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Information System for Environmental Technologies

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INFORMATION SYSTEM FOR ENVIRONMENTAL TECHNOLOGIES

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Abstract

Geographical Information Systems (GIS) play an important role in environmental management solutions, and they are being used with increasing frequency in environmental studies. The use of GIS technology in environmental studies provides a better way to manage, analyze, display and share the information.

In this thesis, I automated a process for constructing GIS maps of odor complaints and inspections that have been used to study odor complaints in the vicinity of three landfills in Jefferson Parish. I provided an application that integrates daily environmental observation and monitoring data into a GIS and publishes the resulting maps through the Internet. The user's interaction with the web-based maps does not require any GIS expertise.

A Web-application was also implemented for managing the list of the constructed maps. The maps are deleted or updated through the manager application, a friendly interface application that does not require users to have any GIS technology knowledge.

Chapter 1: Introduction

The rise of the Internet and the World Wide Web (WWW) has created many opportunities for those involved in GIS and decision support research [1]. A Geographic Information System (GIS) is an automated information system that is able to compile, store, retrieve, analyze, and display mapped data. Only a decade ago, this technology was limited to a relatively small number of colleges, universities, and local, state, and federal agencies. Today, it is used by government officials, natural resource and social analysts, and many others. The increased usage of GIS in many disciplines and industries, including urban development [3, 4], environmental research and model building, urban demographic studies, and transportation analysis [2], has intensified in the last two decades [4,5,6].

The availability of technology, software, digital datasets and professional personnel has enabled the expansion of GIS at all levels and in many communities [4]. Google's satellite service further brings GIS to every ordinary citizen. This service offers rooftop photographic views of the United States. Users can zoom to house-level detail only for areas covering about half the population. In those parts, Google Maps' sharp aerial images, taken by satellite, provide street-level views of many homes, businesses and landmarks [15].

The integration of remote data into local GIS processing and the use of the Internet for distributing the data have increased the availability of information and capabilities to remote users. In the past decade this activity has greatly expanded, facilitated by the Open GIS Consortium (OGC), which coordinate between the various stakeholders (government, private industry, and academia) and promotes the interoperability in the geographic information industry [4, 7].

The need of the technology for coupling GIS with Web servers has encouraged GIS vendors such as ESRI to provide products that span from the traditional GIS databases and applications to Web publishing and global data sharing. For example, ArcGIS is one of the suite products created by ESRI. The potential uses of such integrated GIS software are many, including published static and dynamic maps, queries of datasets spatial and non-spatial, and the dissemination of spatial analysis. In the GIS system, ideally the datasets are stored in the database; they are accessed from the GIS software. This centralized data management greatly assists web developers in making and delivering maps and data over the Internet.

In this thesis, I will report on the process of automating the integration of daily environmental observation and monitoring data into a GIS, and the publication of the resulting mapping by an Internet application. The environmental data consist of the odor complaints and the inspection measurements reported relative to three landfills in Jefferson Parish. I have integrated the tabular data into the geographical datasets and published the Web maps. These Web maps will be used in the environmental studies and analysis for solving the odor problems generated by landfills in Jefferson Parish.

My first goal was to provide the users with an easy way of creating Web-based maps that visualize the odor problems generated at the landfills. The maps will give the engineers a geographical view of the common sources of odors. This solution will also help engineers to evaluate the effectiveness of the techniques for reducing odors and where the techniques are more needed.

My second goal was to show how the integration of tabular and geographical data with GIS software (ArcSDE, and ArcIMS) can be used as a solution to environmental problems in which the geographical information plays an important role.

The rest of this document is organized as follows: Chapter 2 provides the background of the information related with this project, as well as a brief description of the ESRI products used in our implementation. In Chapter 3, we review some related work.

In Chapter 4, we present the design that we followed in the implementation. Chapter 5 provides the details of the implementation. Finally, in Chapter 6 we present conclusions and future work.

Chapter 2: Background

In this chapter, we will review the background of the project, Geographic Information Systems, the investigation project of Jefferson Parish landfills and the software solution that has been used for the studies of the odor complaint problems in the landfills.

2.1 Geographic Information Systems

A GIS is a System of computer software, hardware and data, and personnel to help manipulate, analyze and present information that is tied to a spatial location [17]. There are five general functions in a GIS: input, manipulation, management, query and analysis, and visualization [16, 18].

- Input: Spatial and non-spatial data must be translated into a compatible format, which, in the case of geographical data, often involves the digitization of analog information such as traditional paper maps.
- Manipulation: Often necessary prior to analysis, in order to make different data compatible.
- Management: Typically based on relational database concepts and internal reference structures.
- Queries and analysis: The key function and strength of GIS; includes the creation of new geographical structures through topological overlays and the identification of variables within a given distance of an object or area.

- Visualization: GIS enables the display of maps that can be tailored to specific needs, and be rapidly and dynamically updated.

A map in a GIS assists the viewer by relating information from different sources, which are stored in separate layers in its dataset. The graphical information on a map is displayed as layers, where each layer represents a particular type of feature such as streams, lakes, highways, rivers, counties, cities, or homes. A layer may reference the data contained in various resources such as coverages, shapefiles, geodatabases, images, and grids. The data can be stored in files or in a GIS database [12].

GIS programs now cover a wide spectrum of complexity and cost, and many universities and private companies offer degrees and training programs in the use of this technology. In fact, nowadays there are many software firms such as ESRI that offer GIS services and software.

2.1.1 ArcGIS—GIS Software family from ESRI

ESRI provides software suites that span from GIS databases and desktop applications, to web publishing and global data sharing. ESRI's ArcGIS is an integrated collection of GIS software products for building a complete GIS system. The key components of ArcGIS (Figure 2.1) are [19]:

- Desktop GIS—ArcGIS Desktop GIS software products are used to compile, author, analyze, map, and publish geographic information and knowledge.
- Embedded GIS—ArcGIS Engine is a library of GIS desktop software components packaged together for developers to build custom applications.

- Server GIS—ArcGIS Server, ArcIMS, and ArcSDE are used to create and manage server-based GIS applications that share GIS functionality and data within organizations and to many other users on the Internet.
- Mobile GIS—ArcPad coupled with a wireless mobile device that is location enabled is widely used for data collection and GIS information access in the field.

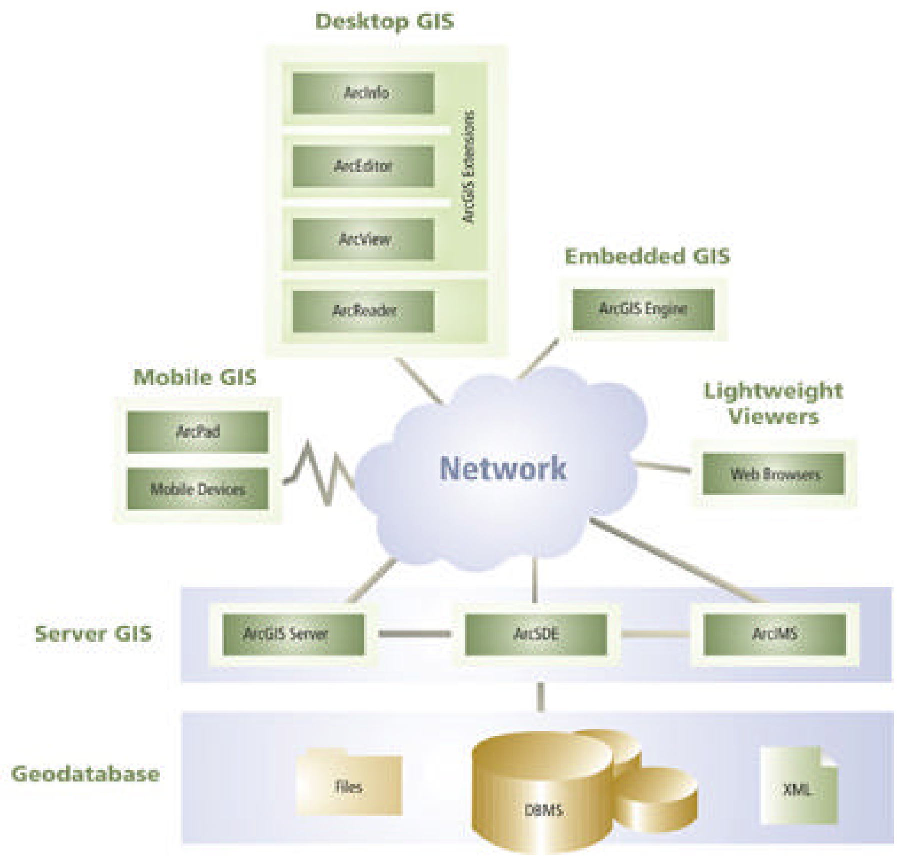


Figure 2.1 ArcGIS Architecture [19]

ArcGIS provides a framework for implementing GIS which can be deployed on a single desktop, or be distributed on a heterogeneous computer network of workstations and servers (including the Web), or mobile devices. Users can deploy various parts of this system to implement a GIS of any size – from a single-user system to large enterprise, and even societal

GIS systems. This architecture, coupled with the geodatabase, gives developers the tools to assemble intelligent geographic information systems [19].

In this thesis, I worked with two of the components of ArcGIS, ArcSDE and ArcIMS. ArcSDE (Arc Spatial Data Engine) is the GIS gateway to relational databases. The SDE can be used to access and manage the GIS data stored in the geodatabase; it mainly serves as an application server that delivers spatial data to many users and applications [9]. I used ArcSDE to integrate spatial and non-spatial data into an Oracle database.

The ArcIMS (Arc Internet Map Server) is web publishing software; it has a well-constructed component architecture which consists of the spatial database, the application server, the manager component, and the web server along with the ArcIMS connectors. The details of these components will be described in Chapter 5. Using the ArcIMS, the GIS content provider designs and publishes interactive web pages using the manager component. The manager generates web pages that are stored in the web server. These web pages interact with the application server in XML requests/responses [10]. I used ArcIMS in order to publish our maps through the Internet.

2.2 Landfill project

As a result of odor complaints received, Jefferson Parish County has developed a program to investigate and gather data relative to the odor complaints. This program has been developed in conjunction with the management staff of the Jefferson Parish Department of Environmental Affairs and is the result of a year-long investigation conducted by CDM, Inc. CDM is a consulting, engineering, construction, and operations firm that delivers services to public and private clients worldwide.

Strategies have been implemented in an attempt to reduce landfill odors, and similar measures have been employed successfully at other landfills throughout the country [11]. The strategies being tested include: (1) Odor Control Management Practices, (2) Topical Application of Odor Control Chemicals by Water Truck, and (3) Application of Chemicals via Misting System.

In the Odor Control Management Practices a software solution has been provided by the project team. A complaint tracking and odor monitoring information Web-based system (Web Data Collector system) has been developed, and is now currently being utilized. This system contains the tools for capturing the information that is stored in a database. Rather than relying on hard copy paper forms for data recording, the system provides a much more effective method of entering and managing data. The Web Data Collector system is currently being used by the landfill inspectors for data entry and is used by CDM personnel for data management and analysis.

The project team decided to develop this system for the purposes of providing:

- the landfill inspectors with an easy means of recording and submitting data to the main CDM office in New Orleans
- an efficient means of recording and tracking odor complaints and inspections
- environmental engineers at the main office with an effective way to store, manage, analyze, and present the recorded data.

The architecture of the system will be explained with detail in Chapter 4. There are three sets of information being collected and maintained with the system: (1) odor complaint information, (2) odor monitoring information, and (3) meteorological information.

Odor complaint information refers to the data recorded by the inspectors when a complaint is received. The data recorded includes: time of complaint, complainant name, address, contact information, odor type, and odor intensity. Odor complaint information also includes information recorded during the response to the complaint, such as response time, odor type, and odor readings at various locations.

The odor monitoring information refers to all data recorded on a daily basis for the odor inspections at and around the landfills. These data include odor intensity readings at odor checkpoints, cover inspections, sludge inspections, and chemical counter agent specifics.

The meteorological information is collected from the weather station in the scale office located at the landfill/county is proprietary. Unfortunately, it is not currently possible to remotely connect the Web Data Collector system to the weather station for a direct download of the weather data, due to security issues. This problem has been solved on a monthly basis when the weather data is manually exported from the weather station and imported into the database of the Web Data Collector system.

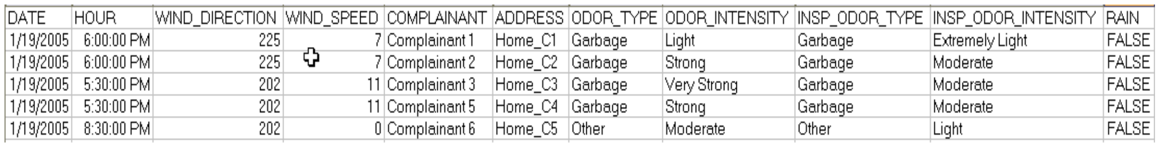
The data collected with the systems is being used in a number of ways. One of the benefits of using the system is that the database can be used in order to extract the information based on defined criteria. One example of this would be finding the number of complaints during given time periods. Queries have also been used to extract information in order to compare the number of complaints with meteorological data. Another aspect of using this system is the ability to translate the data collected onto GIS maps. This point will be explained in the next section.

The Web Data Collector system has provided a better way to record and centralize the information. Its database is used to generate different reports that are useful resources in the analysis to find potential solutions to landfill odor problems.

2.3 *Actual process for constructing a complaints map*

The database that contains the collected information at the landfill is used as a means to obtain different kinds of reports. A large number of types of report have been created, including charts that represent the total number of complaints generated at a given period of time, charts showing according to the wind speed how many complaints have been reported at a period of time, and charts that classify the number of complaints by odor type and odor intensity.

A good source for generating GIS maps is the report matching complaints with the corresponding wind direction and wind speed at the time the complaints were received (Figure 2.2). A GIS specialist translates this report into a GIS map, where wind vectors are drawn according to wind direction from the perspective of the complaint locations. Although wind direction can vary greatly, and does not always travel in a perfect straight line, this gives us some insight about possible odor sources.



DATE	HOUR	WIND_DIRECTION	WIND_SPEED	COMPLAINANT	ADDRESS	ODOR_TYPE	ODOR_INTENSITY	INSP_ODOR_TYPE	INSP_ODOR_INTENSITY	RAIN
1/19/2005	6:00:00 PM	225	7	Complainant 1	Home_C1	Garbage	Light	Garbage	Extremely Light	FALSE
1/19/2005	6:00:00 PM	225	7	Complainant 2	Home_C2	Garbage	Strong	Garbage	Moderate	FALSE
1/19/2005	5:30:00 PM	202	11	Complainant 3	Home_C3	Garbage	Very Strong	Garbage	Moderate	FALSE
1/19/2005	5:30:00 PM	202	11	Complainant 5	Home_C4	Garbage	Strong	Garbage	Moderate	FALSE
1/19/2005	8:30:00 PM	202	0	Complainant 6	Home_C5	Other	Moderate	Other	Light	FALSE

Figure 2.2 A match of complaints with its corresponding wind direction and wind speed.

In the construction of the map, the GIS specialist uses ArcView 3.x and ArcMap 9.x tools. This technology is GIS software created by ESRI Company. ArcView 3.x is an older version of the ESRI software; however it provides access to scripts, macros, and tools that are sometimes not readily available for use with the current versions [8]. In ArcGIS, a map is created using ArcMap, in which a set of layers that containing different features are overlaid with one another [12].

A map of complaints usually contains the following layers:

- Addresses – All the existent addresses in Jefferson Parish
- Jefferson Parish landfills
- Street lines – the limits of the streets in Jefferson Parish
- Addresses of the complainants – the locations of each complainant home
- Wind vectors – the lines representing the complaint and its wind direction at the time the complaint happens

During different periods of time complainant locations will change. This makes it necessary to create a new match of complaints, with complaint locations and wind vectors each time a new set of complaints is needed. The rest of the layers don't suffer any changes, they are static. The process for creating the GIS map entails the following steps:

1. Create a match of complaints.
2. Export the result in an Excel spreadsheet file (.xls).
3. Convert the xls file in a dbf (dBase database format) file.
4. Import the dbf file into ArcMap.
5. Using the ArcMap Geocoding tool, geocode all the addresses of the complainants and create the layer of points file (this is the layer of the complainants addresses). Geocoding is the process of creating geometric representations for description location [12].
6. Export the layer of complainants' addresses file from ArcMap and import it into ArcView 3.x.

7. In ArcView 3.x, run the script for drawing the wind vectors over the layer of complainants' addresses. The script is written in Avenue which is the object-oriented program native to the 3x versions of ArcView [13]. This script receives as input the layer of complainants' addresses which contains the starting point of the vectors. The GIS specialist indicates to the script that the attribute of the complainants' addresses layer to be used as the lines' bearing is the wind speed.
8. The wind vectors are created as graphics that will be converted into a layer of lines.
9. Export from ArcView the layer of wind vectors, and import it into ArcMap.
10. Use ArcMap for creating a map with the layer of complainants' addresses, the layer of wind vectors, and include the static layers.
11. Save in ArcMap the project that will contain all the layers for display in the map of complaints. The GIS map will show the match of complaints with its corresponding wind direction and wind speed at the time the complaints were received (Figure 2.3).

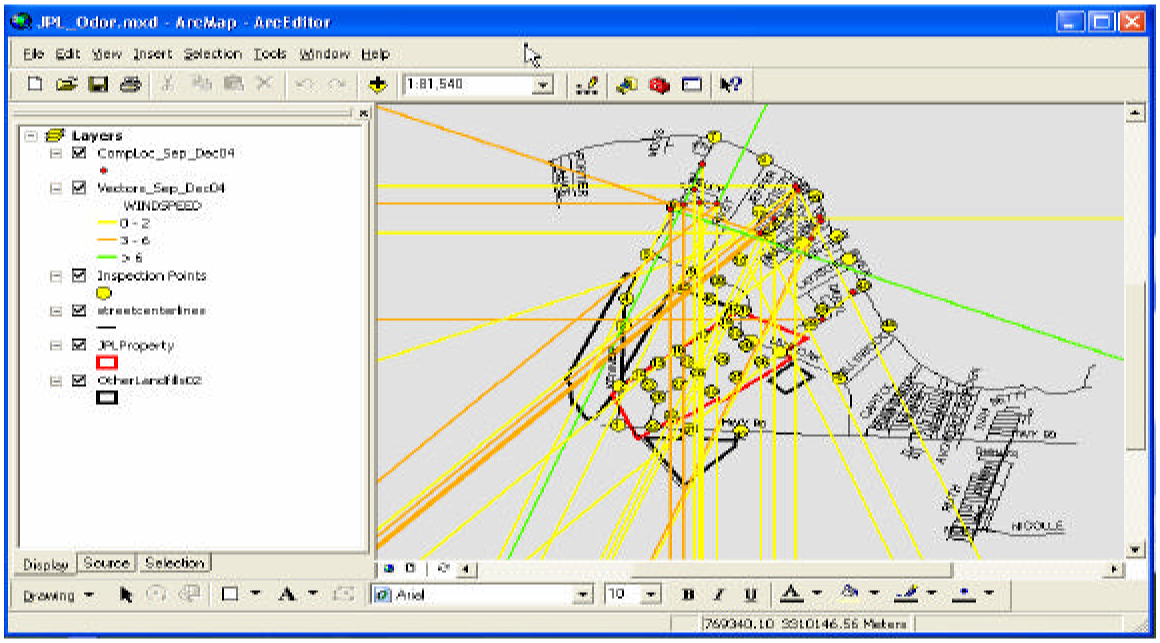


Figure 2.3 Complainants Map from September to December 2004.

Each time a complainants vector map is requested for showing a different period of time, the steps mentioned above must be executed by the GIS specialist. He has to go back and forth from ArcView to ArcMap many times, and has to repeat the entire process each time a new map is needed. This makes the process very laborious and it can take multiple hours of work to complete.

We have found that this process can be automated and this solution will give us the benefits of: (1) completing the above steps in a few minutes, (2) publishing it on the Internet, and (3) allowing the results to be examined by people that do not have GIS expertise. Our automation will include the integration of tabular and geographical data with two of ESRI's GIS products ArcSDE and ArcIMS.

Chapter 3: Related Work

In the Internet era, Geographical Information Systems (GIS) are often the convergence point that integrates all kinds of spatial attribute data into the models -- the layers of information in various themes. The layers can be superimposed upon each other, revealing complex spatial relationships between variables. Thus, GIS have become an integral tool in many applications including environmental management systems [16].

In this chapter we will describe two GIS projects that have been implemented by others. They are: (1) an ArcIMS system for city parcel mapping and (2) a set of GIS applications to manage and disseminate emissions activity data. We studied from these projects the approach used for publishing GIS data on the Internet.

3.1 An ArcIMS System for City Parcel Mapping.

This project refers to the construction of a land parcel management application created for the City of Winona. Using Geographic Information Systems (GIS) and other mapping software, the Geospatial Service Center (GSC, Department of Resource Analysis, St. Mary's University) developed an intranet based parcel mapping system to allow all employees to access the parcel data. The project's goals were: (1) to implement an intranet based parcel viewing and querying system that would allow city employees to obtain information about city parcel data; (2) to demonstrate the effectiveness and efficiency of Internet GIS access to city officials as a means to make city data available to the public [20].

The project was completed using a variety of software products, including ArcIMS, ESRI's Site Starters applications (Web-based Active Server Pages templates), Microsoft Access, and ArcView 3.2. They also use ArcIMS ActiveX Connector for allowing GIS data and maps to be integrated into existing ASP applications, Microsoft's ActiveX controls and Internet Information Services (IIS) were also used.

The project went through the following stages:

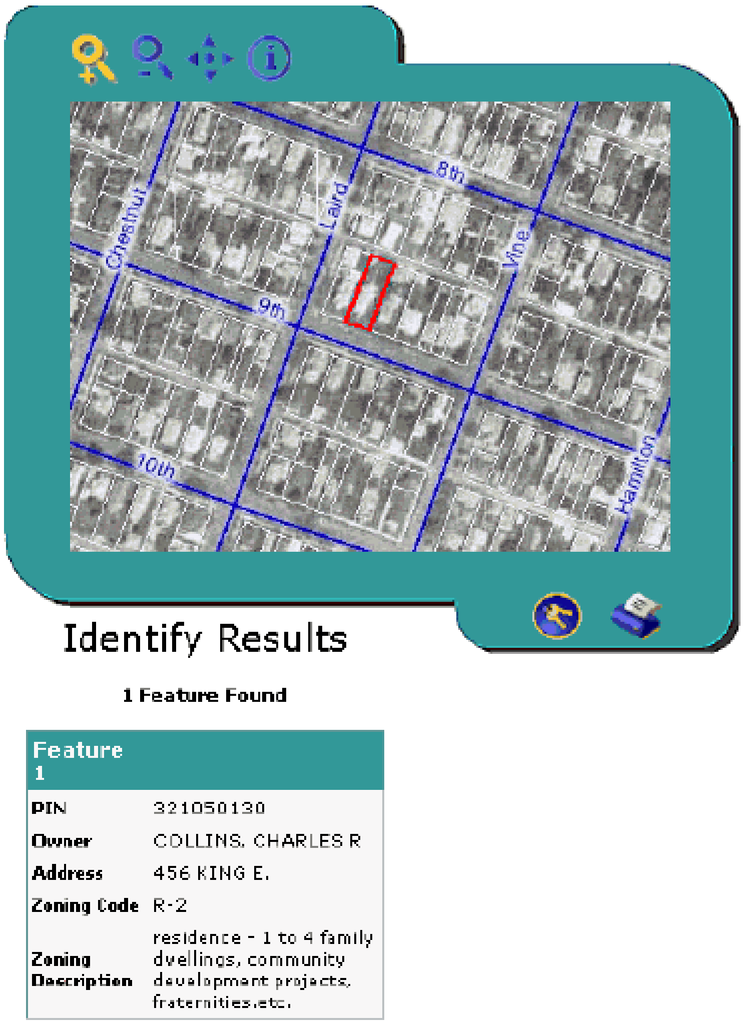
1. identification of the data to be used
2. preparation of the data for being used in the maps
3. development of the content map
4. creation of an intranet viewer application
5. the creation of an intranet based application that includes three types of searches (the Parcel Identification Number (PIN), owner name or address)
6. integration of the tools in a homepage

The project embraced the following specific coverages: the Winona County parcels coverage, Winona County roads coverage, Winona City limits coverage, Winona City zoning coverage and the Winona Rivers and Lakes coverage. These coverage files were converted into shapefile format and used by ArcView 3.2 and ArcIMS. In addition to the GIS data, there were three tables containing information relating to the parcels shapefile. These three tables stored the property, legal and owner information into the database.

For preparing the data to be used in the maps, the project team used ESRI's Geoprocessing Wizard to clip out the parcels of the City Limits from the shapefile. Using the Edit Tools extension, they transferred attributes from the zoning shapefile to the parcels shapefile. The final step in data preparation included creating an image catalog of the aerial photographs for Winona County.

Once the data was ready, they developed the content of the map using ArcIMS Author tool. The data layers added to the map frame were the parcels, roads, city limits and rivers and lakes shapefiles. The image catalog was added to the map by manually editing the map configuration file in a text editor. Having the file configuration of the map, they create an Image Map Service using ArcIMS Administrator tool. For the Website they used ArcIMS Designer tool.

In the next stage of the project they created an intranet viewer application that would allow a user to obtain parcel information by clicking on a feature button on a map. When a parcel is clicked on a map, the Parcel Identification Number, Address, Owner Name, Legal Description, Zoning Code and Zoning Description would be returned. In order for this to function correctly, they required to edit the parcels shapefile several times. Using Microsoft's Internet Information Services Manager (IIS), a virtual directory (viewer) was created hosting the viewer data folder containing all of the viewer files (Figure 3.1).



Identify Results

1 Feature Found

Feature 1	
PIN	321050130
Owner	COLLINS, CHARLES R
Address	456 KING E.
Zoning Code	R-2
Zoning Description	residence - 1 to 4 family dwellings, community development projects, fraternities.etc.

Figure 3.1 Viewer Application and identification results [20].

This project also included the creation of an intranet-based application that would allow a user to search for a parcel based on Parcel Identification Number (PIN), owner name or address. Because three different types of searches were allowed, the Site Starters searches the application files and extracts them to three different folders (pin, owner and address). They developed a search application for each type of search. Finally, using Microsoft's Internet Information Manager (IIS), three directories were creating pointing to the three different search application folders.

A homepage was created for integrating the viewer and the three search applications. The homepage was also designed to create an easy to use interface and help dialog for those not familiar with GIS.

The Winona land parcel management application is a successful GIS application. In this project, we can see that using the applications of the ArcIMS suite and other ESRI products developers can integrate non-spatial and spatial data, and provide GIS functionality without the logistical costs. One of the advantages of this application is that it makes accessible the information through the Web. This reduces the time of processing the information and gives a more efficient service to the community. Another advantage of this application is that it does not require the users to be GIS experts to operate the system by providing user-friendly Web pages for the city employees. However, the access to this application is limited to an intranet where only city employees accessed it.

3.2 GIS Applications to Manage and Disseminate Emissions Activity Data.

The California Regional PM10/PM2.5 Air Quality Study (CRPAQS) is a multi-year program involving meteorological and air quality monitoring, emission inventory development, data analysis, and air quality simulation modeling. In the development of the database that supports managing emissions activity, Sonoma Technology, Inc. (STI) gathered and processed information from public records, commercial databases, and government sources to characterize activity patterns throughout the CRPAQS domain. They compiled all the collected information using ArcInfo over the Microsoft Access, and spatial resolved information about the emissions activity into the databases that are compatible with Geographic Information System (GIS) software [21].

This project included the creation of an Internet application, through which all the research teams can browse and query GIS data, logs, and an on-line archive of digital photographs. The Internet application is called the CRPAQS On-line Atlas (Figure 3.2) with Regional and Site-specific Events (COARSE). The COARSE application is a Web site with interactive mapping tools and options that allow users to explore and download information from the CRPAQS emissions activity databases. ArcIMS, was used in conjunction with the Web programming tool ColdFusion in the development of the applications.

The CRPAQS emissions activity data collection phase involved gathering and processing (1) short-duration emission events data that may impact CRPAQS air quality measurements and (2) highly resolved activity data in the immediate surroundings of selected CRPAQS monitoring sites [21].

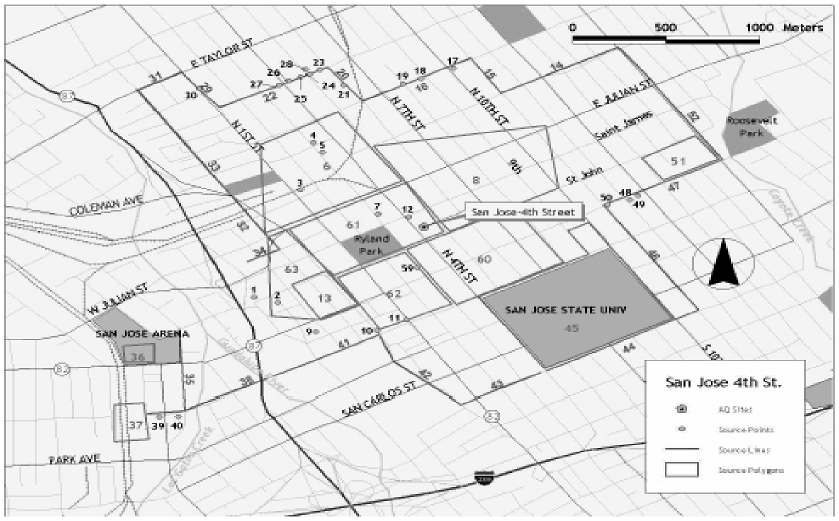


Figure 3.2 Example of spatial emissions activity information contained in the Atlas of the CRPAQS [21].

Once the collected data were placed into ArcGIS format, processed, and to assure the quality, the COARSE (Figure 3.3) Internet application was deployed. The COARSE Internet application enables users to query and display emissions activity data for 24 CRPAQS monitoring sites. The application interface includes mapping, navigation, data query tools, and access to data archives (i.e., on-line movie archives).

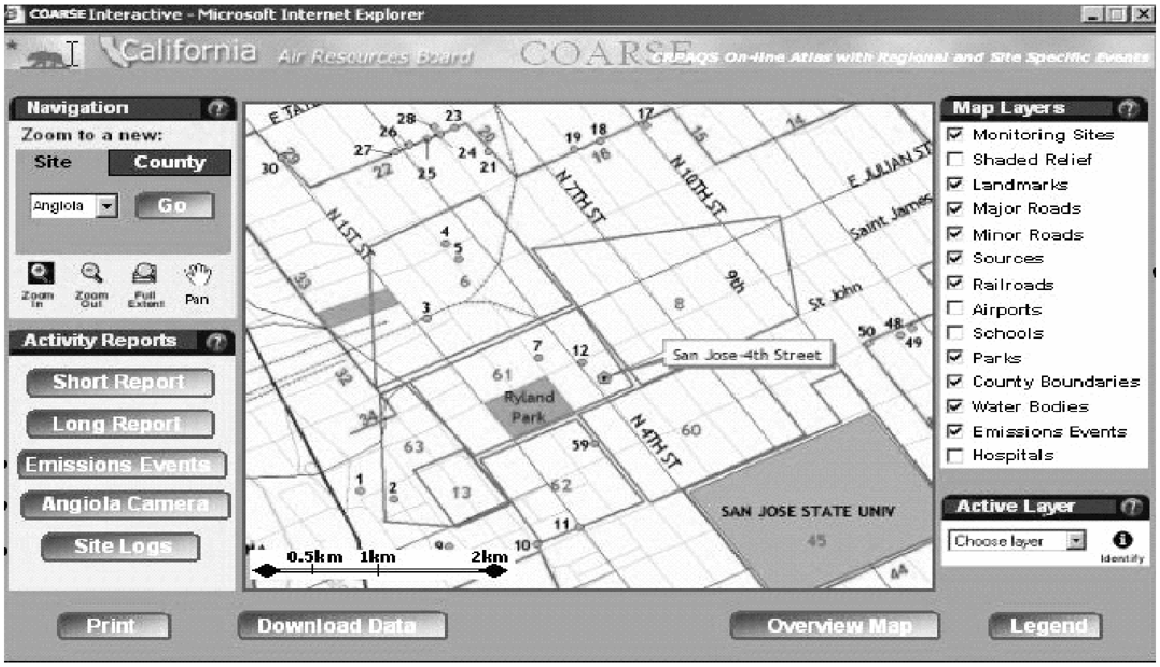


Figure 3.3 COARSE [21].

The CRPAQS On-line Atlas and the COARSE applications are good examples of GIS applications that show how GIS technology can be used in environmental studies. CRPAQS had a well designed database of spatial and non-spatial information that has been used as a good source for sharing the information through the Internet among research teams that are responsible for the analysis and interpretations of the air quality. In COARSE, I observed that the use of the ArcIMS suite facilitated the creation of the Web applications that publish maps through the Internet. These maps disseminate the air quality information of any user chosen locations. They are very intuitive and easy for non-GIS experts to use.

There are hundreds of GIS applications for environmental studies. I have chosen the above two because their usage is very similar to that of our project, even though we have utilized different technology – Java-based components. A similar feature is that the systems all emphasize on publishing dynamic information, the daily observation data.

Chapter 4: System Design

The work reported in this thesis is the result of working in conjunction with the CDM staff on a year-long investigation of odors from Jefferson Parish landfills. When I joined in this project, a simple Web application was in place. It is called the Web Data Collector. This system provides the landfill inspectors with an easy means of recording and submitting data to the main CDM office in New Orleans. It is also used as an efficient means of recording and tracking odor complaints. This Web application has been providing the environmental engineers at the main office with an effective way to store and manage data. To support engineering analysis, the odor complaint data were manually converted into maps using a GIS desktop application, ArcView.

Based on my experience in maintaining and enhancing the Web Data Collector system and my studies on the GIS integration technologies, I successfully developed a solution that automated the process of generating the odor complaint maps. Furthermore, I enhanced this solution to include visualization of the landfill inspection data. In this work, I have combined the information collected from the Web Data Collector and the geographical information of the area, and generated map layers of the odor complaints and the odor inspections. In this project, I have been using the COTS(Commercial Off-The-Shelf) GIS software products ArcIMS and ArcSDE, in order to publish the resulting maps to the Internet and manage the digital map at the enterprise level. The programs produced in this project are helpful in the study and analysis for finding potential solutions to the odor problems.

I believe that, in implementing this system, I have established a general-purpose framework for integrating the data that are bound to geographic coordinates into digital maps. The interaction of all the components of our system is reflected in our Web application. The results are delivered to two types of viewers, the HTML Viewer and the Java Viewer. Our design considers the following features:

- integration of spatial and non-spatial information
- construction of a web application
- integration of the web application with the ArcIMS viewers

At the system level, my design follows the Model-View-Controller pattern that leads to its flexibility. In this chapter, I will first describe the Web Data Collector System, and then the architecture of my automated map service system and discuss the design decisions that led to the system.

4.1 Web Data Collector.

The Web Data Collector consists of a database and a number of JSP forms which provide the landfill inspectors with the ability to enter their collected information into a Web page form. When a form is submitted by the inspectors, the JSP calls a servlet which processes the data and inserts them into the database. The JSP forms and the servlet are deployed in an Apache TOMCAT version 5.0 server.

The database was designed and implemented in Microsoft Access 2000. It is a typical relational database. The data model is shown in Figure 4.1, which is in the Third Normal Form, Loss Less-join and preserves the functional dependency. The dynamic data are inserted and updated by a component based on JDBC. This component handles all the database communication required for the application. Figure 4.1 shows a diagram illustrating the structure of the system.

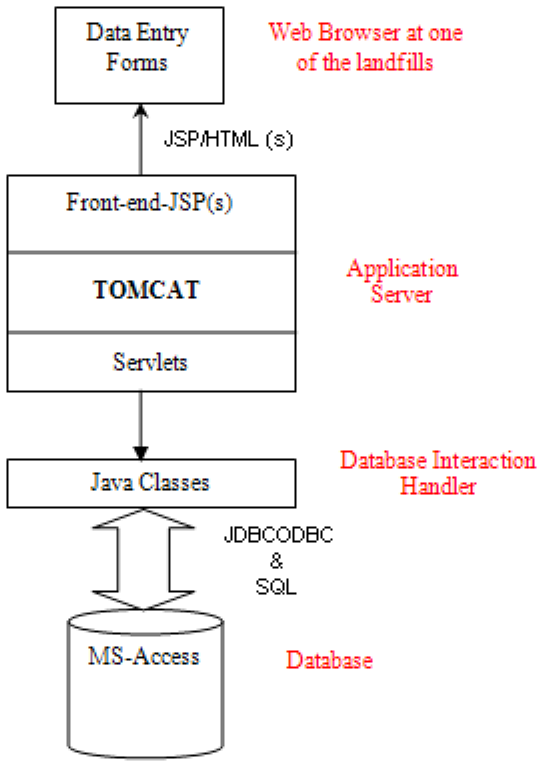


Figure 4.1 Architecture of the Web Data Collector.

4.2 The Model-View-Controller Architecture of the Web Map Application.

The Model-View-Controller (MVC) pattern is one of the most profound and earliest one in the software design patterns establishment. It is a widely applied in interactive applications. It divides functionality among objects involved in maintaining and presenting data to minimize the degree of coupling between the objects. The MVC pattern brings traditional application tasks--input, processing, and output--to the graphical user interaction model. The MVC model is also rigorously applied to the multi-tier Web-based enterprise applications [24].

The architecture followed by the MVC pattern (Figure 4.2) divides applications into three layers--model, view, and controller--and decouples their respective responsibilities. Each layer handles specific tasks and has specific responsibilities to the other areas.

- A model represents business data and business logic or operations that govern access and modification of this business data.
- A view renders the contents of a model. It accesses data from the model and specifies how that data should be presented. It updates data presentation when the model changes. A view also forwards user input to a controller.
- A controller defines application behavior. It dispatches user requests and selects views for presentation. It interprets user inputs and maps them into actions to be performed by the model. In a Web application, user inputs are HTTP GET and POST requests to the Web tier. A controller selects the next view to display based on the user interactions and the outcome of the model operations.

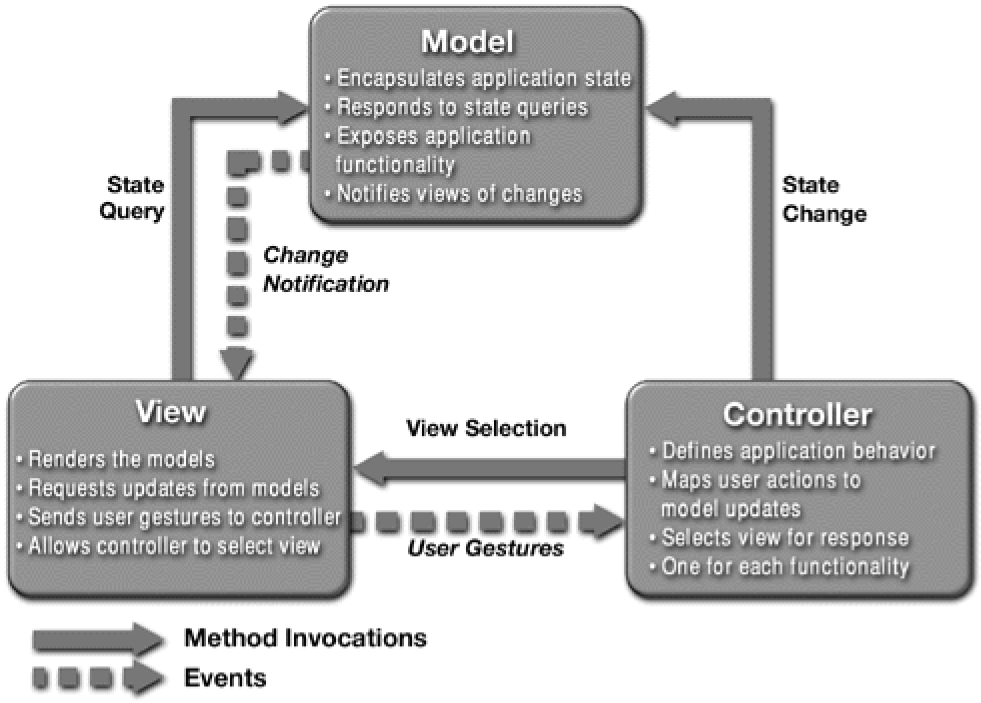

Model
• Encapsulates application state
• Responds to state queries
• Exposes application functionality
• Notifies views of changes
State Query
Change Notification
State Change
View
• Renders the models
• Requests updates from models
• Sends user gestures to controller
• Allows controller to select view
View Selection
User Gestures
Controller
• Defines application behavior
• Maps user actions to model updates
• Selects view for response
• One for each functionality
Method Invocations
Events

Figure 4.2 Model View Controller Architecture [24].

In our system (Figure 4.3) the “Model” Layer are corresponding to the business objects. The business objects handle the data stored in the database, the objects managed by the ArcSDE server, and the objects that create and manage the images services. The database stores the non-spatial data that refers to the information recorded at one of the landfills for the odor complaints and odor inspections. The ArcSDE server stores and manages the geographical information associated with the odor complaints and inspections. The ArcSDE also stores all the data in the same database (an Oracle database). These business objects are in charge of extracting and updating the data (Section 5.4.1 provides the implementation details). The objects that work with the image services communicate with the ArcIMS Spatial Server in order to request, add, or remove any image service (Section 5.4.3 provides more details).

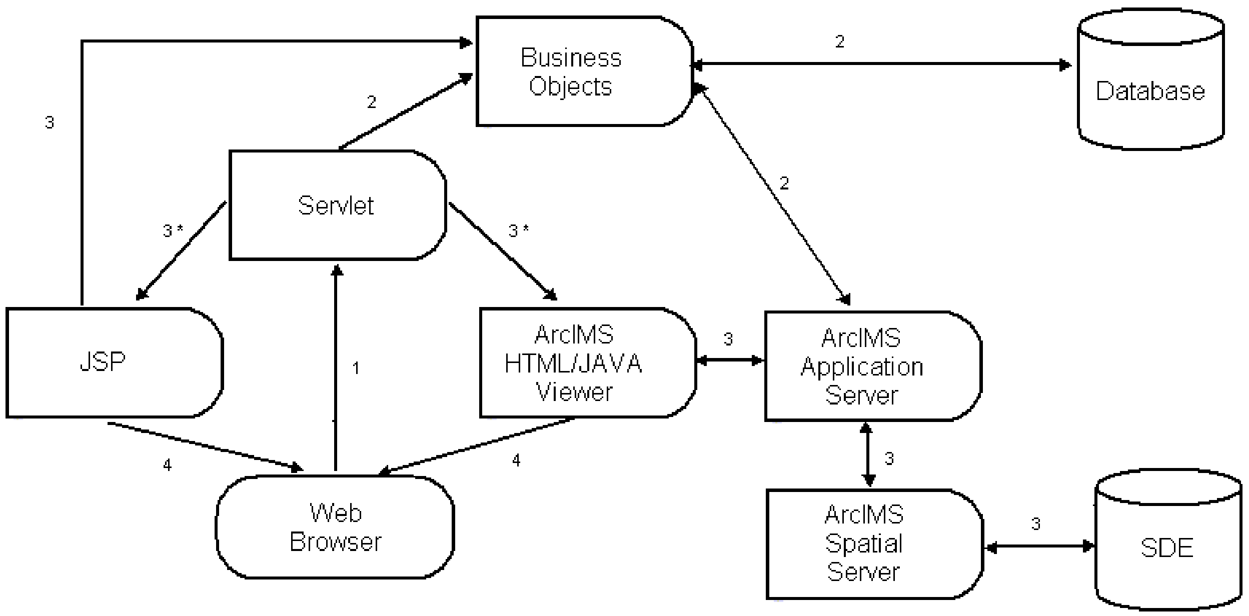


Figure 4.3 MVC approach (3* indicates that the servlet can invoke the JSP or the ArcIMS HTML/JAVA Viewer).

In our design, the “Controller” Layer consists of the Servlet program that handles the users’ requests. When the Servlet gets the result from the business objects, if the result refers to an error, then the Servlet redirects the control to the JSP. Otherwise, the Servlet invokes the ArcIMS Viewer.

One of the characteristics of the GIS application is the complexity of the viewers. As mentioned in the Background chapter, maps are composed of multiple Layers. The Layers can be of images or vector data that have been rendered dynamically. To handle all the complexity effectively, we have chosen the Leading GIS software products ArcIMS. Thus my tasks have been shifted to integration and adaption: to collect to data sets from different resources, to specify the data sources, to configure the viewer, and to create and activate the map services for Web publication. For the viewer we are using two views the HTML viewer and the Java Viewer. Once the users get into any viewer all the control is delegated to the ArcIMS Application Server which handles all the requests related with the map displayed in the viewers.

4.3 Integrating the COTS GIS Software Products into the System

In our system, we decided to use ArcIMS for creating the maps. Using the ArcIMS Java Connector API, we were able to establish the communication with the ArcIMS Server Application and the ArcIMS Spatial Server in order to construct the Image Services of our maps. We used ArcSDE to store the geographical data associated with the odor complaints and the odor inspections.

4.3.1 ArcIMS Architecture

ArcIMS is a GIS solution which allows us to build and deliver maps, data, and tools over the Internet. ArcIMS makes it possible to share information and data with Internet users. ArcIMS is also a flexible and scalable tool to publish maps and develop applications [10].

ArcIMS runs in a distributed environment and consists of both client and server components (Figure 4.4). The ArcIMS HTML Viewer and the ArcIMS Java Viewer are the client-side components. On the server side, the ArcIMS provides three different types of services. The ArcIMS Spatial Server, the ArcIMS Application Server, and the ArcIMS Manager, as well as the ArcIMS Application Server Connectors (for Java, ColdFusion, and ActiveX) [10].

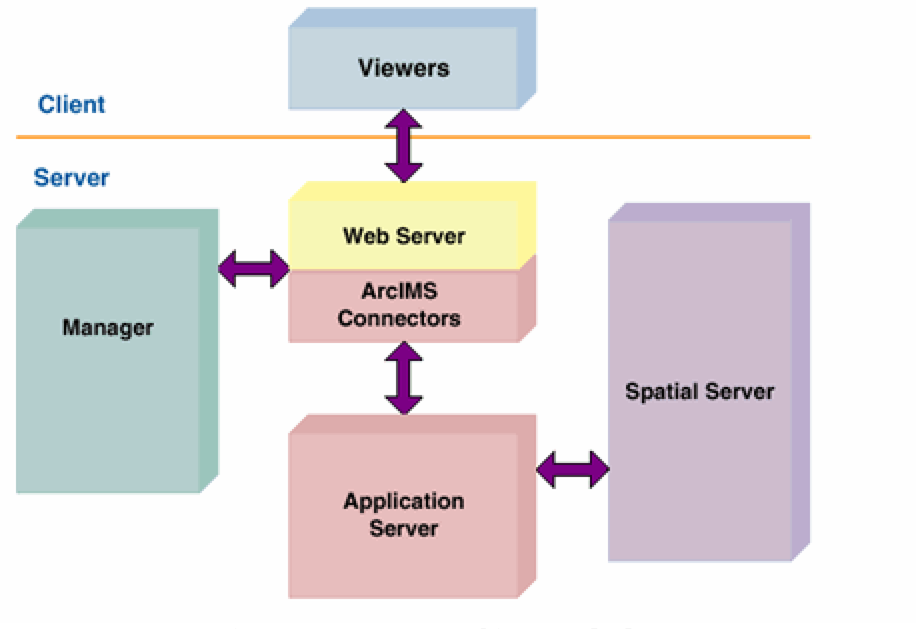


Figure 4.4 ArcIMS Architecture [10].

4.3.2 Spatial Server Architecture

The ArcIMS Spatial Server (Figure 4.5) is the backbone of ArcIMS. It processes the requests for maps and the related information. The Spatial Server can perform seven services such as the Image, Feature, Query, Geocode, Extract, Metadata, and Route services.

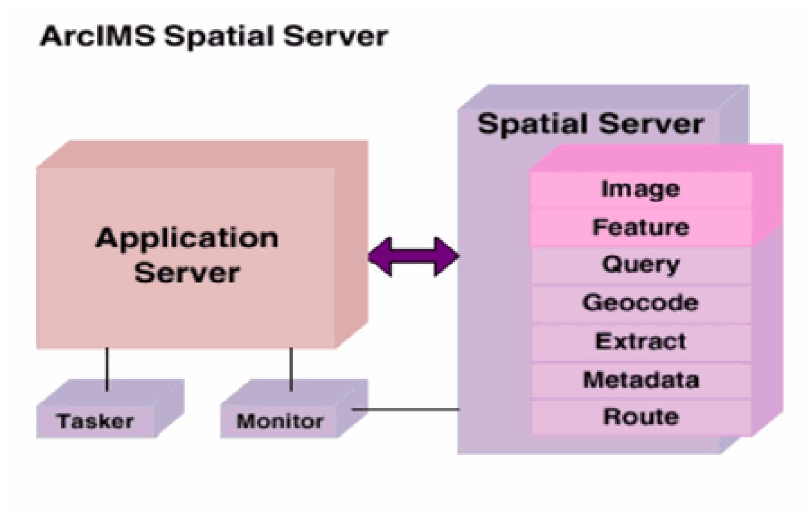


Figure 4.5 ArcIMS Spatial Server [10].

The ArcIMS Spatial Server works with multiple Spatial Services through the use of Virtual Servers. Virtual Servers group a number of Spatial Servers together and define the types of requests that will be processed by them. The following six Virtual Servers install with ArcIMS are the Image, Feature, Metadata, Geocode, Query, and Extract virtual servers [10].

The Image and Feature Services are used to publish maps over the Internet. The Image and Feature Services may appear similar in a Web browser. However, an Image Server sends snapshots of a map to the client, while a Feature Server streams map features [10]. The choice of the Virtual Servers depends on two factors: (1) how the developer wants to deliver the map to the users (as images or as streamed features), and (2) the level of functionality that the developer wants to provide. In the implementation of our system, we chose to use the Image Server; our system creates map images that are displayed on the client's browser. This way requires the least configuration on the client side.

The Image Server accepts shapefiles (layers), ArcSDE, and image data. It uses information about data layers to create complete map images. The map configuration files (the files with .axl extension) contain the information about the map content and symbology. The creation of an Image Service involves registration of a map configuration file with the ArcIMS Application Server. When a user requests an Image Service, a map image is created on the ArcIMS Spatial Server, and then sent to the client. A new map image is generated upon each client's request. The image can be sent to the client in one of the three formats – as a JPEG, GIF, or PNG file [10].

Using the ArcIMS Java Connector API, I implemented a Java Bean that communicates with the ArcIMS Application Server. Through the Application Server, we get access to the Image Spatial Server. Once we have opened this channel of communication, our bean will be able to request, add, or remove an Image Service (Figure 4.6). In our system each time users request a map of complaints for a given period of time, an Image Service is called in order to show the map.

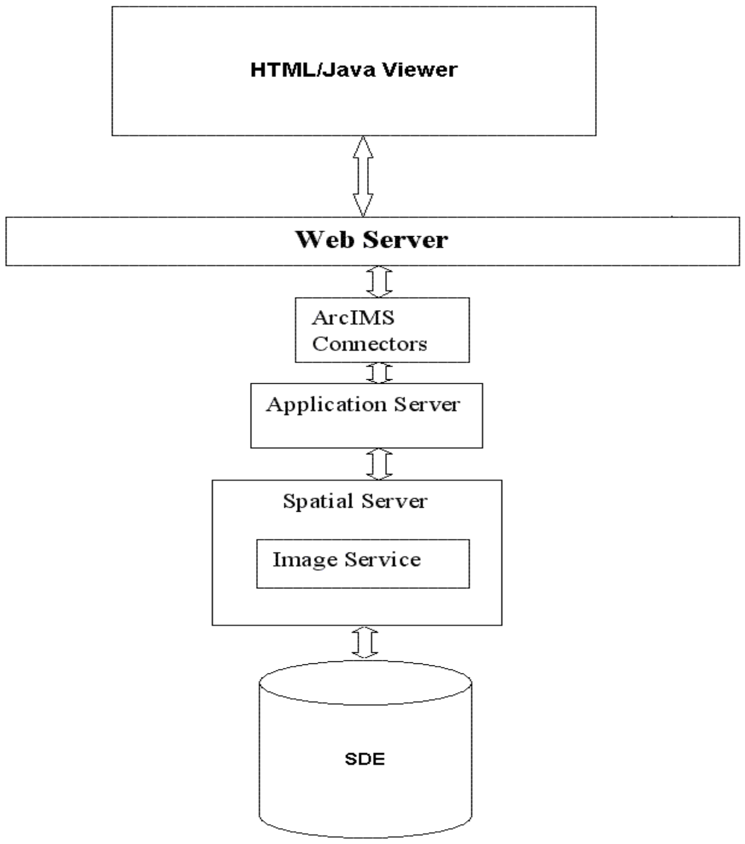


Figure 4.6 Communication with the ArcIMS Spatial server.

4.3.3 Adapting the ArcIMS Viewers to Our System

In the implementation of our system we decided to provide users with two different ways for displaying a map. We use the two viewers that come with ArcIMS: the HTML Viewer and the Java Viewer. Using ArcIMS Designer tool we constructed two Web applications: one based on the HTML Viewer, and the other one based on the Java Viewer. In order for making these viewers work with different map images services, I had to make some modifications for them.

4.3.3.1 HTML Viewer

Using ArcIMS Designer, we create output files including the HTML and JavaScript files (.js) that form the foundation of the HTML Viewer. These files are allocated in the directory structure depicted in Figure 4.7. The HTML files are used to deliver the Web page content; the JavaScript functions allow for the user to interact with the map [22].

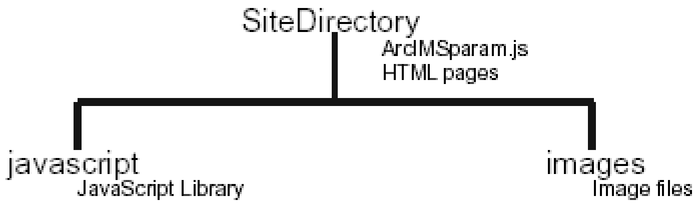


Figure 4.7 Directory Structure of the HTML Viewer [22].

For our HTML Viewer, we modified two files. Since ArcIMSparam.js is the javascript file that contains a set of variables that affect the Web pages look and behavior, we modified it as described in Section 5.5.2. We converted the Viewer.htm into Viewer.jsp file. The Viewer.jsp receives as a parameter the name of the Map Image Service to display; this will let our HTML Viewer be able to load different Image services as described in Section 5.5.2. Our HTML Viewer calls the files showed in the sequence as Figure 4.8. The structure of the HTML viewer directory will be a subdirectory inside our Web application defined in the TOMCAT Server (Figure 4.9).

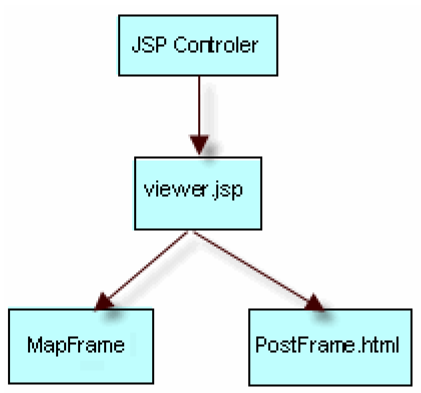


Figure 4.8 Calling Sequence of the HTML viewer.

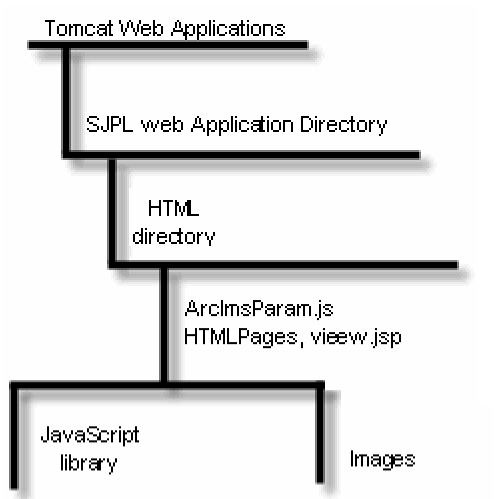


Figure 4.9 File Structure Directory of the HTML Viewer.

4.3.3.2 Java Viewer

Using ArcIMS Designer, we create our Web site based on the Java Viewer. The default Java Viewer is a set of HTML pages and JavaScript files. The HTML files are used to load the component of each Web page, and to interact with the applets. The Java Viewer differs from the HTML viewer by using Java applets to display the map, the legend, and the scale bar, and to send requests to the ArcIMS Spatial Server [23].

In our Java Viewer, we modified three files including the default.js, map.htm, and frame.htm. With the changes we made in these files, our Java Viewer is able to load different Map Image Services. In the case of the frame.htm, we converted it into frame.jsp. The frame.jsp will receive the name of the Image Service to be displayed as a parameter. It passes this datum to the default.js and the map.htm. (Section 5.5.2 will provide more details.)

The sequence of how the files are called in our application is shown in Figure 4.10.

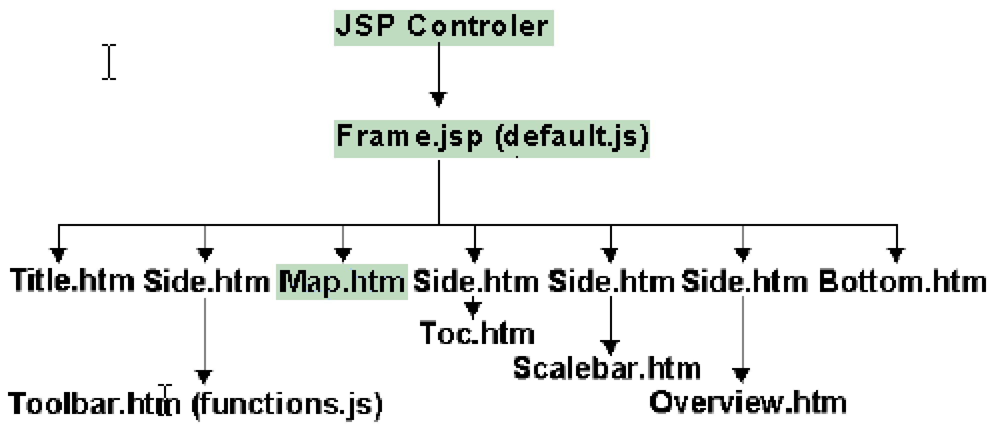


Figure 4.10 Sequence in which the files of our Web site are called.

Since our Web application is able to call different Image Services, this implies that the directory in which resides the files of the viewer will also contain the axl file associated with the Image Service. The map.htm file calls for the map applet (the IMSApplet). The map.htm sets the parameters to invoke the IMSApplet including the applet name, Java version, and the configuration (*.axl) file associated with the ImageService to load into the IMSApplet. The new map will be displayed in our viewer. The directory of this application contains the html files, the frame.jsp, default.js, other javascript files, and the axl files. The axl files refer to all the Image Services that will be called using our modified Java Viewer. The directory structure of our Java Viewer is shown in Figure 4.11.

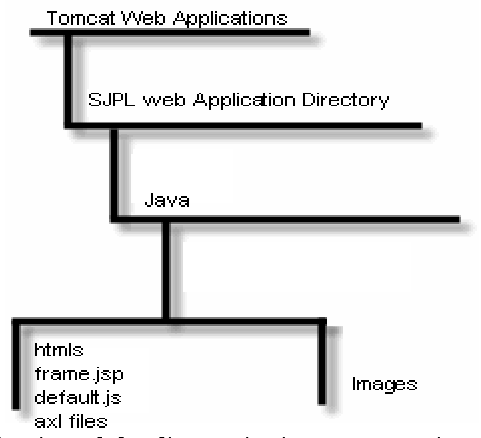


Figure 4.11 Organization of the directories in our Java Viewer web application.

Chapter 5: Implementation

In this thesis work I have automated the process of creating dynamic map layers that represent the reported odor problems around the Jefferson Parish landfills. Our approach is to integrate the existing information into an off the shelf software (COTS) product ArcIMS and Web maps. Users will have a Web tool in which they select the period of time that they need to review. Once the map is displayed, they will be able to query specific information interactively.

In our system, a map consists of a number of layers and is specified by a configuration file that makes the requests for the layers to the ArcSDE server. The map configuration file is in the ArcXML language. Our ArcSDE server stores and manages all the map layers. The layers are classified into static and dynamic. The static layers are those that do not change often. These layers include the addresses, the street divisions, and the three Jefferson Parish landfills of interest. The dynamic layers are the layers that will constantly change. Each time a user request a map that includes a new period of time, our process will insert the information on the layers extracted from our Oracle Database.

Having the layers specified by a configuration file, we will run the process that creates a new ArcIMS service. In our web application users will have the option to request either an existing map or a new map. The existing map has an ArcIMS service running on the ArcIMS Application Server. In this case, the user can decide if he wants to regenerate the information. If the user request is referring to a new map, the process will include extracting the information from the database, inserting it into the layers, creating a new configuration map file, creating a new ArcIMS service, starting the ArcIMS service, and calling up the map. This process will take a little longer than the process of calling up an existing map.

The maps can be viewed by any modern Web browser with some basic features, or by a Java Plug-in for browsers with enhanced interactive features.

I have also provided users with a maintenance Web tool that will be used for handling the Image Map Services. With this tool users can delete an existing map, or modify the map's title. The users' interaction with the tool is very friendly and users do not require any specialized GIS knowledge in using ArcIMS.

5.1 Technology used

In this section, I introduce the technologies used in my project.

5.1.1 ArcSDE server and Java API

ArcSDE is the ESRI GIS gateway to relational databases. SDE (Spatial Data Engine) can be used to access and manage the GIS data stored in the geodatabase, it mainly serves as an application server that deliver spatial data to many users and applications [9]. SDE server is responsible for receiving the spatial data request and serving the client request with spatial data accordingly. SDE server also maintains the data integrity, manage the transaction and tune the overall performance of the spatial data service [26].

ArcSDE uses standard DBMSs to define and manages geodatabases. A geodatabase is a repository of your spatial data inside a DBMS. It contains all of your vector data, raster data, tables, and other GIS objects. The simplest geodatabase is one that contains a number of independent feature layers. Each feature layer can contain points, lines, polygons, or annotations that represent geographic features (objects with location), networks and topology (objects having spatial relationships with other features), annotation features, and other more specialized feature types [27].

ArcSDE server provides a set of APIs for querying and processing spatial information [28, 29]. These include the ArcSDE Client API for C programmers and ArcSDE Client API for Java programmers. These APIs provide GIS functions for advanced application development.

The ArcSDE Java API provides the interfaces to process and analyze spatial information. It contains three Java packages,

1. Client package
2. Geometry package, and
3. Projection package.

Applications created with the client package can establish a connection to an ArcSDE instance, query a layer, and otherwise communicate with an ArcSDE server. The Geometry package contains classes that implement the OGC (Open GIS Consortium) Geometry interfaces. The Projection package provides classes to define coordinate systems and to transform data between different coordinate systems.

5.1.2 ArcIMS and Java Connector API

ArcIMS (Arc Internet Map Server) is a powerful Internet-based GIS tool that enables creating and managing geography-based websites. ArcIMS (Figure 5.1) gives the solution to the Web developers who know little about GIS by deploying the power and functionality of GIS over the Internet [20]. ArcIMS includes the client and the server components. The client side is conformed by the ArcIMS HTML Viewer and the ArcIMS Java Viewer. The server side consists of the ArcIMS Spatial Server, ArcIMS Application Server, the ArcIMS Manager, and ArcIMS Application Server Connectors [10].

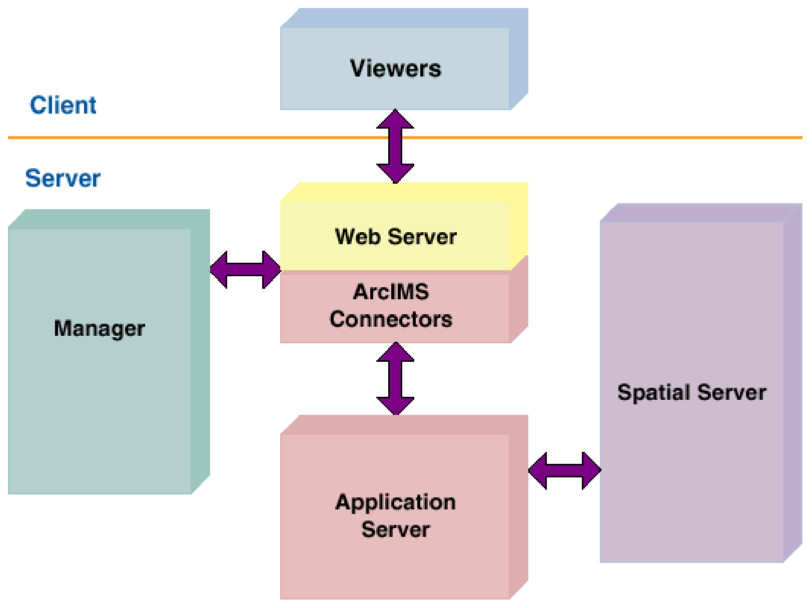


Figure 5.1 ArcIMS Architecture.

The HTML viewer is a lightweight viewer that allows users to interact with a map by using a set of GIS tools [10]. It requires the least client-side processing of the ArcIMS Viewers. The Java viewer has two versions the Java Standard Viewer and the Java Custom Viewer. These viewers are "fat" clients. In order to use the Java Viewers on the client side, the user will have to install a Java plug-in into the browser.

The ArcIMS Spatial Server is the backbone of ArcIMS. The spatial server can accept map request from Internet client. The server forwards the request to ArcSDE server that will in turn access the geo-spatial database and retrieve the spatial data of the interest [26]. The spatial dataset is transmitted back to the server and the server will serve the client with a map. ArcIMS Spatial Server performs the following services:

- Image- creates image files from maps created in either ArcIMS Author or ArcMap
- Feature- streams map features
- Query- searches for features matching search criteria
- Geocode- performs address-matching operations
- Extract- creates shapefiles from selected map features
- Metadata-publishes metadata
- Route-calculates routes between a set of two or more stops

The ArcIMS Application Server handles incoming requests and tracks which services are running on which ArcIMS Spatial Servers. The Application Server hands off a request to the appropriate Spatial Server.

ArcIMS has four applications to help users create and administer web sites. They are: ArcIMS Manager, ArcIMS Author, ArcIMS Administrator, and ArcIMS Designer. ArcIMS Manager is a Web-based application that supports the three main tasks in ArcIMS—map authoring, Web site design, and site administration.

The ArcIMS Application Server Connectors connect the Web server to the ArcIMS Application Server. The ArcIMS Servlet Connector is the standard connector used with ArcIMS. The connectors reside on the Web server computer. The Java Connector communicates with the ArcIMS Application Server via a JSP client or a standalone Java application.

The ArcIMS Java Connector (Figure 5.2) is a set of libraries that includes a JavaBeans^{TM} Object Model Library and a rich set of custom JSP tags supported in the form of a Tag Library.

The JavaBeans and JSP tags libraries help developers to establish communication with an ArcIMS Application Server —via an HTTP, HTTPS, or TCP/IP connection—and begin sending ArcXML requests to it. Once the Application Server receives the request, it processes it and returns the appropriate response [30].

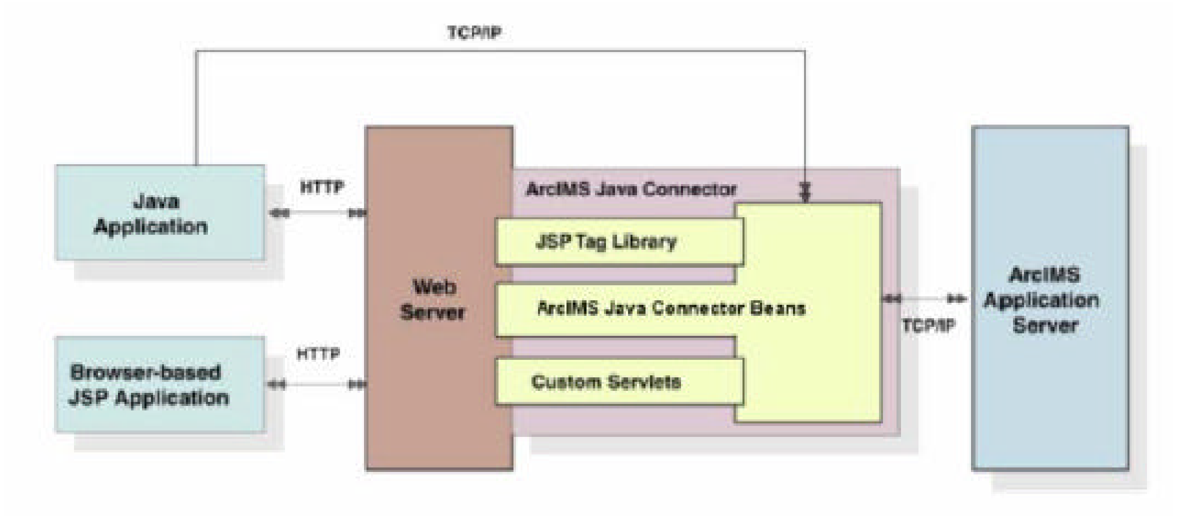


Figure 5.2 Java Connector Architecture [30].

The Java Connector Object Model is a collection of server-side JavaBeans that implement the ArcXML specification. The object model beans and their methods can be used to implement map display functions; perform rendering and symbology; add dynamic layers; and perform feature and spatial queries, address geocoding, projections, and metadata functions.

The Java Connector Tag Library is a collection of custom JSP tags built on the Java Connector Object Model. This library is very helpful for those developers with little or no knowledge of Java since they can easily develop advanced mapping applications or integrate mapping capabilities into existing applications using the JSP Tag Library. Applications developed using the JSP architecture encapsulate the business logic—such as database access, security, and transaction integrity—and isolate it from the underlying complexity.

5.1.3 ArcXML

ArcXML (The Arc Extensible Markup Language) is the protocol for communicating with the ArcIMS Spatial Server. ArcXML works as a built-in map request language based on XML. It is used to handle ArcIMS services, requests, and responses relate to each other and how they interact with the ArcIMS Spatial Server. Figure 5.3 is a diagram showing the interaction between the ArcIMS Spatial Server and configuration files, services, requests, and responses.

The communication to the ArcIMS server in ArcXML is performed in four steps:

Step 1. Developer creates a configuration file.

Step 2. Developer uses ArcIMS Administrator to start an ArcIMS Service on the ArcIMS Spatial Server. The configuration file from Step 1 is the input to the service.

Step 3. The ArcIMS Spatial Server receives a request in ArcXML.

Step 4. The ArcIMS Spatial Server generates a response in ArcXML.

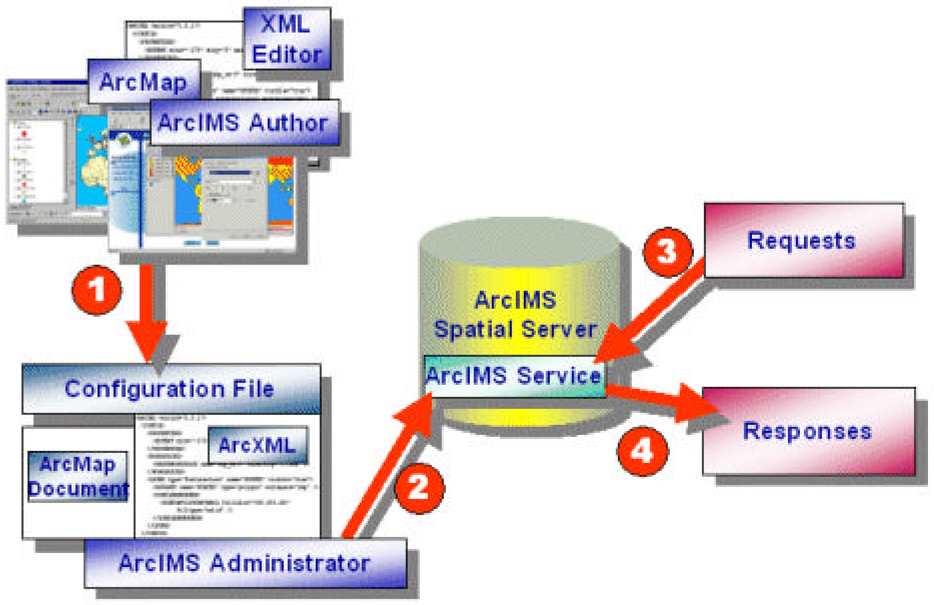


Figure 5.3 Interaction between ArcIMS and ArcXML [31]

A map configuration file includes:

• A prolog, which is used to define the XML version and encoding.

• An ArcXML element, which is used in all ArcXML statements.

• A CONFIG element, which is used in all configuration files.

• An ENVIRONMENT element, which is used to define the locale.

• A MAP element, which is used to define the map.

The ArcXML element works as the root element of the configuration file. Its child element is CONFIG. The only CONFIG child elements are ENVIRONMENT and MAP. ENVIRONMENT is used to set up information about the environment used in the ArcIMS service. Once the environment is established, clients in one locale can access a service created in another locale [31].

Child elements of ENVIRONMENT include the following:

• LOCALE. (Required) LOCALE is used to set the country and language for the locale of the ArcIMS site.

• UIFONT. (Required) UIFONT is used to set a default font for the dialogs in ArcExplorer 9 and the ArcIMS Java Viewers.

• SEPARATORS. (Optional) SEPARATORS is used to denote characters to separate x,y coordinates and coordinate pairs.

• SCREEN. (Optional) SCREEN is used to set the resolution of the screen for the computer generating the map configuration file.

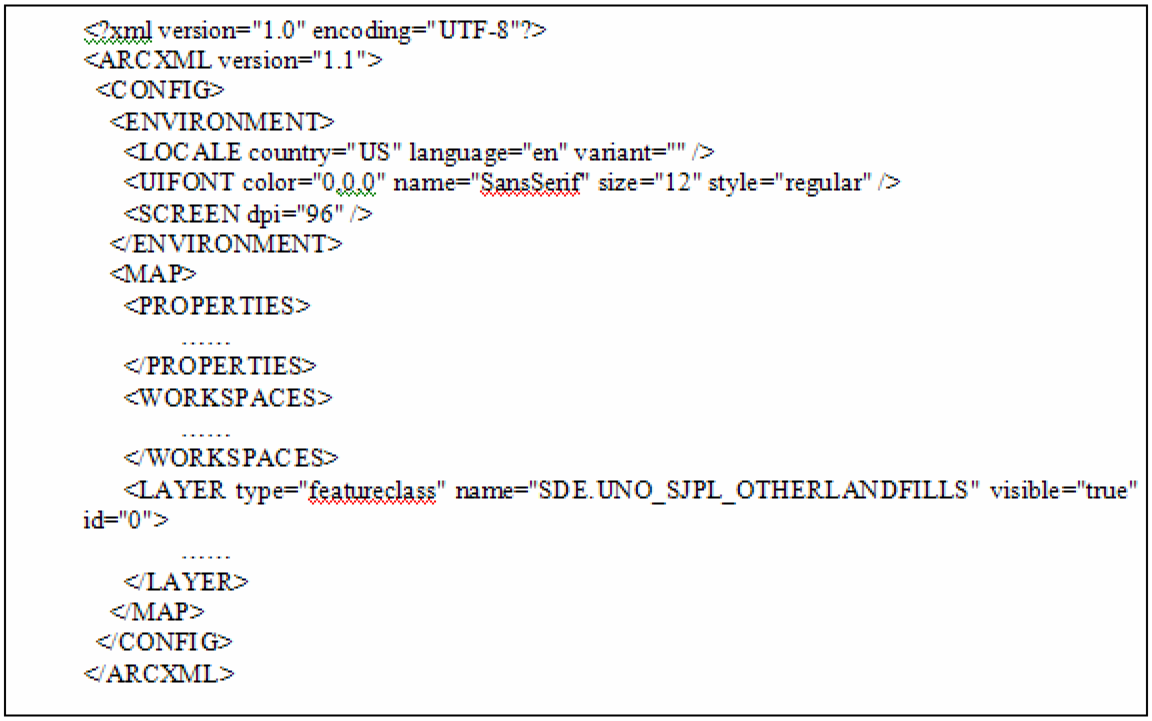
The element MAP contains all the instructions for generating a map. Its child elements include:

• PROPERTIES. The PROPERTIES section includes the initial map extent, map units, and current projection, as well as additional instructions used for Image Services.

• WORKSPACES. The WORKSPACES section includes the location of all the data used to create map layers.

• LAYER. One LAYER element is used for each layer in a map. LAYER contains the information about how the data should be symbolized.

In order to create a configuration file in ArcXML the developer has to create the file using a basic structure (Figure 5.4), this basic structure is a template for specifying as many tag elements as he needs for defining how the map should be displayed.



```
<?xml version="1.0" encoding="UTF-8"?>
<ARCXML version="1.1">
 <CONFIG>
  <ENVIRONMENT>
   <LOCALE country="US" language="en" variant="" />
   <UIFONT color="0,0,0" name="SansSerif" size="12" style="regular" />
   <SCREEN dpi="96" />
  </ENVIRONMENT>
  <MAP>
   <PROPERTIES>
        ......
   </PROPERTIES>
   <WORKSPACES>
        ......
   </WORKSPACES>
   <LAYER type="featureclass" name="SDE.UNO_SJPL_OTHERLANDFILLS" visible="true"
id="0">
        ......
   </LAYER>
  </MAP>
 </CONFIG>
</ARCXML>
```

Figure 5.4 ArcXML configuration file basic structure.

5.1.4 Java XML APIs

The Java 2 Platform, Enterprise Edition (J2EE) is a set of APIs that provides solutions for developing, deploying, and managing multi-tier server-centric applications. The J2EE platform adds the capabilities necessary to provide a complete, stable, secure, and fast Java platform to the enterprise level [32]. J2EE includes a set of packages for processing XML documents, these are:

- javax.xml.transform
- javax.xml.parsers

The javax.xml.transform package is a generic API for processing transformation instructions, and performing a transformation from source to result. The classes included in this package are:

- OutputKeys - Provides string constants that can be used to set output properties for a Transformer, or to retrieve output properties from a Transformer or Templates object.
- Transformer - An instance of this abstract class can transform a source tree into a result tree.
- TransformerFactory - A TransformerFactory instance can be used to create Transformer and Templates objects.

The javax.xml.parsers package provides classes allowing the processing of XML documents. These classes support two types of parsers:

- SAX (Simple API for XML), an event-driven, serial-access mechanism for accessing XML documents. This is a common protocol used for servlets and network-oriented programs for transmitting and receiving XML documents [33].

- DOM (Document Object Model) consisting of a tree structure, where each node contains one of the components from an XML structure. Developers can use DOM functions for creating nodes, removing nodes, changing their contents, and traversing the node hierarchy.

Using these two packages, developers can easily read XML files and modify them. In this thesis work, I decided to use DOM instead of SAX because DOM provides a tree structure of the document which makes easy modify the files.

5.2 Construction/Modification of layers

A map is a graphical presentation of geographic information [12]. The graphical information on a map is displayed as layers, where each layer represents a particular type of feature such as streams, lakes, highways, rivers, counties, cities, or homes. A layer may reference the data contained in various resources such as coverages, shapefiles, geodatabases, images, and grids. The data can be stored in files or in a GIS database. In this thesis work, we stored our geographical information in the SDE server whose repository resides in an Oracle database.

ArcSDE serves the data openly to ArcGIS Desktop, ArcIMS, and other applications. ArcGIS Desktop is a suite of tools that includes: ArcMap, ArcCatalog, and ArcToolBox. ArcIMS is an Internet-based GIS tool that enables creating and managing geography-based websites. In my work, I used two tools: (1) ArcCatalog, to connect to the SDE server for organizing and managing our GIS data, and (2) ArcIMS, for handling our Internet-GIS based maps.

As mentioned at the beginning of this chapter, our maps contain two types of layers, the static layers and the dynamic layers. Each one of these types of layers requires a different procedure to construct.

We use the ArcCatalog functionality for creating the static layers. First, we identified the static layers. These layers include:

- SDE.UNO_SJPL_ADDRESSES. Layer of addresses, this layer contains the addresses for all the homes in Jefferson Parish.
- SDE.UNO_SJPL_STREETCENTERLINES. Layer of street limits. The one that has the street division lines of the addresses.
- SDE.UNO_SJPL_JPLLANDFILL. Layer of Jefferson Parish landfills.
- SDE.UNO_SJPL_OTHERLANDFILLS. Layer of landfills.
- SDE.UNO_SJPL_INSPECTIONPOINTS. Layer of inspection points.

Knowing the static layers and having their shape files, we created a connection to the SDE server by using the option in ArcCatalog “add a connection”. With this connection, we got the access to the SDE server and we used its option called “import a shape file” to upload each one of the static layers. Once we have the layers in the SDE server, we can use them in our map. This is straightforward.

On the other hand, three sets of data dynamically change. They are represented by the dynamic layers:

- SDE.UNO_SJPL_DATEMAPLINES. The layer of the lines that represent each of the complaints reported about the landfills odor problems.

- SDE.UNO_SJPL_COMPLAINANTSADDRESSES. The layer of the points that represent the complainant addresses. This layer contains the addresses for all the complainants that already exist in the database.
- SDE.UNO_SJPL_IPONOFFSIDE_MAPLINES. The layer of the lines that represent the inspections. This layer contains the information about the odor readings recorded at the on site and off site inspection points on a specific date. By on site points we refer to the points that are inside one of the landfills. The off site points are those points near all the landfills.

In the construction of the dynamic layers we use the Java SDE API which provides the interfaces to process and analyze spatial information. I implemented a set of classes for managing the connection to the SDE server, construction of each layer, and updating the data in the layers. All these classes were put in a package called **edu.uno.sjpl.sde.** A diagram of the classes of this package is shown in Figure 5.5. The classes are: DataLayer.java, LayerComplainantsAddresses.java, LayerMapComplaintsLines.java, and LayerInspectionPoints.java.

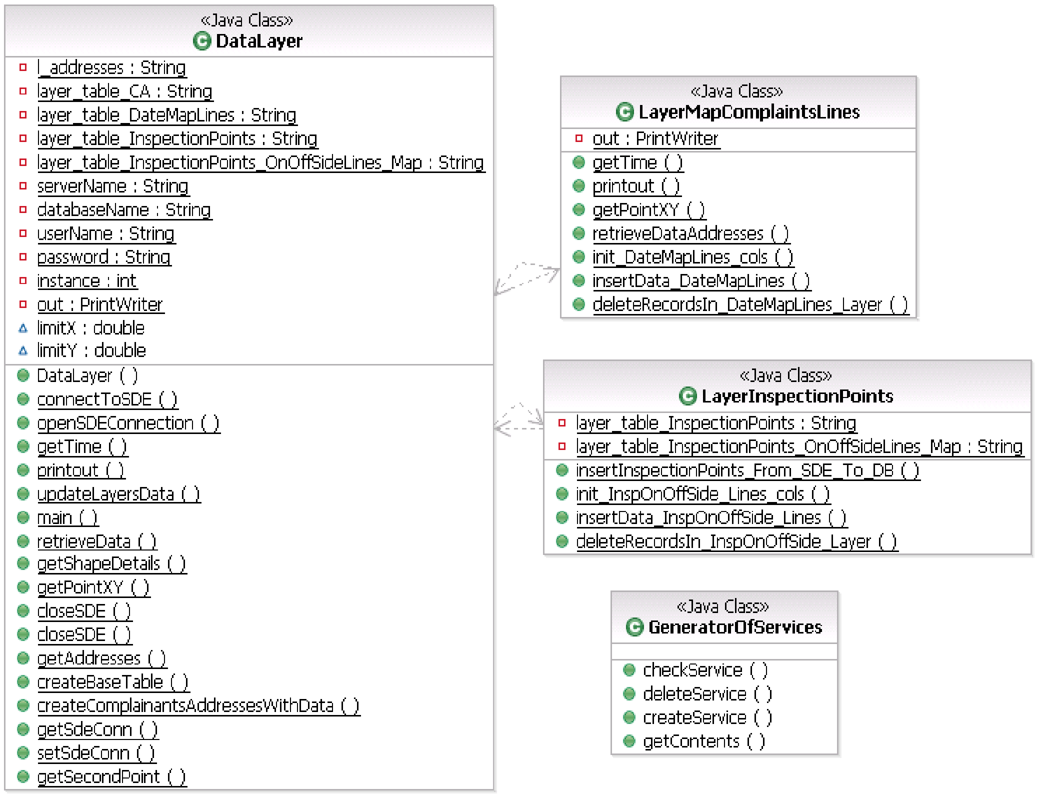
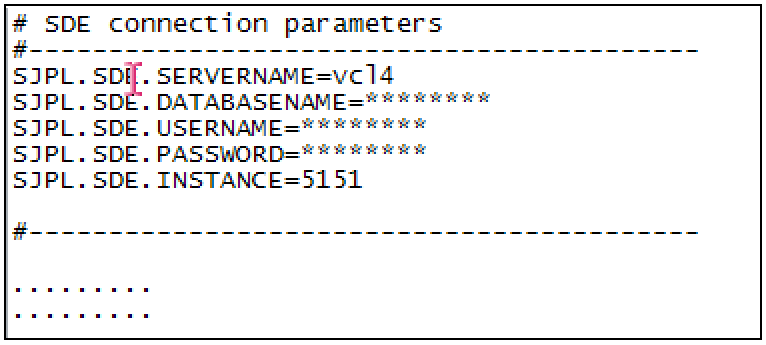


Figure 5.5 Diagram of classes of the Java classes defined in the edu.uno.sjpl.sde package.

The DataLayer class is a utility class. It contains the methods for connecting and disconnecting to the SDE server, the method for constructing a layer, the method for generating the end point of a line, and other general methods. The methods to connect and disconnect to the SDE server do not receive any parameters since the attributes of the connection are taken from a property file (Figure 5.6) in which all the SDE parameters of connection are declared.


```
# SDE connection parameters
#-------------------------------------------
SJPL.SDE.SERVERNAME=vcl4
SJPL.SDE.DATABASENAME=********
SJPL.SDE.USERNAME=********
SJPL.SDE.PASSWORD=********
SJPL.SDE.INSTANCE=5151

#-------------------------------------------

.........
.........
```
Figure 5.6 Parameters of the SDE connection declared in the config properties file.

The method that constructs a layer needs the following parameters: an array of the column names of the layer, name of the table to be associated with the layer, description of the layer, and the type of layer to construct. The type can be single line, multiple line, single points, multiple points, polygons, and other shapes defined by ArcIMS.

The method for generating the end point of a line receives the parameters: the x value of the start point of the line, the y value of the start point of the line, an angle, the distance of the line, and the extent of the layer. The start points are the coordinates of the house in which a complaint happens; the angle represents the wind direction and the distance of the line is given by the wind speed, this data is taken from the weather information at the closest time the complaint happens; the extent of the layer is given by the area that is going to be covered with the map.

The LayerComplainantsAddresses class has the method for inserting data into the SDE.UNO_SJPL_COMPLAINANTSADDRESSES layer. The parameters of the method are: the SDE connection, the layer, and a vector. This vector will contain all the new complainants inserted in the table UNO_SJPL_COMPLAINANTSADDRESSES. When a new complainant is created, this will be inserted in the Oracle database and in the SDE server. Nowadays, in the Web Data Collector system each time a new complainant is created, the inspector needs to fill out a form that contains the complainant's data. This form will have to be modified in order to standardize the syntax of the complainant's address. In the actual form, the address of the complainant is just a text area field, in which the inspector types in the address. However, when the inspector types this data, it contains many mistakes that the address then cannot be matched (geocoded) with an actual address in Jefferson Parish. The solution to this problem will be to create a new form in which the address of the complainant will be taken from the table of all the addresses declared in Jefferson Parish homes. With this, we are going to ensure that the address will be correct. Once the complainant information will be inserted in the database this will already contain its geographical information for being inserted in the SDE.UNO_SJPL_COMPLAINANTSADDRESSES layer.

The LayerMapComplaintsLines class was implemented to handle the data of the SDE.UNO_SJPL_DATEMAPLINES. This class has the methods for inserting and deleting data in the layer. The method that inserts the data receives the next parameters: the SDE connection, the layer, the database connection, and both the start-date and the end-date of the complaints period of time. Having this information the process will start. First, I query the information in which I match the complaints with the weather information. Here, I am assuming that the database has the up-to date information. In the query, I match each complaint with the date of the complaint and the closest hour that it is in the weather. The result of the match will be a set of records that contains the information of each complaint and its respective information of the weather at the moment the complaint happens. Once I have the response from the database each record is going to be inserted in the SDE.UNO_SJPL_DATEMAPLINES layer. Second, from the information I get in the database response, I have the start point of the line that represents a complaint, however for creating the line I need to create its end point. Third, the end point of each line is created with the information of the start-point, and the wind-direction. Fourth, with the start and end points my method creates a line and each line with its respective complaints information is inserted in the SDE.UNO_SJPL_DATEMAPLINES layer.

The method for deleting has the following parameters: an SDE connection, the layer, start date, and the end date. The deleting process is going to be executed over the data that exists in the SDE layer. The process of this method is to execute a delete query over the SDE.UNO_SJPL_DATEMAPLINES layer using a WHERE clause in which the start date and end date are going to be the limits. Once this process is executed the data will be deleted from the SDE layer.

By using the insert and delete methods over the SDE.UNO_SJPL_DATEMAPLINES layer, we are performing a kind of update in the layer and we are ensuring that no duplicate data is going to exist in the layer.

The LayerInspectionPoints class has the methods for inserting and deleting data in the SDE.UNO_SJPL_IPONOFFSIDE_MAPLINES layer. These methods are very similar to the insert and delete methods of the LayerMapComplaintsLines respectively. The only differences are that in the insert method of LayerInspectionPoints class, we are matching the information among the UNO_SJPL_INSPECTIONS, UNO_SJPL_INSPECTIONS_ONOFFSIDE, and the weather information tables. But, we are using the same criteria to match the information in which we are going to match the date and time of the inspection with the date and closest hour of the weather data. All the next steps for inserting in the SDE.UNO_SJPL_IPONOFFSIDE_MAPLINES layer are going to be the same as they are in insert method of the LayerMapComplaintsLines class. In the case of the delete method of the LayerInspectionPoints class, the process is exactly the same as that of the delete method of the LayerMapComplaintsLines class.

The classes in the **edu.uno.sjpl.sde** package can be used to update the information about the dynamic layers in our system. The methods in these classes can easily be called from any other sources, and their process will be transparent for the developers.

5.3 *Web Map*

5.3.1 Authoring a map

Authoring a map is the first step toward creating an Internet GIS application. ArcIMS Author helped us to add data layers, set layer symbology, limit the information that we want to show by making spatial queries to the layers, create stored queries, and then save the edited map as a map configuration file written by ArcXML (AXL file) [10] (Figure 5.7). With Author users can insert layers from file-based and from SDE servers.

Using ArcIMS Author, we created the AXL file that is used as a template for generating a new map configuration file.

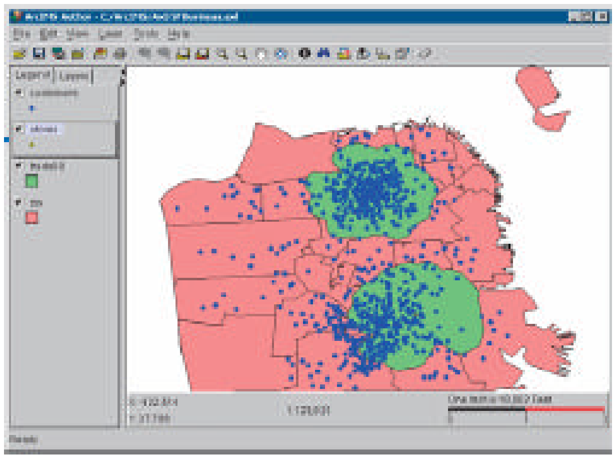


Figure 5.7 ArcIMS Author used to create a map configuration file

5.3.2 Templates used for creating new AXL files

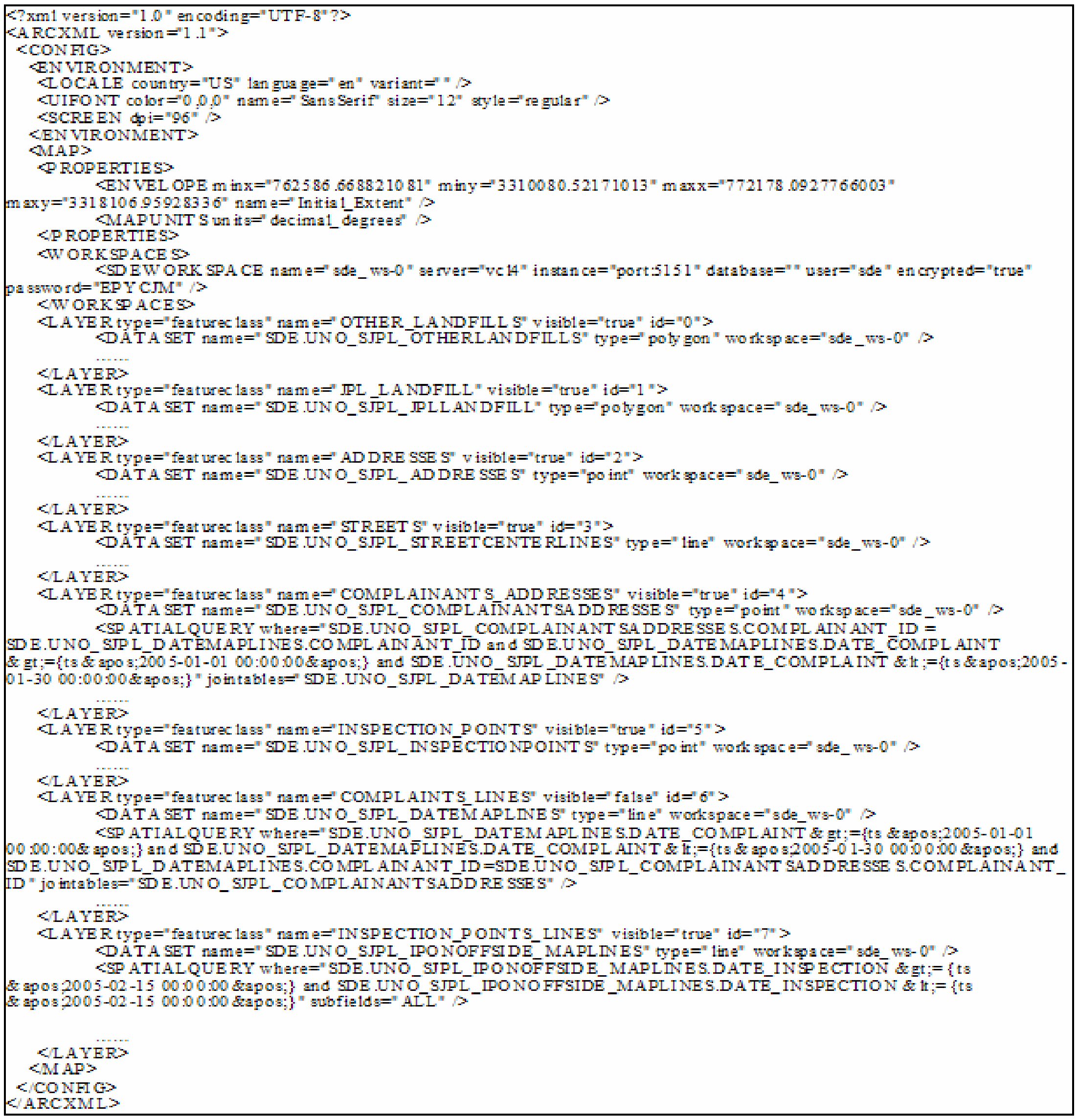
In our system each time a user request a new map, the system will create two different AXL files. The first one is the file that is going to contain the configuration of our map. The second AXL file will contain the definition of the service to be called.

5.3.2.1 Template of the configuration file

Using ArcIMS Author application, we created a file in which we are defining the order of the layers, setting up its displaying parameters, and limiting the information of the dynamic layers which is going to call the data that is in the range of the period of time selected by the user. Figure 5.8 shows the structure of this file. Our map is going to include the next layers:

1. SDE.UNO_SJPL_OTHERLANDFILLS
2. SDE.UNO_SJPL_JPLLANDFILL
3. SDE.UNO_SJPL_ADDRESSES
4. SDE.UNO_SJPL_STREETCENTERLINES
5. SDE.UNO_SJPL_COMPLAINANTSADDRESSES
6. SDE.UNO_SJPL_INSPECTIONPOINTS
7. SDE.UNO_SJPL_DATEMAPLINES
8. SDE.UNO_SJPL_IPONOFFSIDE_MAPLINES

The dynamic layers (5, 7, and 8) will show the data specified in the SPATIALQUERY tag. The SPATIALQUERY element is a child element of the LAYER tag. This is used to select a subset of the layer. Applying SPATIALQUERY as a filter, we will be able to show on the viewing map only the subset of the layer that corresponds with period of time (start date and end date) from which the user requests a map. Since the data outside the subset is not going to be showed in the viewing map it will not be necessary to apply any validation when the user interacts with the map.



```xml
<?xml version="1.0" encoding="UTF-8"?>
<ARCXML version="1.1">
 <CONFIG>
   <ENVIRONMENT>
    <LOCALE country="US" language="en" variant="" />
    <UIFONT color="0,0,0" name="SansSerif" size="12" style="regular" />
    <SCREEN dpi="96" />
   </ENVIRONMENT>
   <MAP>
    <PROPERTIES>
            <ENVELOPE minx="762586.668821081" miny="3310080.52171013" maxx="772178.0927766003"
maxy="3318106.95928336" name="Initial_Extent" />
            <MAPUNITS units="decimal_degrees" />
    </PROPERTIES>
    <WORKSPACES>
            <SDEWORKSPACE name="sde_ws-0" server="vcl4" instance="port:5151" database="" user="sde" encrypted="true"
password="EPYCJM" />
    </WORKSPACES>
    <LAYER type="featureclass" name="OTHER_LANDFILLS" visible="true" id="0">
            <DATASET name="SDE.UNO_SJPL_OTHERLANDFILLS" type="polygon" workspace="sde_ws-0" />
            ......
    </LAYER>
    <LAYER type="featureclass" name="JPL_LANDFILL" visible="true" id="1">
            <DATASET name="SDE.UNO_SJPL_JPLLANDFILL" type="polygon" workspace="sde_ws-0" />
            ......
    </LAYER>
    <LAYER type="featureclass" name="ADDRESSES" visible="true" id="2">
            <DATASET name="SDE.UNO_SJPL_ADDRESSES" type="point" workspace="sde_ws-0" />
            ......
    </LAYER>
    <LAYER type="featureclass" name="STREETS" visible="true" id="3">
            <DATASET name="SDE.UNO_SJPL_STREETCENTERLINES" type="line" workspace="sde_ws-0" />
            ......
    </LAYER>
    <LAYER type="featureclass" name="COMPLAINANTS_ADDRESSES" visible="true" id="4">
            <DATASET name="SDE.UNO_SJPL_COMPLAINANTSADDRESSES" type="point" workspace="sde_ws-0" />
            <SPATIALQUERY where="SDE.UNO_SJPL_COMPLAINANTSADDRESSES.COMPLAINANT_ID =
SDE.UNO_SJPL_DATEMAPLINES.COMPLAINANT_ID and SDE.UNO_SJPL_DATEMAPLINES.DATE_COMPLAINT
&gt;={ts&apos;2005-01-01 00:00:00&apos;} and SDE.UNO_SJPL_DATEMAPLINES.DATE_COMPLAINT &lt;={ts&apos;2005-
01-30 00:00:00&apos;}" jointables="SDE.UNO_SJPL_DATEMAPLINES" />
            ......
    </LAYER>
    <LAYER type="featureclass" name="INSPECTION_POINTS" visible="true" id="5">
            <DATASET name="SDE.UNO_SJPL_INSPECTIONPOINTS" type="point" workspace="sde_ws-0" />
            ......
    </LAYER>
    <LAYER type="featureclass" name="COMPLAINTS_LINES" visible="false" id="6">
            <DATASET name="SDE.UNO_SJPL_DATEMAPLINES" type="line" workspace="sde_ws-0" />
            <SPATIALQUERY where="SDE.UNO_SJPL_DATEMAPLINES.DATE_COMPLAINT &gt;={ts &apos;2005-01-01
00:00:00&apos;} and SDE.UNO_SJPL_DATEMAPLINES.DATE_COMPLAINT &lt;={ts &apos;2005-01-30 00:00:00&apos;} and
SDE.UNO_SJPL_DATEMAPLINES.COMPLAINANT_ID=SDE.UNO_SJPL_COMPLAINANTSADDRESSES.COMPLAINANT_
ID" jointables="SDE.UNO_SJPL_COMPLAINANTSADDRESSES" />
            ......
    </LAYER>
    <LAYER type="featureclass" name="INSPECTION_POINTS_LINES" visible="true" id="7">
            <DATASET name="SDE.UNO_SJPL_IPONOFFSIDE_MAPLINES" type="line" workspace="sde_ws-0" />
            <SPATIALQUERY where="SDE.UNO_SJPL_IPONOFFSIDE_MAPLINES.DATE_INSPECTION &gt;={ts
&apos;2005-02-15 00:00:00&apos;} and SDE.UNO_SJPL_IPONOFFSIDE_MAPLINES.DATE_INSPECTION &lt;={ts
&apos;2005-02-15 00:00:00&apos;}" subfields="ALL" />

            ......
    </LAYER>
   </MAP>
 </CONFIG>
</ARCXML>
```

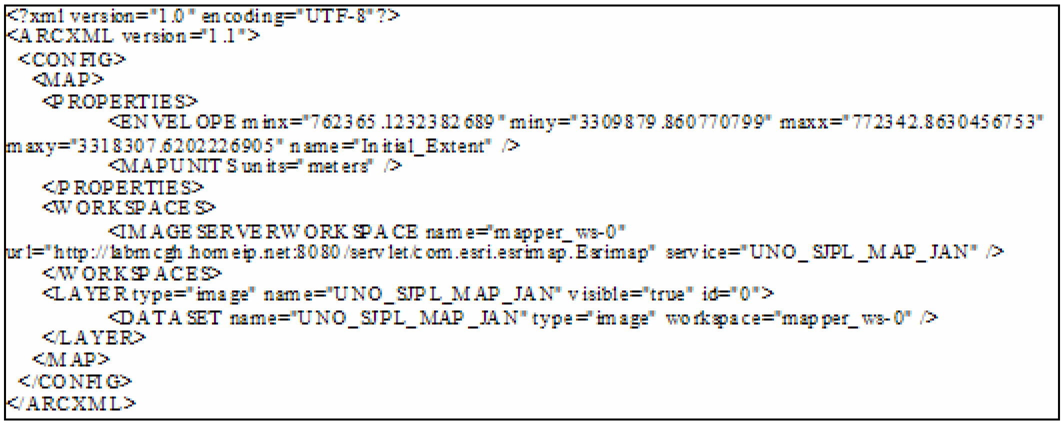
Figure 5.8 Structure of the template for the configuration map file.

Note: This image is not showing the renderers and symbols that are used for displaying the information in the map.

5.3.2.2 Template of the map service file

This file will contain the definition of the service to be called. Each time a user requests a new map, our system will create a new Image Service Map. In the Java Viewer a file that contains the name of the service will be called. We refer to this file as the map service file.

Figure 5.9 shows the structure of the file. In the IMAGESERVERWORKSPACE element, its attribute service will refer to the new service that has been created.



```
<?xml version="1.0" encoding="UTF-8"?>
<ARCXML version="1.1">
 <CONFIG>
   <MAP>
     <PROPERTIES>
           <ENVELOPE minx="762365.123238 2689" miny="3309879.860770799" maxx="772342.8630456753"
maxy="3318307.6202226905" name="Initial_Extent" />
           <MAPUNITS units="meters" />
     </PROPERTIES>
     <WORKSPACES>
           <IMAGESERVERWORKSPACE name="mapper_ws-0"
url="http://labmcgh.homeip.net:8080/servlet/com.esri.esrimap.Esrimap" service="UNO_SJPL_MAP_JAN" />
     </WORKSPACES>
     <LAYER type="image" name="UNO_SJPL_MAP_JAN" visible="true" id="0">
           <DATASET name="UNO_SJPL_MAP_JAN" type="image" workspace="mapper_ws-0" />
     </LAYER>
   <MAP>
 </CONFIG>
</ARCXML>
```

Figure 5.9 Structure of the service map file

5.4 Automation Process

5.4.1 Business Objects

In our system we handle two types of data, the tabular data and the geospatial data. As we mentioned in Chapter 2, the tabular data refers to the information that is stored from the Web Data Collector system and is stored in our Oracle database; the geospatial data is represented by the layers referring to the geographic features such as the Jefferson Parish landfills, the addresses in Jefferson Parish, the street divisions, the addresses of the complainants, the inspection points, the complaints, and the on site and off site inspection points. Both the tabular and the geospatial data are used to generate our web maps. In section 5.2 "Construction/Modification of layers", we explained how we handle the geospatial data. In this section, I am going to explain how we manage the tabular data. I implemented the Java Beans objects and the datamanager objects using the IBM WebSphere Studio Application Developer Integration Edition 5.1. This is a comprehensive integrated development environment for visually designing, constructing, testing and deploying Web services, portals, Web applications, and Java™ 2 Enterprise Edition (J2EE) applications [34].

The Java Beans objects represent the structure of different tables in our database. These Java beans are:

- Address – A bean whose structure corresponds with the table in the Oracle DB called UNO_SJPL_ADDRESSES.
- ComplainantAddress – Its structure corresponds with the table UNO_SJPL_COMPLAINANTSADDRESSES.
- SJPLMap – Its structure corresponds with the table called UNO_SJPL_MAPS.

These Java beans are declared in the package named **edu.uno.cs.sjpl.db** (Figure 5.10). Both Address and SJPLMap beans have their corresponding DataManager which is a class that can be used for modifying the linked table in the Oracle DB to the beans. The DataManager objects are:

- DataAddresses – It is the manager that contains the methods for modifying the data in the UNO_SJPL_ADDRESSES table.
- DataMaps – It is the manager whose methods can be used for updating the data in the UNO_SJPL_MAPS table.

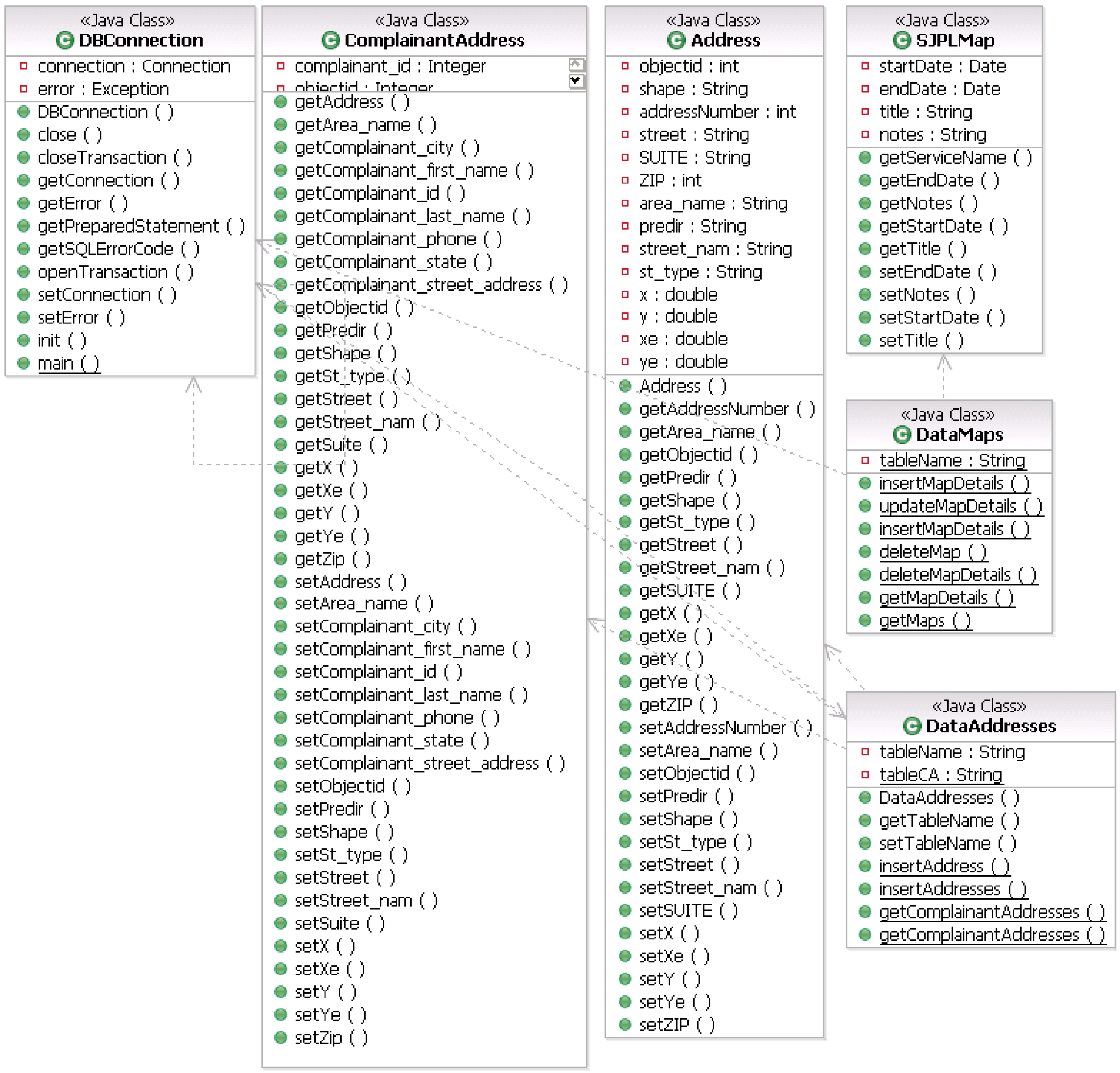
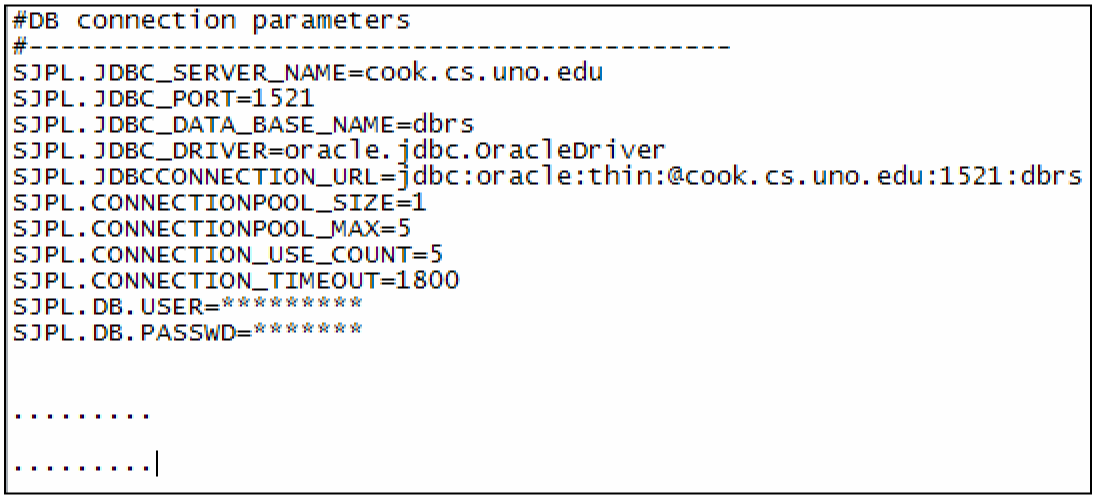


Figure 5.10 Diagram class of the Java classes declared in the edu.uno.cs.sjpl.db package.

In order to handle the connection to the Oracle database, I created another Java bean. This bean is called DBConnection. It has the methods to connect and disconnect to the database. The parameters of the connection are taken from the config properties file, where the database parameters are declared (Figure 5.11 shows the config file). The DBConnection bean also includes other methods for managing transactions and using prepared statements for executing queries in the database.

With the datamanager objects we are able the managing the database information in a straightforward. Also, they are reusable code.



```
#DB connection parameters
#--------------------------------------------
SJPL.JDBC_SERVER_NAME=cook.cs.uno.edu
SJPL.JDBC_PORT=1521
SJPL.JDBC_DATA_BASE_NAME=dbrs
SJPL.JDBC_DRIVER=oracle.jdbc.OracleDriver
SJPL.JDBCCONNECTION_URL=jdbc:oracle:thin:@cook.cs.uno.edu:1521:dbrs
SJPL.CONNECTIONPOOL_SIZE=1
SJPL.CONNECTIONPOOL_MAX=5
SJPL.CONNECTION_USE_COUNT=5
SJPL.CONNECTION_TIMEOUT=1800
SJPL.DB.USER=*********
SJPL.DB.PASSWD=*******


.........

.........|
```

Figure 5.11 Parameters of the database connection declared in the config properties file.

5.4.2 Creation of AXL files

I implemented the CreatorAXLFile, a class that contains the methods for creating AXL files based on template files. This class is defined in the package **edu.uno.cs.sjpl.util** (Figure 5.12). In this class I have used the packages from the Java^{TM} 2 Platform Enterprise Edition, v 1.4. They are javax.xml.transform and javax.xml.parsers.

In my class, I chose to use the DOM parser because with DOM developers can easily get a tree structure of the file and traversing it in different ways. These features provide the developers an easy way to modify the elements in the XML document.

The public methods of the CreatorAXLFile class are:

- createAXLMapConfig
- createAXLServiceConfig

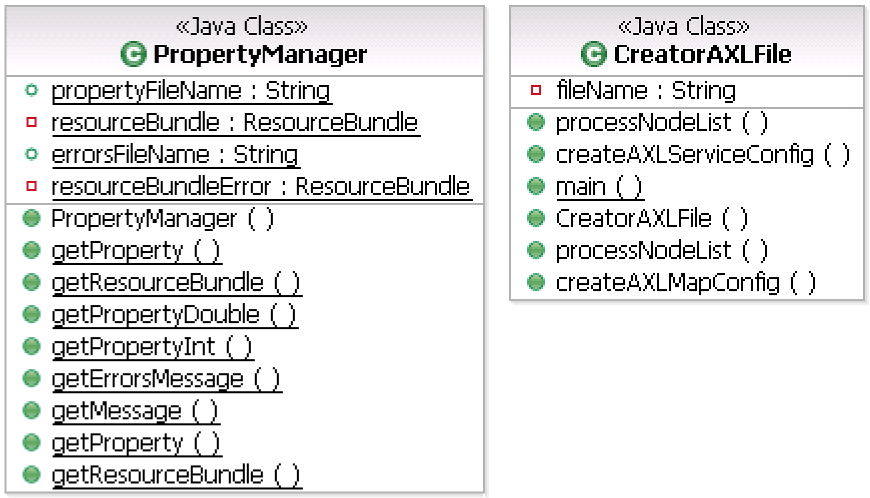


Figure 5.12 Diagram of classes defined in the edu.uno.cs.sjpl.util package.

The input value for the createAXLMapConfig method consists of the following parameters: start time, end time, xml template file, and new xml file. The process of this method uses the template file for the structure of the file, and uses the start time and end time parameters in order to change the "where" attribute of the SPATIALQUERY element. In the template file, the layers that include the SPATIALQUERY elements are: SDE.UNO_SJPL_COMPLAINANTSADDRESSES,SDE.UNO_SJPL_DATEMAPLINES, and SDE.UNO_SJPL_IPONOFFSIDE_MAPLINES. The SPATIALQUERY element of each layer is going to be updated. Our process creates the new structure of the new map configuration file. This is saved with the name passed as the new xml file parameter. The result of this method is the map configuration file that is created in the directory where AXL files are keeping. This directory is specified in the configuration file properties.

The createAXLServiceConfig method receives the following parameters: the name of the new service to be called, name of the template file, and name of the new service map file. In this method, we follow a very similar process as we did with the createAXLMapConfig method. We take the template, extract its structure, and modify the following elements: the "service" attribute of the IMAGESERVERWORKSPACE element, the "name" attribute of the LAYER element, and the "name" attribute of the DATASET element (see Figure 5.9 Structure of the service map file). The resulting configuration file is saved as the new service config map file with the name of the parameter received. This file is stored in the directory of the Java Viewer Website. The name of this directory is also taken from the config file properties.

By making a simple call to the methods of our class, we create automatically the configuration map file and the configuration service map file, each time the users request a new map that covers a different period of time.

5.4.3 ArcIMS services

In our system, each time a user requests a new map, our process is going to create a new Image Service. ArcIMS Administrator provides the functions for managing the ArcIMS services, the servers, and the folders. However, we wanted to make the creation of the image service transparent for the user, so that the user does not need to use the ArcIMS Administrator to create a new Image Service manually. With my implementation, the new image service is created automatically. We want to leverage the most functions that we can get from ArcIMS, and to help the users avoid using many tools in order to get a new map.

Using the Java Connector API of ArcIMS, we created a class named GeneratorOfServices, this is declared in the package **edu.uno.cs.sjpl.sde**. This class has the method for generating an image service. The input parameters of this method includes: the name of the new service and the name of the map configuration file. The steps for creating a new service are:

1. Open a connection to the ArcIMS Spatial Server

2. Setting the parameters of the new Image Service, these include: the name of the service, the map configuration file that define the new map, the contents of the map configuration file, the output directory where the snapshots are created, the URL of the output directory, the size of the image, and the type of image.
3. Add the service to the Spatial Server
4. Start the service

When a user requests in our system a new map, we will call this method and the new service will be created.

5.5 *Publishing the map on Internet*

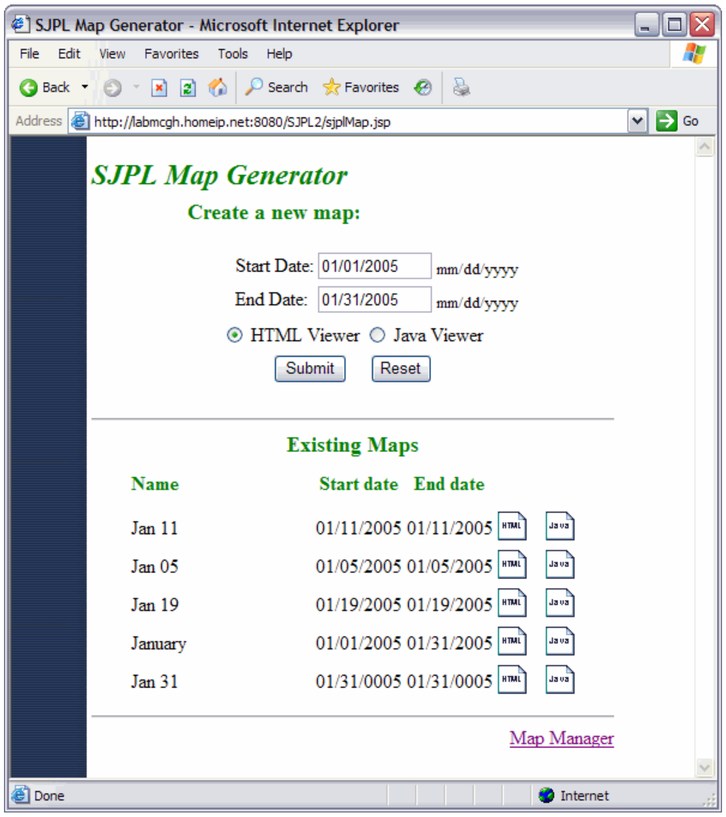
There are two process involved in the publishing a map, one of them is all the process for constructing the map, and the other process is displaying the map on the viewer. In this section we will review in detail the two processes.

5.5.1 Servlet in charge of controlling the process

In order to publish a map on the Internet, the users will use a browser that invokes a servlet (the MapServlet file), which controls all the process. The MapServlet invokes the business objects that execute the process, and it gets the result. There is also an input form, the JSP file (Figure 5.13), that it will be used to capture the start date and the end date. In our system we want to provide users the tool for creating a new map of complaints and inspections by just typing the period of time from which they want a map. Once the user defines the period of time, they click on the submit button, then the MapServlet will be in charge of all the process for publishing a map.

When the MapServlet is processing the users' request, it will follow the steps:

1. Call the process to insert the complaints into the SDE.UNO_SJPL_DATEMAPLINES and SDE.UNO_SJPL_IPONOFFSIDE_MAPLINES layers.
2. Create the two AXL files that contain the configuration of the map for being displayed. The first one will contain a complete configuration of the map in which the layers from SDE have been called up, the tag to be changed in this AXL is the SPATIALQUERY. This query will limit the data to display in the Map, in this case the new map will only reflect the complaints and the daily inspections that correspond exactly to the period of time specified by the user. The second file will contain the configuration of the new service to be called. This file it is used by the Java Viewer. This process is declared in the CreatorAXLFile class.
3. Create of a new service in an automatic way. This service will be added into the ArcIMS server. The service will call the new configuration map file (AXL) created. This process is declared in the GeneratorOfServices class.
4. Start the service.
5. Insert the new map in the UNO_SJPL_MAPS table. This process is declared in the DataMaps class.
6. Invoke the viewer which will receive as a parameter the name of the new service, so the configuration map associated with the new service will be called.
7. Now the user can interact with the new map


SJPL Map Generator - Microsoft Internet Explorer

http://labmcgh.homeip.net:8080/SJPL2/sjplMap.jsp

SJPL Map Generator

Create a new map:

Start Date: 01/01/2005 mm/dd/yyyy

End Date: 01/31/2005 mm/dd/yyyy

[✓ HTML Viewer] Java Viewer

Submit Reset

Existing Maps

Name	Start date	End date
Jan 11	01/11/2005	01/11/2005
Jan 05	01/05/2005	01/05/2005
Jan 19	01/19/2005	01/19/2005
January	01/01/2005	01/31/2005
Jan 31	01/31/0005	01/31/0005

Map Manager

Figure 5.13 The input form for the users (SJPLMap.jsp)

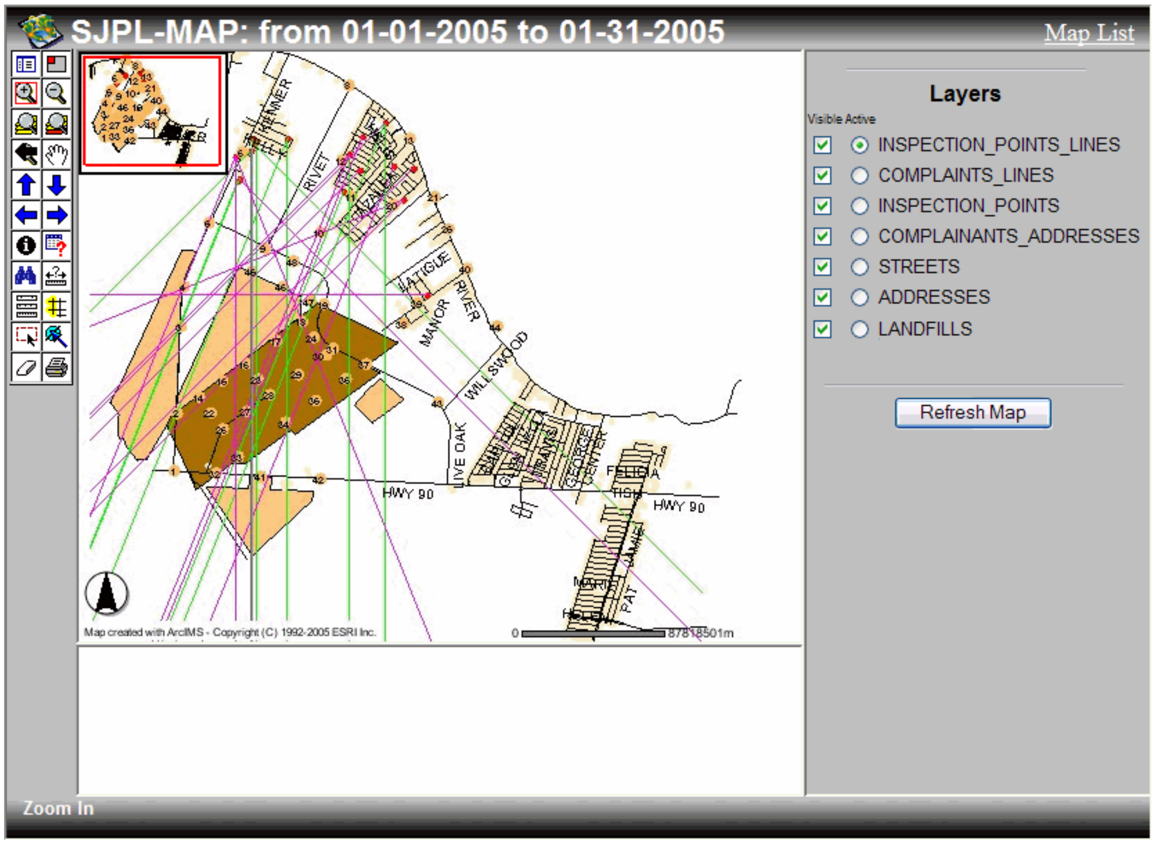
5.5.2 Displaying results in the viewers.

I created with the ArcIMS Designer tool two websites: one of them is based on the HTML Viewer, and the other one is based on the Java Viewer. I refer to these websites as the two components that I integrated into our system for displaying the maps. Once I had the components, I proceed to adapt them so the viewers can show different Image Map Services.

When users create a Website with the ArcIMS Designer tool, this site is linked to the service map that is going to be published on the viewer. In the HTML Viewer, this link is declared in a file called ArcIMSparam.js. In the Java Viewer, the association of the service map to the Web site is declared in the files default.js and default.axl.

Since our system requires that each time the user requests a new map a new map service has to be created, we decided that users should not have to create for each new service a new website. To solve this issue, we improved the functionality of the two Web site components that we handle.

In our component that is based in the HTML Viewer (Figure 5.14), we created a JSP file called viewer.jsp. This file is based on the viewer.htm that normally handles the HTML Viewer. Using this JSP helps us call it by passing the name of the new service and the title of the map. Once the servlet controller is ready to publish the map, it is going to invoke the viewer.jsp with the parameters. Then the new map will be displayed. As we mentioned above, there is an ArcIMSparam.js file associated with the map service. In order to solve this, I defined in the viewer.jsp a JavaScript global variable that has the name of the new map service. After that, I modified the ArcIMSparam.js. The modification was to make that the ArcIMSparam.js file takes the name of the new map service from its parent frame that is defined in the viewer.jsp. Each time we invoke the viewer.jsp with a new map service it changes the value of its global variable, then ArcIMSparam.js (Figure 5.15, Figure 5.16) will always take the new map service. This action is making our component based on the HTML Viewer works dynamically for any map service.

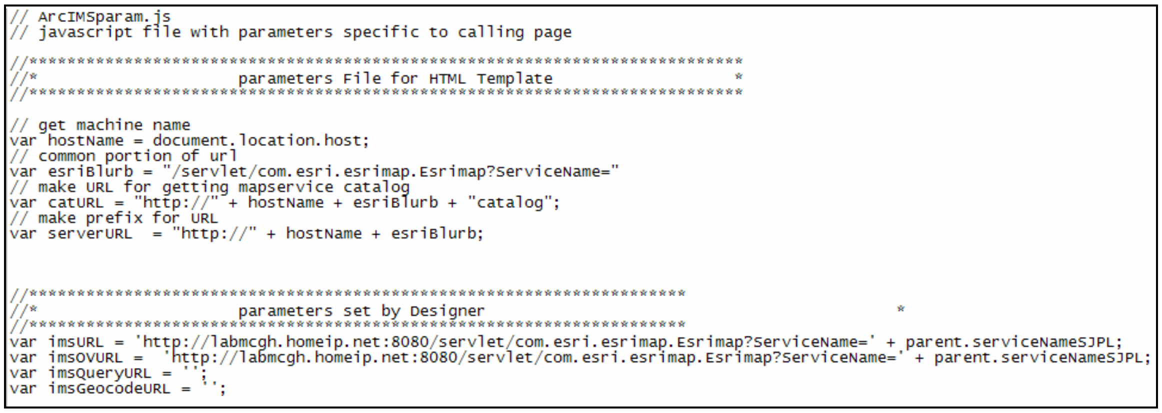


✓	●	INSPECTION_POINTS_LINES
✓	○	COMPLAINTS_LINES
✓	○	INSPECTION_POINTS
✓	○	COMPLAINANTS_ADDRESSES
✓	○	STREETS
✓	○	ADDRESSES
✓	○	LANDFILLS

Figure 5.14 Our component based on the HTML Viewer, displaying a map of complaints and inspections.

```
<%@page contentType="text/html"%>
<%@page pageEncoding="UTF-8"%>
<%
    String serviceName = "";
    serviceName = request.getParameter("serviceName");
    String title = request.getParameter("title");

%>

<META HTTP-EQUIV="Pragma" CONTENT="no-cache">
<meta http-equiv="Content-Type" content="text/html; charset=ISO-8859-1">
<HTML>
<HEAD>
        <SCRIPT LANGUAGE="JavaScript" SRC="javascript/aimsResource.js" TYPE="text/javascript"></SCRIPT>
        <SCRIPT TYPE="text/javascript" LANGUAGE="JavaScript">

                // Designer will set the next variable - theTitle
                var theTitle = '<%=title%>';

                var serviceNameSJPL = '<%=serviceName%>';
```

Figure 5.15 Part of code of the viewer.jsp (service name global variable).



```
// ArcIMSparam.js
// javascript file with parameters specific to calling page

//*****************************************************************************
//*                        parameters File for HTML Template                 *
//*****************************************************************************

// get machine name
var hostName = document.location.host;
// common portion of url
var esriBlurb = "/servlet/com.esri.esrimap.Esrimap?ServiceName="
// make URL for getting mapservice catalog
var catURL = "http://" + hostName + esriBlurb + "catalog";
// make prefix for URL
var serverURL  = "http://" + hostName + esriBlurb;



//***********************************************************************
//*                        parameters set by Designer                              *
//***********************************************************************
var imsURL = 'http://labmcgh.homeip.net:8080/servlet/com.esri.esrimap.Esrimap?ServiceName=' + parent.serviceNameSJPL;
var imsOVURL =  'http://labmcgh.homeip.net:8080/servlet/com.esri.esrimap.Esrimap?ServiceName=' + parent.serviceNameSJPL;
var imsQueryURL = '';
var imsGeocodeURL = '';
```

Figure 5.16 Part of the code of ArcIMSparam.js (making reference to the parent.serviceNameSJPL global variable)

In the case of our component based on the Java Viewer (Figure 5.17), we did something slightly differently. We created a file name frame.jsp, this file is based on the frame.htm that is commonly used by the Java Viewer. When we call this JSP, we are going to pass as parameters the name of the new service file and the title of the map. The servlet controller calls frame.jsp once the service is ready. In this component, we also made the modifications that let this component to invoke different services. As we mentioned before the Java viewer calls the default.axl file in which the Image Service Map is declared. For making our component works dynamically with any Image Service Map, we are creating a new service configuration file (Section 5.4.2 provides the details). The frame.jsp is similar to the viewer.jsp. Each time it is called, it sets its service name global variable with the parameter it receives as the new service map. Then, when the frame.jsp invokes the Javascript default.js, this will call the new service map from the variable that is declared in the frame. jsp (Figure 5.18,Figure 5.19).

We modified our components for making them capable of calling different map services without creating a new Web site. This implies that our components, the one based on the HTML Viewer and the other one based on the Java Viewer, are independent of the map service.

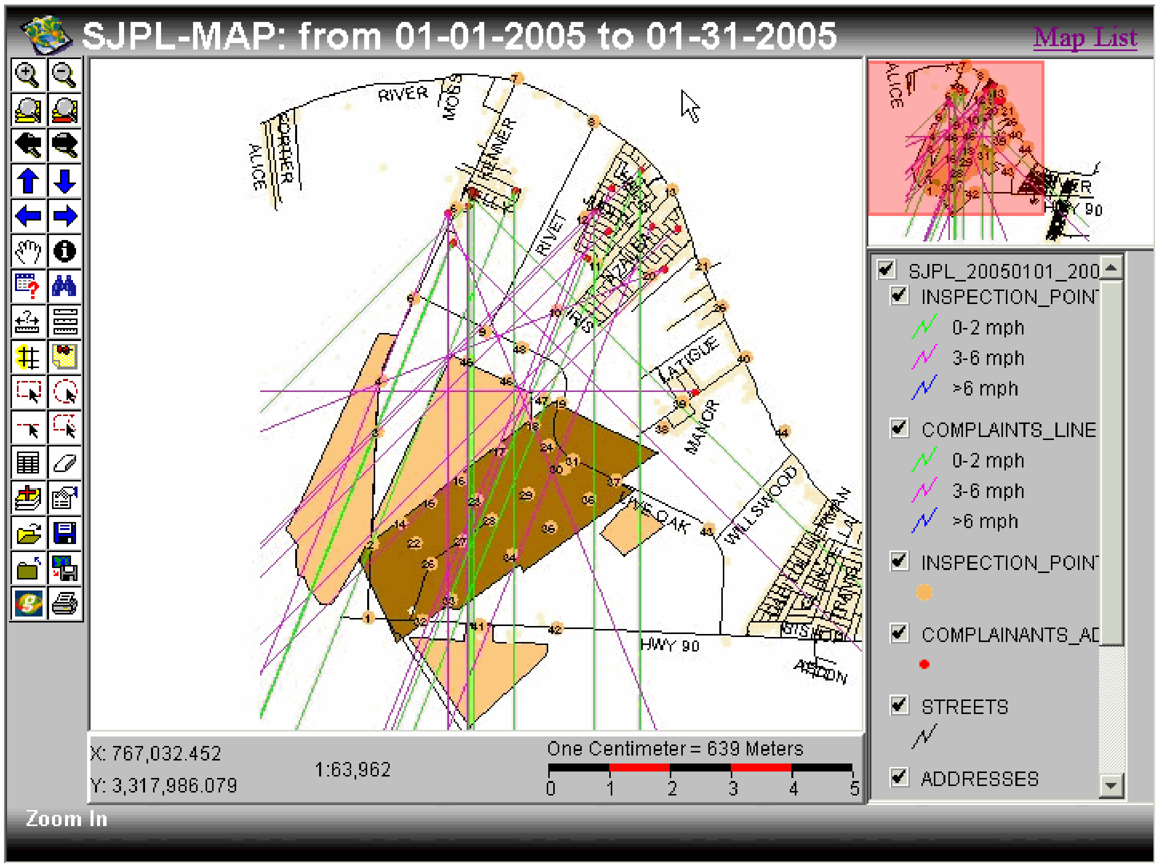


Figure 5.17 Our component based on the Java Viewer, displaying a map of complaints and inspections.

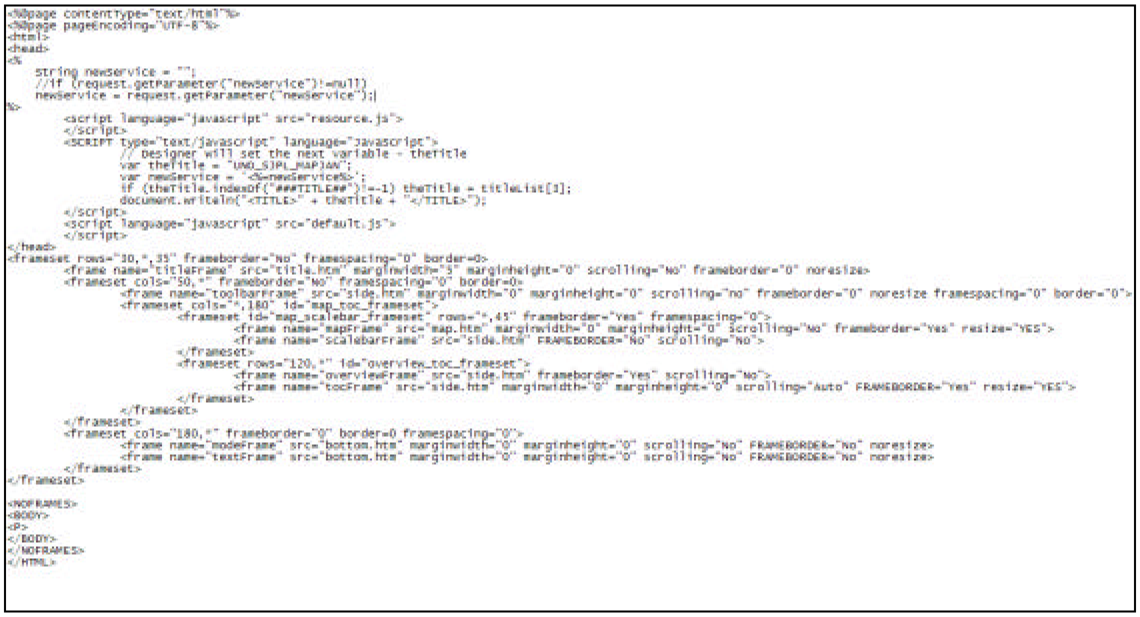
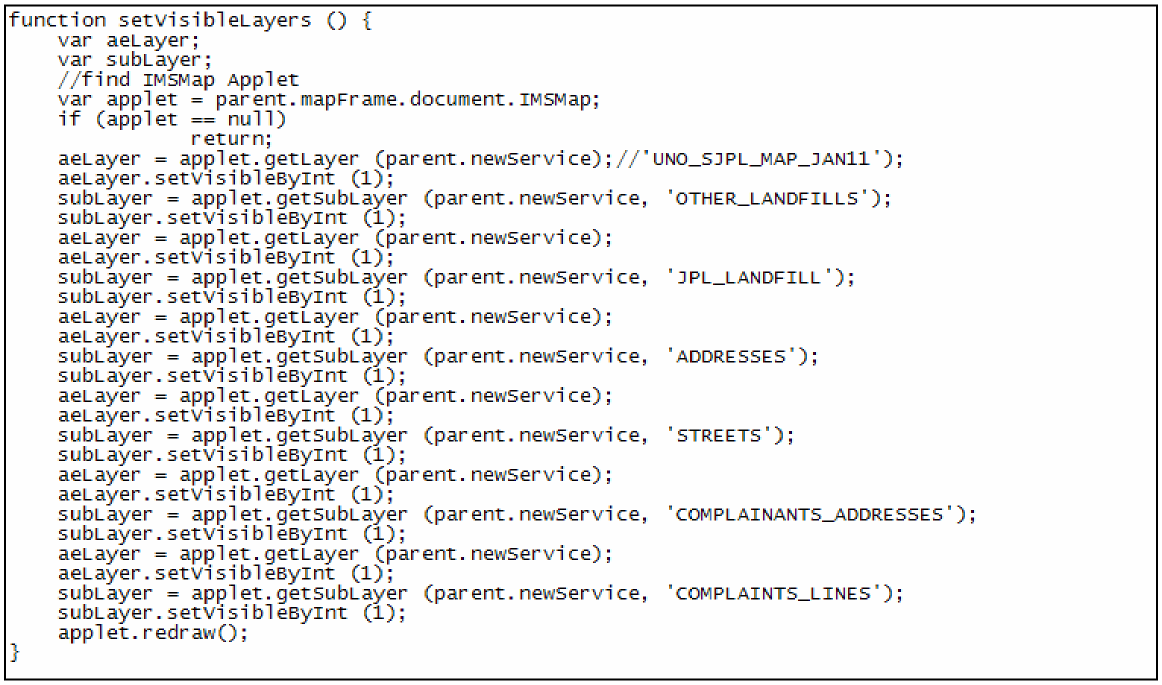

```
<%@page contentType="text/html"%>
<%@page pageEncoding="UTF-8"%>
<html>
<head>
<%
    String newService = "";
    //if (request.getParameter("newService")!=null)
    newService = request.getParameter("newService");
%>
        <script language="javascript" src="resource.js">
        </script>
        <SCRIPT type="text/javascript" language="javascript">
                // Designer will set the next variable - theTitle
                var theTitle = "UNO_SJPL_MAPJAN";
                var newService = '<%=newService%>';
                if (theTitle.indexOf("###TITLE##")!=-1) theTitle = titleList[3];
                document.writeln("<TITLE>" + theTitle + "</TITLE>");
        </script>
        <script language="javascript" src="default.js">
        </script>
</head>
<frameset rows="30,*,35" frameborder="No" framespacing="0" border=0>
        <frame name="titleFrame" src="title.htm" marginwidth="5" marginheight="0" scrolling="No" frameborder="0" noresize>
        <frameset cols="50,*" frameborder="No" framespacing="0" border=0>
                <frame name="toolbarFrame" src="side.htm" marginwidth="0" marginheight="0" scrolling="no" frameborder="0" noresize framespacing="0" border="0">
                <frameset cols="*,180" id="map_toc_frameset">
                        <frameset id="map_scalebar_frameset" rows="*,45" frameborder="Yes" framespacing="0">
                                <frame name="mapFrame" src="map.htm" marginwidth="0" marginheight="0" scrolling="No" frameborder="Yes" resize="YES">
                                <frame name="scalebarFrame" src="side.htm" FRAMEBORDER="No" scrolling="No">
                        </frameset>
                        <frameset rows="120,*" id="overview_toc_frameset">
                                <frame name="overviewFrame" src="side.htm" frameborder="Yes" scrolling="No">
                                <frame name="tocFrame" src="side.htm" marginwidth="0" marginheight="0" scrolling="Auto" FRAMEBORDER="Yes" resize="YES">
                        </frameset>
                </frameset>
        </frameset>
        <frameset cols="180,*" frameborder="0" border=0 framespacing="0">
                <frame name="modeFrame" src="bottom.htm" marginwidth="0" marginheight="0" scrolling="No" FRAMEBORDER="No" noresize>
                <frame name="textFrame" src="bottom.htm" marginwidth="0" marginheight="0" scrolling="No" FRAMEBORDER="No" noresize>
        </frameset>
</frameset>

<NOFRAMES>
<BODY>
<P>
</BODY>
</NOFRAMES>
</HTML>
```

Figure 5.18 The code of the frame.jsp

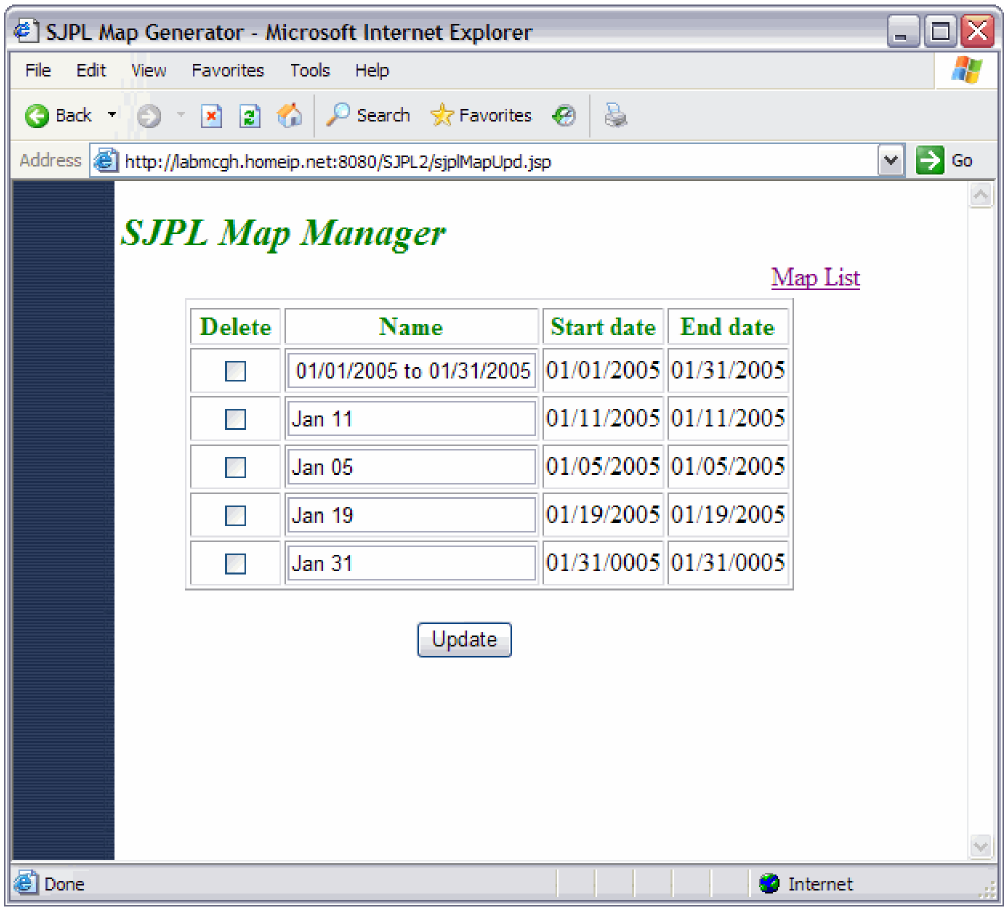


```
function setVisibleLayers () {
    var aeLayer;
    var subLayer;
    //find IMSMap Applet
    var applet = parent.mapFrame.document.IMSMap;
    if (applet == null)
               return;
    aeLayer = applet.getLayer (parent.newService);//'UNO_SJPL_MAP_JAN11');
    aeLayer.setVisibleByInt (1);
    subLayer = applet.getSubLayer (parent.newService, 'OTHER_LANDFILLS');
    subLayer.setVisibleByInt (1);
    aeLayer = applet.getLayer (parent.newService);
    aeLayer.setVisibleByInt (1);
    subLayer = applet.getSubLayer (parent.newService, 'JPL_LANDFILL');
    subLayer.setVisibleByInt (1);
    aeLayer = applet.getLayer (parent.newService);
    aeLayer.setVisibleByInt (1);
    subLayer = applet.getSubLayer (parent.newService, 'ADDRESSES');
    subLayer.setVisibleByInt (1);
    aeLayer = applet.getLayer (parent.newService);
    aeLayer.setVisibleByInt (1);
    subLayer = applet.getSubLayer (parent.newService, 'STREETS');
    subLayer.setVisibleByInt (1);
    aeLayer = applet.getLayer (parent.newService);
    aeLayer.setVisibleByInt (1);
    subLayer = applet.getSubLayer (parent.newService, 'COMPLAINANTS_ADDRESSES');
    subLayer.setVisibleByInt (1);
    aeLayer = applet.getLayer (parent.newService);
    aeLayer.setVisibleByInt (1);
    subLayer = applet.getSubLayer (parent.newService, 'COMPLAINTS_LINES');
    subLayer.setVisibleByInt (1);
    applet.redraw();
}
```

Figure 5.19 Part of the code of the default.js file (making reference to the parent.newService global variable).

5.6 Handling the Image Services.

In our system each time the user request a new map, a new Image Map Service will be created in order to display the requested map. The ArcIMS Spatial Server is in charge of controlling all the Image Services; in fact, with the ArcIMS Administrator tool, the ArcIMS users can create, delete, or update the services. In our system, we want to provide the users with a maintenance tool that does not require learning many concepts in order to use it. I implemented the MapManager a friendly JSP form (Figure 5.20). This MapManager is used as a maintenance tool to administer the maps created with our system.


SJPL Map Generator - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Back Search Favorites
Address http://labmcgh.homeip.net:8080/SJPL2/sjplMapUpd.jsp
Go

SJPL Map Generator - Microsoft Internet Explorer

SJPL Map Manager

Map List

Delete	Name	Start date	End date
☐	01/01/2005 to 01/31/2005	01/01/2005	01/31/2005
☐	Jan 11	01/11/2005	01/11/2005
☐	Jan 05	01/05/2005	01/05/2005
☐	Jan 19	01/19/2005	01/19/2005
☐	Jan 31	01/31/0005	01/31/0005

Update

Figure 5.20 Map Manager

The users instead of using the ArcIMS Administrator tool will use the MapManager. The MapManager displays a list that contains all the maps that have been create with our application. The list of the maps is stored in an Oracle table called UNO_SJPL_MAPS (Section 5.4.1 provides the details). Even though, for the MapManager a map is internally an Image Service that has its own configuration files, for the users the Image Maps are only maps. The user can select all the maps he wants to delete; he also can modify the maps' title.

When the user clicks on the "Update" button, the MapManager invokes the MapServlet (Section 5.5.1) which handles the processes for deleting the maps and modifying the maps' title. The MapServlet calls two methods each one declared in a different Java class. The

GeneratorOfServices contains the deleteService method, which will be invoked for removing the selected Image Map Service. When an Image Map Service is deleted its configuration files will be also deleted. The DataMaps class has the method updateMapDetails that will be called for the MapServlet in order to update the maps’ title.

Chapter 6: Conclusions and Future Work

Geographical Information Systems have become an integral tool in a number of applications, including environmental management [15]. The use of GIS technology in environmental studies provides a better way to manage, analyze, display and share the information. In this thesis we implemented a GIS Web Maps application. This tool provides the maps of odor complaints and inspections that will be used in the environmental studies and analysis of odor problems from Jefferson Parish landfills. The studies and analyses form part of the investigation project that has been conducted by CDM Inc.

The need to identify the location of the odor problems lead the CDM staff to create GIS maps based on the odor information, including odor complaint information, odor monitoring information, and meteorological information, collected in its database. This database contains all the information recorded during the daily inspections as well as complaints that have occurred in the vicinity of the three Jefferson Parish landfills. The process for creating GIS maps was developed by a GIS specialist at CDM. This process turned out to be very laborious because of the many steps involved, and often people that received the maps lacked the knowledge of GIS technology necessary for accessing and using the maps directly.

Working with the GIS specialist we found that it would be better to provide users with maps that did not require of GIS expertise in order to access the information. In this thesis our goals were:

- to provide the users with an easy way of creating Web-based maps that can show for an specific time of period the odor problems of the landfills.

- to show how the integration of tabular/geographical data with GIS software (ArcSDE, and ArcIMS) can be used as a tool in the analysis of environmental problems in which the geographical information plays an important role.

We implemented the Map Generator tool that can be accessed through the Web. Our application can be used by non-GIS experts and the maps generated contain information that is as accurate and complete as the maps on which our project was based. The user only needs to enter a start date and an end date, click on the submit button, and the map will be displayed. We provide two options to display the maps. One is by using the ArcIMS HTML viewer that requires less client-side processing. The second option is the ArcIMS Java Viewer in which the users will have to install a Java plug-in into the browser. Both options display as specific information as users need from the map; they differ in the number of tools that they provide users for interacting with the maps, and in the look and feel of their interfaces.

In our development, we learnt that combining ArcIMS and ArcSDE manages GIS information more efficiently. ArcIMS may provide the perfect solution by bringing GIS capabilities to non-users of GIS by deploying the power and functionality of GIS over the Internet [16]. ArcSDE is a powerful gateway for managing geographical data; its Java API gives an easy solution for processing and analyzing spatial information.

In our implementation, we also created the Map Manager. This is a web application that will be used for handling the Images Map Services and their associated configuration files. The users can easily administrate the images services without the need of knowledge of the ArcIMS Administrator tool. The users can simply select the image service to be deleted and our application takes care of the rest of the process.

In summary, we can say that the use of GIS technology makes the analysis and modeling of environmental data more accessible and more understandable.

As we mentioned in the chapter that describes our implementation, the addresses of the complainants play an important role in the construction of the maps. However, until now the format of those addresses has not follow any standardization; this is why some complainants may not appear on the map. We are proposing to implement a new JSP form that will be used to capture the complainants' addresses in a standard way and each complainant's address will be associated to an actual home in the Jefferson Parish County. This will facilitate their location on the map, and each complainant that has a complaint will be displayed on the map. This form will replace the actual form that has been used to capture a new complainant information.

Working with CDM staff in this investigation we have developed other tools for analyzing the odor problems. One of these tools is the Reports Generator a stand alone application for creating the reports with the information stored in the database. The Reports Generator is a tool that was developed in Java. With this tool the user enter a start date and end date, click on the "Create reports" button, and the result is a set of charts that display the number of complaints in that period of time, the number of complaints per odor type, the number of daily inspections, etc. Since all these applications, including the Web Data Collector System, the Reports Generator, and the Map Generator are related with CDM's investigation we believe that the integration of all of them can provide more useful resources for the analysis of odor problems. For example, the integration of the Reports Generator and the Maps Generator can give as a result maps that can contain charts explaining with tabular data what we are visualizing in the maps. Those charts can display also data such as the average of number of complaints per period of time, the average of the odor type recorded in the complaints per period of time, the average odor intensity in the on site and off site inspection points, the number of complaints by the wind speed that was recorded at the time the complaints were reported, etc. Combining these tools can give us an integral tool that provides more informative maps which can work more efficiently in the studies of the odor problems. Conveying maps with graphs will give the environmental engineers a view of the odor common sources, an easy way to compare the data displayed on the maps, and an evaluation of the techniques effectiveness for reducing the odors.

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Vita

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