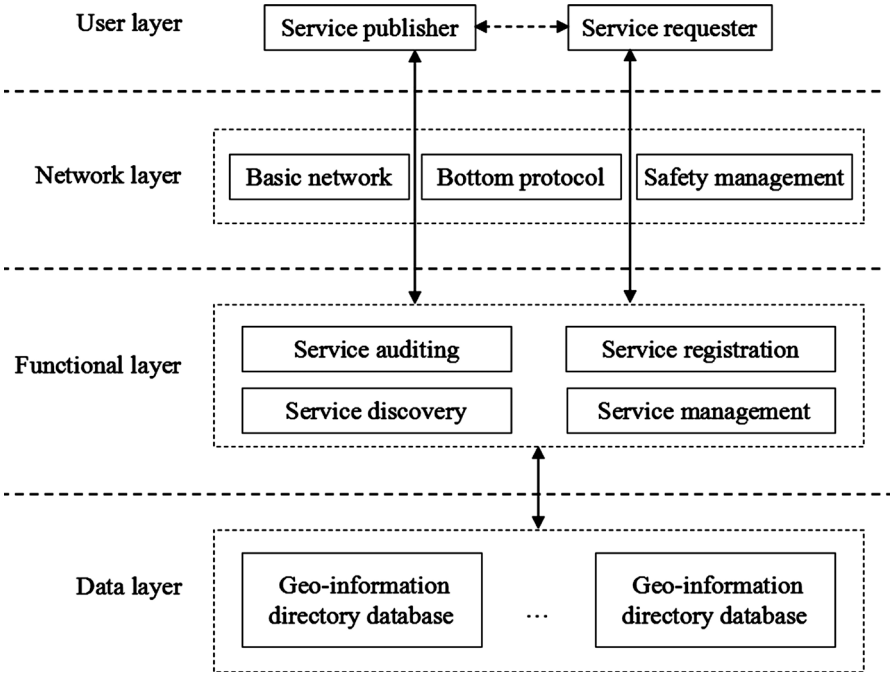


Figure 3. Overall framework of directory service model for geographic information.

published to be discovered, bound and called by more users and their service products more competitive, and service users can quickly find, discover and match the services meeting their requirements. At the same time, between service publisher and the service requester, the framework can provide a virtual service communication channel to realize the web geographic information service registration, access and management.

2) Network layer: Located in the middle of the functional layer the user layer, it serves as the basis for the interaction between the user application and model function module. It is mainly used to ensure the transmission security of users' metadata information for login authentication testing and service, which ensures that only authorized users can acquire safe and effective metadata information for the registered service.

3) Functional layer: Service auditing ensures that only the metadata conforming to the requirements of metadata standards are subject to service registration and discovery, and that the metadata information is normative and complete; service registration mainly provides the registration interface for service metadata information; service discovery mainly provides the discovery interface for service metadata information; service management mainly gathers the set functions for service metadata records, including inserting, changing, updating and deleting the service metadata information.

4) Data layer: It is mainly used to store and manage the service metadata information, time, service category system and other information, and database is used for unified management. As the metadata information for storage service of geographic information directory database is textual information, the data volume is relatively small, and centralized database management system is adopted

in the paper.

The design and realization of the functional layer and the data layer will be detailed below.

4.1. Registration and Discovery of Geographic Information Service

Through the registration of geographic information web service, the service publishers can register the geographic information web service that they have published to the directory database for classifying, describing and storing the service resources, thus giving effective organization and management to the metadata for the registered geographic information service. The processing of service registration and service publication is shown in Figure 4.

Prior to service registration, the service should be validated, including the validation of the identity of the service publisher and the information involved in the published service. Level-3 authority certification method (*i.e.*, service, interface, and operation) is adopted, and the validation of the identity of service provider through the service registration is subject to Level-1 service certification, which means that only the users who have acquired the service authority can register the geographic information service. The validation of information involved in the published service during the service registration is implemented mainly to ensure the correctness and completeness of service during the service publication and prevent abnormal service information from being registered to

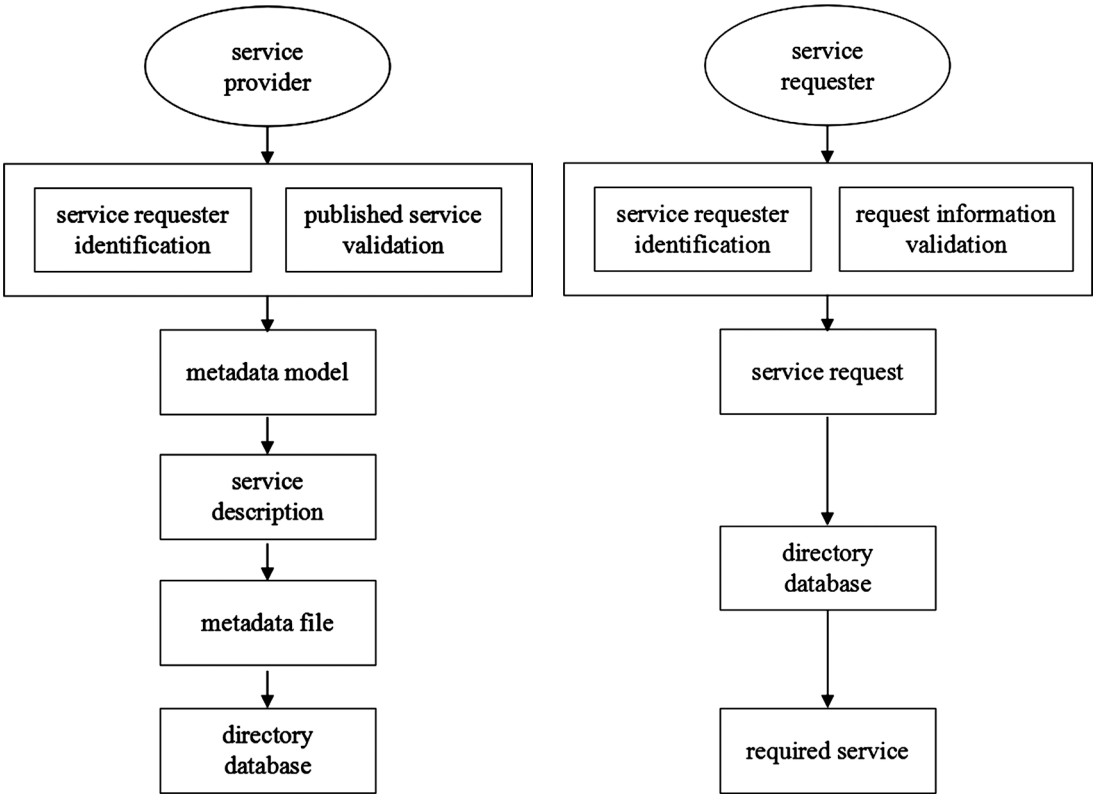


Figure 4. The processing of service registration (a) and publication (b).

the directory database.

The validated service providers can describe and analyze the services according to the predesigned metadata model, which is called the process of acquiring GIS service description files. The sample code of service describe realization is shown in Figure 5. Upon acquiring the service description files, the service providers can describe the service, generate the metadata files, obtain the service identification, service metadata information, the type, reference space, source, spatial scope and inserting time of service according to the metadata model for geographic information web service expanded from the previous metadata standard, and store the generated metadata files to the database by the data structure of directory database, thus completing the registration of geographic information service.

Through the service discovery function of directory service for geographic information, users can quickly position the required services by searching and matching in the service directory database according to their requirements. In this process, the directory service model for geographic information provides a platform for the service requestors to search, select and access to the services. Prior to service discovery, the service should also be validated, including the validation of the identity of the service requester and the information involved in the service request. Similarly, Level-3 authority certification method is adopted for service discovery, and the required service can be acquired from the directory database according to the authority and the information involved in the request. The sample code of service discovery realization is shown in Figure 6.

4.2. Directory Database

Considering the text feature of metadata information for directory database selection and realization, in order to make its storage structure applicable to metadata registration and publication, the metadata file information is fully stored to *x* ml field in the format of *x* ml for geographic information service registration, which makes the service registration simple and easy to operate and supports the storage of a large volume of data considering the small space occupied by the text. During the service discovery, the service searching information submitted by the service provider will be matched with the information of this field

```
record = parse_record(ttype['xml'])
self.log.debug('Transaction operation: %s' % record)
if record.has_key('identifier') is False:
    return self.exceptionreport('NoApplicableCode',
    'insert', 'Record requires an identifier')
record['source'] = 'local'
record['insert_date'] = util.get_today_and_now()
try:
    self.repository.insert(record)
    inserted += 1
except Exception, err:
    return self.exceptionreport('NoApplicableCode',
    'insert', 'Transaction (insert) failed: %s.' % str(err))
```

Figure 5. The sample code of service describes realization.

to acquire the required service information, thus easily satisfying the service discovery requirements.

For this purpose, SQLite database is used in this paper to build up the directory database. SQLite database is a relatively lite database and a relational database management system observing ACID rules. Considering the cross-platform, high-performance, simple and flexible characteristics of SQLite database, according to the practices on storage of directory service model for geographic information, SQLite database is selected and it can fully satisfy the storage requirements for geographic information web service metadata. The data sheet structure of directory database that the paper designs is shown in Table 2.

```
node = etree.Element(util.nspath_eval('csw:GetRecordByIdResponse'),
namap = config.NAMESPACES)
node.attrib[util.nspath_eval('xsi:schemaLocation')] = \
'%s %s/csw/2.0.2/CSW-dsicovery.xsd' % \
(config.NAMESPACES['CSW'], self.config.get('server', 'ogc_shcemas_base'))

#query repostory
self.log.debug('Querying repostory with ids: %s.' % self.kvp['id'][0])
results = self.repostory.query_ids(self.kvp['id'])

if raw: # GetRepositoryItem request
    self.log.debug('GetRepositoryItem request.')
    if len(results) > 0:
        return etree.fromstring(getattr(results[0], 'xml'))

if result in results:
    if getattr(result, 'typename') == 'csw:Record':
        node.append(self._write_record(
        result, self.repostory.queryables['_all']))
    else: #it's a profile output
        node.append(
        self.profiles['loaded'][getattr(result, 'schema')].write_record(
        result, self.kvp['elementsetname'],
        self.kvp['outputschema'].self.repostory.queryables['_all']))

if raw and len(results) == 0:
    return None

return node
```

Figure 6. The sample code of service discovery realization.

Table 2. Data sheet structure.

Field Name	Field Type	Constraint	Values
Identifier	VARCHAR (256)	Primary Key	Custom identification
Type name	VARCHAR (32)	NOT NULL	gmd: MD_Metadata, smmd: Metadata, csw: Record
Schema	VARCHAR (256)	NOT NULL	http://www.isotc211.org/2005/gmd http://www.opengis.net/cat/csw/2.0.2
Bbox	TEXT	NULL	Boundaries POLYGON
Xml	TEXT	NOT NULL	The whole metadata is stored in the field in text
Source	VARCHAR (256)	NOT NULL	Source of metadata
Insert_date	VARCHAR (20)	NOT NULL	Date

5. Experiment and Results

Based on New Map GIS software developed by the Chinese Academy of Surveying and Mapping and Google's Cloud Computing product Google App Engine, this paper completes the deployment experiment of directory service model for geographic information. The supporting environment of the experiment is shown in **Table 3**.

NewMapServer 4.0 is a geographic information network service platform original developed by the Chinese Academy of Surveying and Mapping [12]. It adopts the SOA framework and provides a variety of geographic information services, which can integrate seamlessly with the cloud environment, and realize task decomposition and service delivery through different load balancing algorithms.

Google App Engine (often referred to as GAE or simply App Engine) is a web framework and cloud computing platform for developing and hosting web applications in Google-managed data centers. Applications are sandboxed and run across multiple servers [13]. App Engine offers automatic scaling for web applications—as the number of requests increases for an application, App Engine automatically allocates more resources for the web application to handle the additional demand [14].

In particular, the function module realization and database connection of directory service model for geographic information designed and realized in the paper is completed in New Map GIS before registering the web geographic information service published by NewMapServer to the directory database. Services applied in the experiment include web map service (WMS), web feature service (WFS), and web coverage service (WCS). Taking vector data in shapefile format as an example, the process of WMS publishing using NewMapServer is introduced as follow.

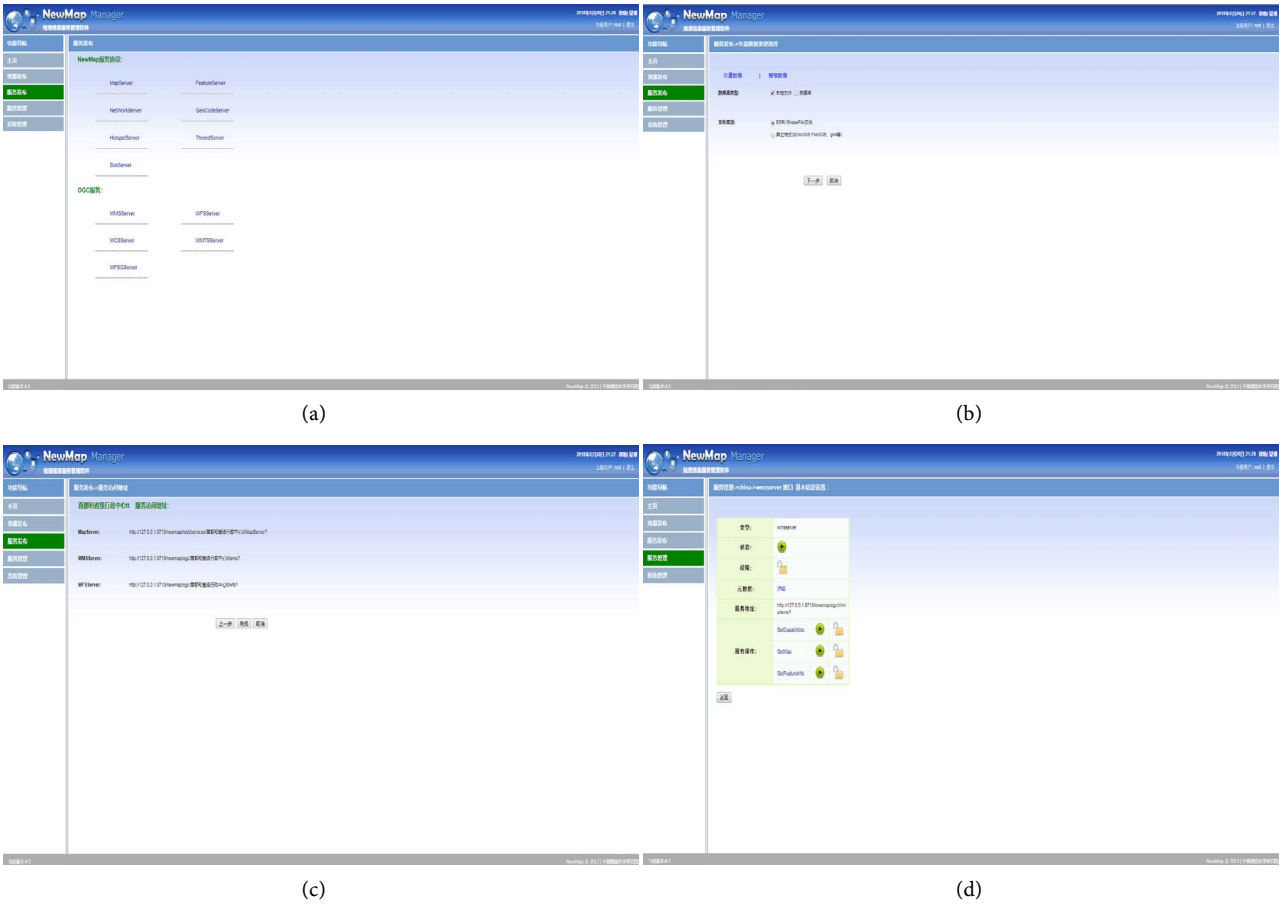
Step 1: Select the service type. As shown in **Figure 7(a)**, we select the WMS option.

Step 2: Select the data format. As shown in **Figure 7(b)**, we select the shapefile format.

Step 3: Select the data sets and set the service parameters. As shown in **Figure 7(c)**, we can get the service access address.

Table 3. Supporting environment.

Field Name	Field Type
Operating system	Centos 6.2
Web Server	Nginx, WSGI Server, Google App Engine
GIS platform	NewMapServer 4.0
Cloud computing platform	Google App Engine
Development framework	Hadoop
Development language	Python
Insert_date	VARCHAR (20)



(a) (b)

(c) (d)

Figure 7. The running windows of service publication and registration. (a) select the service type; (b) select the data format; (c) get the service access address; (d) complete the service registration.

Step 4: Complete the service publishing, then we can register services and discover services directly in the directory database.

Step 5: Complete the service registration. As shown in **Figure 7(d)**, the WMS service has been registered in the service center.

When the published service is registered to the directory database, its metadata can be updated and deleted. For example, the title, description, projection, key words and other information of the service metadata can be updated. The sample of service request and response is shown in **Figure 8**. When the model function module is realized in NewMapServer, the experiment is deployed in Google's Cloud Computing product Google App Engine, the running window of which is shown in **Figure 9**, for validating the correctness and feasibility of model design.

6. Conclusion

According to the research of the directory service model for geographic information under the Cloud Environment, this paper establishes the service expression-oriented metadata information model for geographic information web service and accordingly provides flexible and convenient service registration

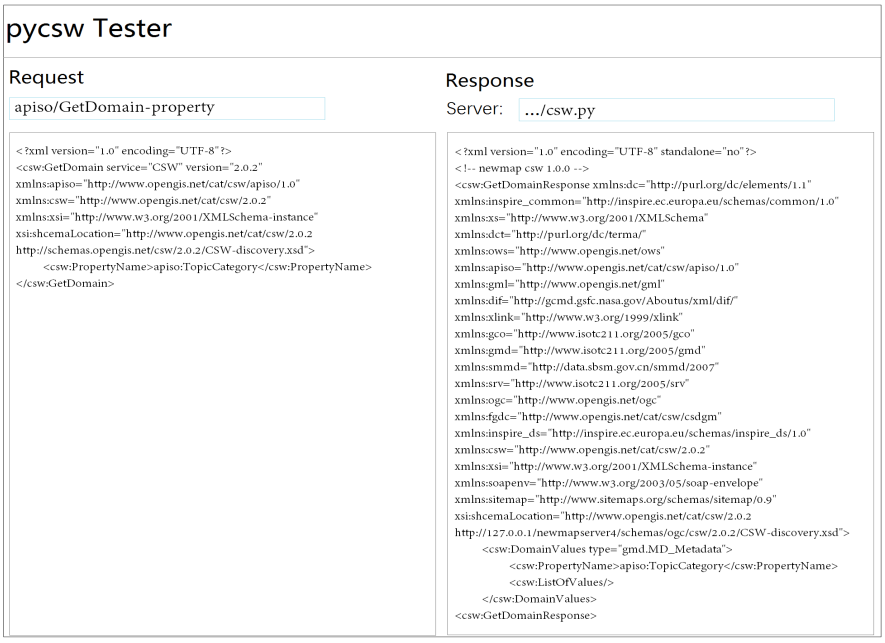


Figure 8. The sample of service request and response.

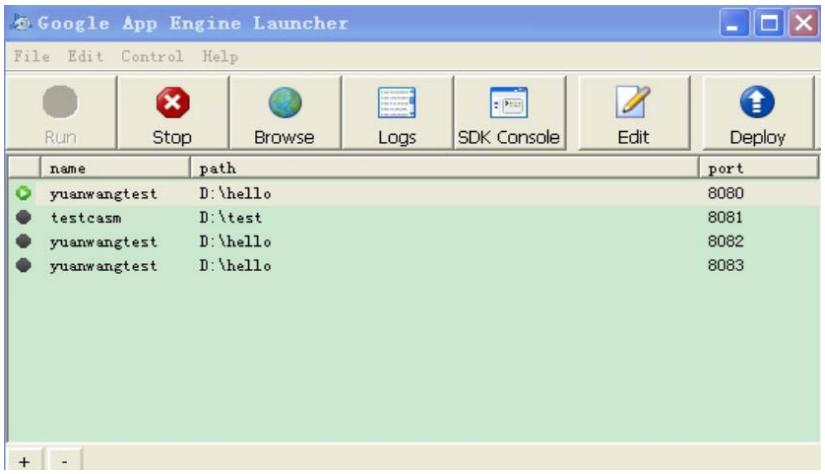


Figure 9. Running window of Google App engine launcher.

mechanism and discovery mechanism, setting up a service transaction platform between the service providers and the service requesters, through which the geographic information services are provided and requested according to the requirements to finally realize the sharing of geographic information resources as well as the integration and interoperation among GIS applications. In the future, the service mechanism for the service agent will be subject to subscription improvement for convenient of the subsequent geographic information directory service in the self-service mode.

Acknowledgements

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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