Water Environment Monitoring Information System Based on ASP.NET and ArcGIS Server

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***Abstract*—According to the application demand of provincial environmental monitoring, designed and developed water environment monitoring information system based on B/S model, realized integration applications of spatial information and water environmental monitoring information, GIS functions developed by ArcGIS Flex API in ArcGIS Server10 platform, other functions developed using C# language in the ASP.NET framework, system functions including: monitoring quality management, monitoring data upload, inspection, audit, evaluation, query statistics and spatial query and online editing of monitoring stations and monitoring points, achieved centralized management and sharing of the provincial monitoring data, unified evaluation methods from all levels of monitoring stations, improved the accuracy and effectiveness of the monitoring information and flexibility of evaluation methods, effectively improved work efficiency of management department, the system has strong extended value.**

Keywords-Water Environment Monitoring ; WebGIS ; Flex API; ArcGIS Server

I. INTRODUCTION

Problems of water environment deterioration have menaced the surviving of human being and sustainable development of social economy. Monitoring river basin water quality and protecting water resources is an important work in provincial monitoring station. The traditional methods of manual monitoring and data processing have some shortages such as heavy workload, long period of data collection, summary and verification, various evaluation methods from all levels of monitoring stations often lead to the results of water analysis and evaluation delay or failure, and affect timely prevention and control of water environment, therefore, urgently need to use modern information technology to quickly and accurately to collect and utilize these information[1-4]. System's development can achieve monitoring data centralized management and sharing, these monitoring data come from all levels of monitoring stations (provincial stations, city stations, county stations), implemented monitoring data standardization, network upload, inspection, audit and automation computing of water quality evaluation, solved inconsistencies of evaluation methods, and may adaptability to adjust the evaluation method according to the need of environmental management. System construction can not only greatly improve efficiency of data processing, but also to ensure the accuracy, scientific, timeliness of evaluation results, it has a very important significance for enhancing operational efficiency of overall province environmental quality monitoring network and improving water environmental quality management ability.

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II. SYSTEM DESIGN

A. System Architecture

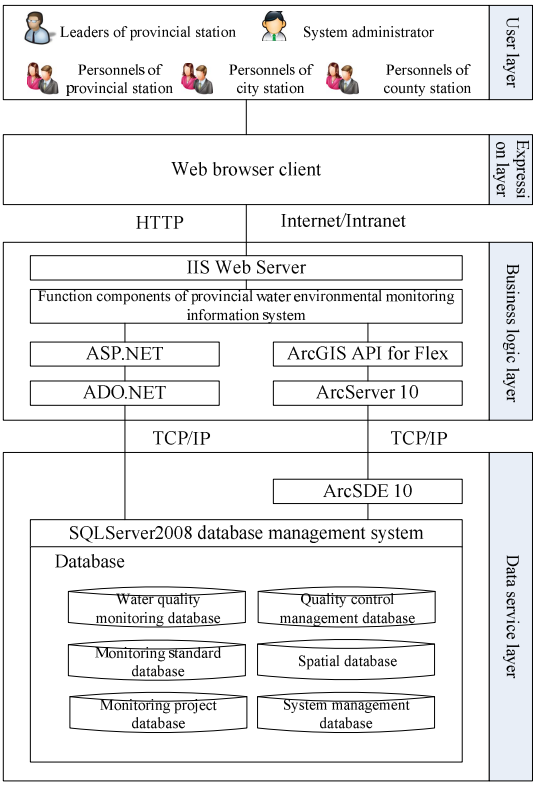

Figure 1. System architecture

System development using three-layer B/S structure, that is, the presentation layer, business logic layer, data access layer, three-layer structure is thin-client model, and the tree layers are separated, this framework has some merits such as high development efficiency, good security and maintenance and excellent expandability. Designed system architecture shown in Figure 1, according to user demand, the system will be logically divided into data service layer, business logic layer,

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DOI 10.1109/WCSE.2012.51

application layer and user layer, data service layer is responsible for managing the data and providing data access services, using Microsoft SQL Server 2008 as background database, the database used to manage the attribute database, while map data management also need to integrate middleware ArcSDE (spatial Data Engine), business logic layer provides various services components to access data service layer and responds to client requests, including water environmental monitoring information system functional components, ASP.NET components, ADO.NET data access components, ArcGIS API map access components, ArcServer spatial server, IIS Web server, etc., application layer is the client browser, user interacts with the background through the visual interface operation, user layer denotes system users that is divided according to user privilege, including provincial station leaders, system administrator, provincial station staff, region and municipality station staff, county station staff.

B. *Systematic function module design*

Considering function system requests and the business characteristics of water environmental monitoring, designed system functions from angles of system application's facility, flexibility and practical trait. Besides some basic functions like query, statistics, print of network information system, the system also has functions of monitoring data upload, inspection, audit，loading, water quality assessment and analysis, quality control management, evaluation criteria and monitoring project management, GIS map application. System function structure shown in Figure 2.

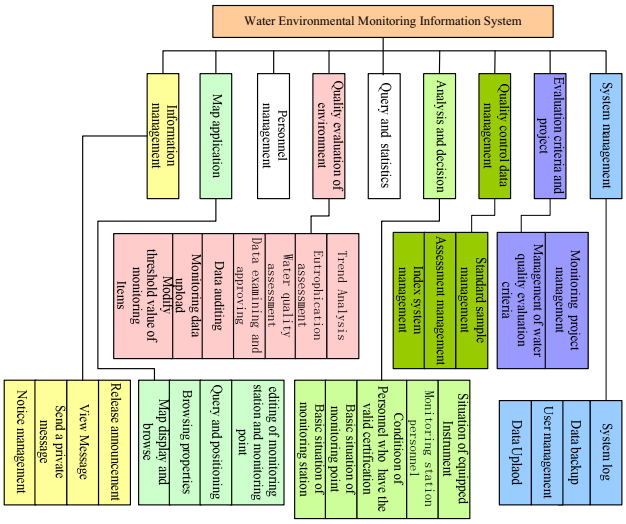

Figure 2. System function structure

C. *Systematic database design*

System deals with various data, these data are centralized management in SQL Server 2008, database named as "HJJCDataBase", logically divided into water quality monitoring database, quality control management database, monitoring standards database, monitoring project database, system management database and spatial database management where spatial data model based on geodatabase model of ArcSDE.

III. KEY TECHNOLOGIES IN SYSTEM

A. *Map storage and publishing*

Storing and managing system's map data by ArcSDE and SQL Server database, ArcSDE is ESRI's spatial database engine, used for data management and driver of massive spatial data and attribute data, provides fast, secure data access services for multiple clients which will concurrent access to databasse. For a mass of base map data(state, river, reservoir, lake), set them as a mxd format project file alone , then publish the mxd file to ArcGIS Server in ArcCatalog, during publishing, enable functions of mapping and KML services, in order to improve data access speed, after map data publishing，need to deal with the map into cache tiles, and publish the map to web according to ArcGISTiledMapServiceLayer model, according to the similar method, save monitoring station layer and monitoring point layer as a mxd format file and publish it, due to the need of data editing, need to select "Feature Access" service when enable the service function, map distributing according to ArcGISDynamicMapServiceLayer model.

B. *ArcGIS Flex API*

ArcGIS API for Flex (referred to as "ArcGIS Flex API") is a new Client Development Kit for WebGIS released by ESRI in 2008， used for RIA development, provides a new development methods for ArcGIS Server，its advantages are running faster, provide users with excellent user experience. Introduced the newest version ArcGIS API for Flex 2.4 in July 2011, you can perform various processing by using the ArcGIS Server map and task in network program, such as: 1) show an interactive map that contains own data; 2) execute GIS model and display the results on the server; 3) overlay your data in ArcGIS Online base map and displays them; 4) find and display features or their attributes in your own GIS data; 5) locate by address and display the results; 6) edit data (required that release map according to feature service); 7) to create mashups (information are composed of multiple network resources. Among them, in the respect of map on-line editing, ArcGIS API for Flex 2.4 adds the following classes: *AttributeInspector* component, *EditTool*, *DrawTool*, *TemplatePicker* component, *AttachmentInspector* component, etc. used to support online editing.

C. *Integration of GIS and MIS*

System involves integration between two types of system, one is the internet-based information management system (MIS), MIS is mainly used for processing relative information about text and data, but lack of intuitive and visibility for information expression, the other is the geographic information system (GIS), which enables monitoring stations, monitoring points visually and intuitively displayed on the map, easy for spatial query, positioning and analysis. Combination of GIS and MIS can enhance level of water environment monitoring information management. GIS and MIS integrated in two aspects in this paper, one is data-level integration, spatial data

and attribute data is centrally managed in a SQL Server database, spatial data and attribute data associated by keyword. Second, at the function-level, achieve integration of MIS and GIS through calling on web page, the concrete method as follow: after GIS functions developed by ArcGIS Flex API in Flash Builder environment, through the "Export Release" function in Flash Builder create HTML page for MIS calling.

IV. SYSTEM IMPLEMENTATION

According to system design, synthetically used ASP.NET 2008, ArcGIS Server 10, ArcSDE 10, ArcGIS API for Flex 2.4, Microsoft SQL Server 2008, successfully developed water environment monitoring information system software, achieved designed functions, system effect shown in Figure 3.

(a) Main interface of system

(b) Browsing attribute

Figure 3. Some user interfaces of prototype system

Realization ideas of the key and characteristic system function modules introduced as follows.

A. Water Quality Assessment

System water quality assessment functions including water quality assessment and lakes (reservoirs) eutrophication assessment. Water quality assessment using single-factor evaluation method, the main idea is firstly read reviewed monitoring data from the database, then respectively compare the acquired index value (index refers to the PH value, dissolved oxygen, chemical oxygen demand) with the corresponding index value in the national standard (GB3838 - 2002) [5], determine the grade of each indicator, and then target the grade of the most polluted index as a water quality grade. Lakes (reservoirs) eutrophication evaluation and classification method refers to the technical regulations of China Environmental Monitoring Station ([2001] No. 090).

B. Dynamic updating of monitoring point's symbol

Monitoring point's symbol on the map is needed to update according to recent monitoring water quality information, so as to reflect the latest water quality conditions of monitoring point. Implementing the function mainly by establishing a database trigger, the main idea is: when inserting a record of one monitoring point's latest monitoring data, the system will automatically modify water quality information of the corresponding monitoring point in spatial database (which requires that the feature class of monitoring point is registered as SDE version, and you must select checkbox of "Register the selected objects with the option to move edits to base" before confirming register). If the map web page refreshed again, you can see that the symbol of monitoring point is updated. The trigger code as follows:

```
ALTER TRIGGER [dbo].[监测点_Insert]
    ON [dbo].[MeasurPtWaterQy]
    AFTER INSERT
AS
BEGIN
      update a set a.水质状况=k.水质状况 from (select b.测点代码,b.水质状况 from sde.sde.监测点 b,inserted i
      where rtrim(ltrim(b.测点代码))=i.测点代码) a,
      inserted k
END
```

C. Spatial Query

Realization ideas of spatial query:

1) First, customize the page "查看属性" button, method as follows:

```
<mx:ToggleButtonBar id="tbb"
itemClick="tbb_itemClickHandler(event)" selectedIndex="-1"
toggleOnClick="true" borderVisible="false"
buttonMode="false" maxHeight="20" verticalGap="0" >
      ……<fx:Object
icon="@Embed(source='assets/identity.png')" label=" View
Properties " />……</mx:ToggleButtonBar>
```

2) Custom DrawTool tool, the approach taken by is:

```
<esri:DrawTool id="IdentiydrawTool"

drawEnd="IdentiydrawTool_drawEndHandler(eventfillSymbol="{sfs}"graphicsLayer="{clickGraphicsLayer}"lineSymbol="{sls}" map="{myMap}"showDrawTips="false" markerSymbol="{sms}"/>
```

3) Activate IdentiydrawTool tool in tbb_itemClickHandler (event), namely: *IdentiydrawTool.activate (DrawTool.MAPPOINT)*

4) In order to achieve that querying spatial object properties by clicking the map, need to perform the following tasks in the IdentifydrawTool_drawEndHandler event.

identifyTask.execute(identifyParams, new AsyncResponder(myResultFunction, myFaultFunction, clickGraphic));

D. On-line editing

Map editing has been a difficulty in WebGIS, using FeatureLayer and ArcGIS Server implement map editing need utilize ArcServer 10 and ArcSDE (require data sources are from registered version's ArcSDE) on the condition of ArcGIS API for Flex development mode, allow editing just adopt Feature service when publishing map. System's editing functions involves add, delete and property editing of monitoring stations and monitoring points.

- Method of implementing adding function

1) Custom DrawTool tool. *<esri:DrawTool id="drawTool" drawEnd="draw_drawEndHandler(event)" map="{myMap}"/>;*
2) custom symbol template of adding monitoring station and monitoring point. *<esri: TemplatePicker id = "myTemplatePicker" width = "100%" height = "100%" selectedTemplateChange = "myTemplatePicker_selectedTemplateChangeHandler (event)" />;*
3) achieving my *TemplatePicker_selectedTemplateChangeHandler (event)* function, the main task is to obtain drawing symbol and activate the drawing tool, the key code as below: *if (event.selectedTemplate){drawTool.markerSymbol = event.selectedTemplate.featureLayer.symbol;drawTool.activate(DrawTool.MAPPOINT); };*
4) achieving DrawTool tool's *draw_drawEndHandler (event)* function, the key code as follows: *var newAtttrs: * = myTemplatePicker.selectedTemplate.featureTemplate.prototype.attributes; var newGraphic: Graphic = new Graphic (event.graphic.geometry, null, newAtttrs); myTemplatePicker.selectedTemplate.featureLayer.applyEdits ([newGraphic], null, null, new AsyncResponder (onResult, onFault)); onResult function is used for layer refreshing.*

- Method of implementing delete function

1) customize "Delete Feature" button on the page, the method similar to the "View Properties" button;
2) to active IdentiydrawTool tool in click event of "Delete Feature" button, then to achieve selection of the features to be deleted, the key code as follows: *queryMapClick.geometry = penvelop; myFeatureLayer. selectFeatures (queryMapClick);*
3) after selecting the features, selectionComplete attribute in the <esri:FeatureLayer> tag will trigger myFeatureLayer_selectionCompleteHandler (event) function to achieve deleting features, the code is as follows: *delInsp.addEventListener (com.esri.ags.events.AttributeInspectorEvent.DELETE_FEATURE, fnDelFeature); delInsp.deleteActiveFeature ();.*

- Method of implementing attribute editing

1) First, customize "Edit Properties" button in the page, the method similar to the "View Properties" button;
2) after activating IdentiydrawTool tool in the click event of "Property Editor" button, choose the features to be edited in the IdentifydrawTool_drawEndHandler (event: DrawEvent) event;
3) customize attribute Inspector and field Inspector. customized approach of attribute Inspector: *<esri:AttributeInspector id="attrInsp" updateFeature="attrInsp_updateFeatureHandler(event)" singleToMultilineThreshold="20" formItemsOrder="fieldInspector" formMaxHeight="350" deleteButtonVisible="false">* , customized approach of field inspector: *<esri:FieldInspector featureLayer="{myFeatureLayer}" fieldName="monitoring station name"label=" monitoring station name "/>;*
4) after selecting the features, selectionComplete attribute in <esri:FeatureLayer> tag will trigger myFeatureLayer_selectionCompleteHandler (event) function to display the property editor window, namely, the implementation of myMap.infoWindow.show (pPt).

V. CONCLUSION

This paper designed and implemented provincial water environmental monitoring information system based on B/S model, achieved monitoring information sharing by centralized and standard data management, realized consistency of evaluation methods by unifying evaluation criteria and model, through the development of network information system, achieved computing automation of water quality assessment, improved data timeliness, through the application of GIS, users can more intuitively understanding and managing monitoring stations, monitoring points and water quality. The system has the merits of technology advanced, easy to use, security and scalability, and can greatly improve management level of water environment monitoring work; it has important reference value for informatization construction in water environmental monitoring management department.

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