

The research and implementation of coalfield spontaneous combustion of carbon emission WebGIS based on Silverlight and ArcGIS server

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Abstract. As an important sub-topic of the natural process of carbon emission data public information platform construction, coalfield spontaneous combustion of carbon emission WebGIS system has become an important study object. In connection with data features of coalfield spontaneous combustion carbon emissions (i.e. a wide range of data, which is rich and complex) and the geospatial characteristics, data is divided into attribute data and spatial data. Based on full analysis of the data, completed the detailed design of the Oracle database and stored on the Oracle database. Through Silverlight rich client technology and the expansion of WCF services, achieved the attribute data of web dynamic query, retrieval, statistical, analysis and other functions. For spatial data, we take advantage of ArcGIS Server and Silverlight-based API to invoke GIS server background published map services, GP services, Image services and other services, implemented coalfield spontaneous combustion of remote sensing image data and web map data display, data analysis, thematic map production. The study found that the Silverlight technology, based on rich client and object-oriented framework for WCF service, can efficiently constructed a WebGIS system. And then, combined with ArcGIS Silverlight API to achieve interactive query attribute data and spatial data of coalfield spontaneous emission, can greatly improve the performance of WebGIS system. At the same time, it provided a strong guarantee for the construction of public information on China's carbon emission data.

1. Introduction

In recent years, increasingly significant global warming and declining air quality, which make carbon emission research has become a critical issue. With the rapid economic development, China has become the world's largest emitter of carbon, how to control and reduce carbon emission has become

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China's government departments and academia an important object of study. On the other hand, in the case of rising living standards, people are even more attention of their living quality of living environment, include the carbon emission data. Therefore, constructing the public WebGIS information platform for the carbon emission data and information, which can achieve the data network publishing, data browse and analysis. It is also important that people can know the changes in their surrounding environment.

However, subject to the limitations of the traditional WebGIS system, such as the weakly geographic information-rich spatial expression, a single update mode, the poor user interaction, the slow of data transmission and response speed, the weakly scalability and so on, it is difficult to meet the development requirements. But as the launch of RIA technologies, it designed a new Web application solution that can develop highly interactive, rich user experience and powerful Web client. Currently popular client-side RIA development technologies have Adobe Flash / Flex, Microsoft Silverlight and Sun JavaFX and so on [1]. More importantly for Silverlight and Flex technology, the current mainstream WebGIS platform software (e.g. ArcGIS Server and SuperMap) are provided the methods of REST API to achieve web access and operations for GIS Data, such as ArcGIS API for Silverlight / Flex, SuperMap iClient for Silverlight / Flex, etc., which greatly reduces the difficulty of the WebGIS development. Given Flex technology lacks of the support for the large data transfers, as well as the research of Silverlight technology in WebGIS [2-5], this paper introduces the Silverlight technology, combined with WCF RIA service [6], which can able to quickly carry out large amount of data processing and transmission, rapidly response to user requests, etc., so it can solve the drawbacks of traditional WebGIS system and meet the system development requirements.

2. The design of system architecture

The WebGIS system is as a part of the construction of the Natural process of carbon emission data public information platform website. This website integrated a variety of technologies, such as Asp.Net, Silverlight, WCF RIA Service and some related technologies about WebGIS. In the form of the portal, it provide users a variety of detailed information about natural process of coalfield spontaneous combustion carbon emission, so that users can not only browse the traditional sense of the text messages and picture messages, but also can use the WebGIS client to achieve the function of query, retrieval and interactive access for the coalfield spontaneous combustion attribute and spatial data. Figure 1 shows the logical architecture diagram of the system.

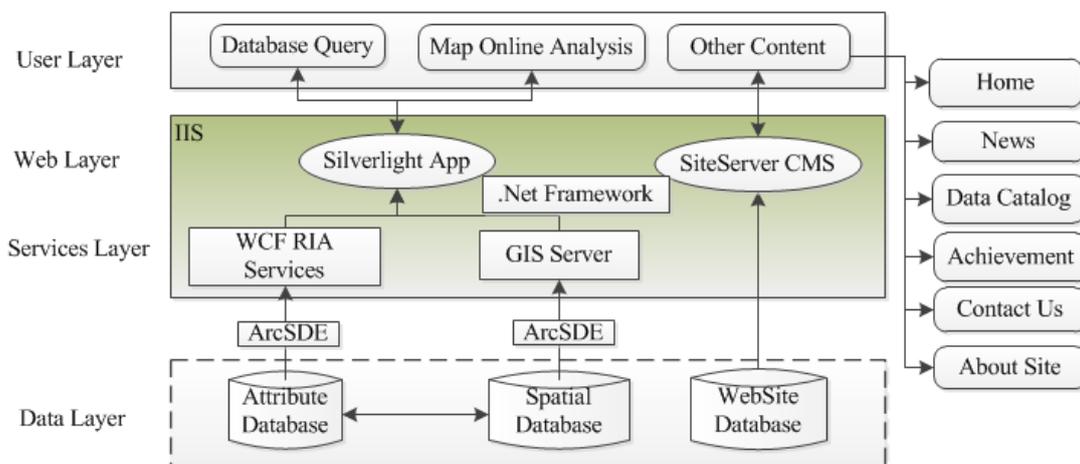


Figure 1. The Overall System Logical Architecture.

1) User Layer: It is also called human-computer interaction layer. It is expressed in the form of a Web

browser, to provide users with website operation interface.

- 2) **Web Layer:** It mainly consists of two parts, one part is the Silverlight App, and the other part is the SiteServer CMS. The former, embedded in an Asp.Net web page, mainly provides data query, browse, analysis, statistics and other functions for the attribute data and spatial data. The latter is mainly used to manage and publish the related text, pictures and other information in the field of coalfield spontaneous combustion.
- 3) **Services Layer:** It is to provide data services for the system and contains WCF RIA services and GIS services. WCF RIA services are primarily used for get data from Oracle database to the web layer for the attribute data query, retrieval and analysis. GIS services, provided by ArcGIS Server, mainly contains the map service, the image service, the geoprocessing service, the GP service and so on. These GIS services are primarily used for spatial data access and processing.
- 4) **Data Layer:** It provides data for the system and mainly contains the project business database and website content database. The former, refers to the coalfield spontaneous combustion carbon emission data, is divided into attribute database and spatial database and is used the way of combination of the Oracle11g and ArcSDE to storage and management. The later include the user data, articles data, picture data and other web data, which is stored and managed by the SQL Server2008.

3. The design of system database and data access

Considering the characteristics of coal spontaneous combustion data, such as a wide range of data collection, data complexity, and a strong geospatial property, the system database adopts dual database storage mode. Attribute data and spatial data are stored separately, and then through the form of fields and tables to link the attribute data and the spatial data, so we can achieve a seamless connection between data and maps

3.1. The attribute database design and access

3.1.1. Introduction about database design. Through the integration of Oracle and ArcSDE, the database can be better for data storage and management [7-8]. ArcSDE serves as a gateway for managing geographic data in relational database management systems (DBMS) and makes data available to clients such as ArcMap, ArcCatalog, and other applications serving data across the Internet. As for the data, the attribute data of coalfield spontaneous combustion carbon emission data include acquisition data, computed data and analysis data. The computed data and analysis data are derived from the acquisition data by the way of calculation and analysis. The database contains 16 tables and a number of calculations and analysis of data tables. The spatial data mainly put the acquisition of vector and raster data import the Oracle database through spatial database connection in ArcCatalog. Implementing ArcSDE with Oracle allows the spatial and business data is managed as a continuous database.

3.1.2. The design of attribute data web access. In the Silverlight application, it mainly by way of using services to achieve access to relational databases. These services mainly include Web Services, WCF Services, ADO.NET Data Service and WCF RIA Service. The table below shows the contrast of the four kinds of service method.

Table 1. The comparison of the four kinds of data communication method.

	Web Service	WCF Service	.NET Data Service	RIA Service
Efficient	Low	Medium	High	High
Expansibility	Medium	Good	Low	Good
Security	Medium	Medium	High	High
Performance	Medium	Medium	Medium	High
DB Compatibility	Good	Good	Low	Low

As can be seen from the table, WCF RIA Service for the data accessed has a strong advantage in the effectiveness, scalability, security, and performance. As for the WCF RIA Service for Oracle database access can be achieved using third-party plug-ins. The web access is implemented as follows:

- 1) Project Link – Silverlight client application and the server web application or library links. Also available through the Silverlight application that is hosted in a Web site and turned the WCF RIA Service options. Only through the link between the two, the client automatically generates the appropriate service code after the solution was recompiled.
- 2) DomainService – It is created in the web server side. DomainService is more like a standard WCF service, but follow some given pattern and provides the basic function, which is the core structure of WCF RIA Service. If you want to create a custom data objects bound to a domain service, you should create a class derived directly from DomainService.
- 3) Domain Operation – You can create some Domain Operations in you DomainService class to access to the database for get data, update data and other operation, but the return type of operation functions must be serializable.
- 4) DomainContext – In the Silverlight client side, it generated DomainContext for each DomainService in the web server side. So we can create an instance of DomainContext to invoke the opening Domain Operation to interact with the database. The following figure is the architecture of the WCF RIA Service.

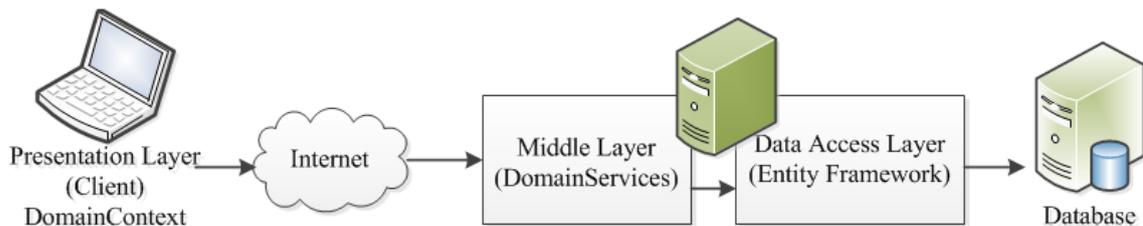


Figure 2. The Architecture of WCF RIA Service.

3.2. The publishing and access to spatial data

The spatial data of Coalfield Spontaneous Combustion carbon emission data mainly contains vector data (including points, lines and polygons) and remote sensing image data. Vector data mainly includes coal spontaneous combustion area range, the sampling point coordinates, administrative divisions, rivers and other factors. Remote sensing image is mainly used to analyse the coalfield spontaneous combustion zone terrain, the surrounding environment and other information. Through ArcGIS Server or ArcCatalog application, the vector data and remote sensing data can be published to the web side, we can achieve the data query and visual analysis at the web client side.

3.2.1. The creation and editing of map data. The creation and editing of map data is mainly through the ArcMap application to achieve. Such as the pre-production shapefile files, layer, image and other basic data, you can edit, rendering, and set other settings in ArcMap application, then save for the MXD document type for the data to prepare for web publishing.

3.2.2. The publish of spatial data and functions. For the spatial data and functions release, we can use the ArcCatalog application or ArcGIS Server software. ArcCatalog is the geographic data resource manager that allows users to organize, manage and create GIS data. It can be connected to the GIS server for data and functions release. ArcGIS Server, by the web server, achieves geographic data and services on the Web-based form of publishing and management. The type of service used in the project as the following table.

Table 2. The Types and Functions of the Publishing Service by ArcGIS Server.

Service Type	Function
Mapping Service	Includes many features, to provide access to maps and layer content. Mainly for cartography, map browsing and layer query.
Image Service	Provide read-only access to the Mosaic images or grid data set
Geodata Service	It can access the geographic database to achieve the geographic database operation through a local network or the Internet.
Geoprocessing Services	Expressed as a series of published operational and analytical tools of geographic information.
Geometry Service	Perform geometric calculations, such as buffer, simplify, calculate the area and length, the projection and so on.

3.2.3. *The access for spatial data.* For all kinds of GIS services hosted by ArcGIS Server all provides a simple, powerful and opening web interface (URL). Using Web client API can be called these GIS Services to access the spatial data. This paper uses the ArcGIS API for Silverlight to invoke GIS services at the Silverlight client side. Take an example of access a map service. Create a Silverlight application, and then import the necessary library file, so you can achieve through XAML statement for services calls [9].

```
xmlns:esri=http://schemas.esri.com/arcgis/client/2009
<esri:Map x:Name="MyMap" WrapAround="True" Extent="40,-5,180,60">
    <esri:Map.Layers>
        <esri:ArcGISDynamicMapServiceLayer ID="CoalBurnMap" Url="" />
    </esri:Map.Layers>
</esri:Map>
```

Url parameter which sets the map service Url address. If you want to achieve other sophisticated GIS functions, you should add others some library files and programming with the ArcGIS Server Rest API.

4. The introduces of the core function about the system

For Coalfield spontaneous combustion carbon emission attribute data (including business data), we use the WCF RIA Service to access the Oracle database at the Silverlight client side through the data channel provided by ArcSDE. Then, put the acquired data bound to a Silverlight DataGrid control, so the data you wanted query can display on a web page. Meanwhile, the client not only provides for data retrieval, filtering, grouping and other analysis, but also provides a graph visualization analysis of data, which can allow user more comprehensive and intuitive understanding of data content.

For Coalfield spontaneous spatial data (including some attribute data), through ArcGIS API for Silverlight to access the published REST services by ArcGIS Server. While also providing some WebGIS commonly functions, such as spatial query, map measure, map labels, bookmarks management, printing, and map layers directory management and other functions. The figure below shows the data access part of the network page.



Figure 3. The interface of spatial data query.

5. Conclusion

The coalfield spontaneous combustion carbon emission data is as the sub-topics of the natural process of carbon emission data, which is also the study object of this paper. By the analysis of the collection data, the computed data, the analysis data and other business data, but also including vector data and remote sensing data, we put these data divided into two major categories that are called attribute data and spatial data, which are all stored in the Oracle database combined with ArcSDE. Meanwhile, the combination of Silverlight technology, WCF RIA Service, ArcGIS Server and ArcGIS API for Silverlight, we have designed the system framework for WebGIS, build a WebGIS system for the coalfield spontaneous combustion of carbon emission data, developed the corresponding WebGIS functions on this basis, to achieve network client query, retrieval, analysis and other capabilities for the coalfield spontaneous combustion carbon emission data. In addition, it also implements the corresponding GIS analysis capabilities for the spatial data. Now, the WebGIS system is designed only for the practice of the coalfield spontaneous combustion sub- project, for the practice in the future, the system should include other sub-project data in order to build the natural process carbon emission public information platform that provide the data foundation for the research of China's overall carbon balance. Finally, the design of the system architecture and the integration of key technologies can be extended to other areas of development and application of WebGIS system for users to build their own WebGIS system has a guiding role.

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