

## Trying Java technology in a Geologic-Mining Information System distributed over an inter/intranet environment<sup>1</sup>

M.Á. Latre, R. Béjar, P. Fernández, P. Álvarez, P.R. Muro-Medrano

Computer Science and System Engineering Department  
University of Zaragoza  
María de Luna 3  
50015 Zaragoza, SPAIN  
{latre, rbejar, pedrofb, alvaper}@ebro.cps.unizar.es,  
prmuro@posta.unizar.es  
<http://diana.cps.unizar.es/iaaa>

**Abstract.** This paper presents a Java approach to develop a geologic-mining information system. User requirements address system features such as GIS visualization and modification, interoperation with tabular data, distributed concurrent access to read and modify GIS data still maintaining, and support for internet browsers. The paper shows the advantages of using Java as the programming language for development and its low cost compared with the use of other commercial approaches. A first version of the system is now in operational use by the regional administration.

**Key words.** Java, distributed systems, geologic-mining information system, inter-intranet, GIS visualization

### Introduction

The continuous decrease in the price of GIS technology over the last few years, has made many organizations account for the possibility of using GIS to provide new services. This behavior has become more apparent in government areas with an increasing interest to provide public access to information, mainly if it is related in some kind with environment data.

This is the case of a Spanish regional public administration mining department. This department manages the administrative information related to diverse mining elements, such as concessions, permits, active mines or treatment plants, as well as their characteristics and location. The importance of keeping the location and shape of all these mining elements was the main reason behind the decision of integrating GIS visualization with their tabular data. The objectives were to facilitate the tracking down of information and the generation of reports including maps and tabular data. Other main objective was to provide other departments in the regional government, as well as the public in general, with several levels of access to the information.

This regional mining department consists of three provincial services and one central service, physically distributed over the region. Each provincial service is allowed to access the data of the entire region, but it can only modify the elements in its province. The central service, however, is granted full access to every mining element in the region. The distributed nature of the mining department, and the intention of making part of its data public, required a distributed approximation to the problem.

In order to distribute geographical data, a solution could have been based in commercial tools such as ESRI's Arcinfo and their Spatial Database Engine. Developing a distributed geographical information system with these tools would have been easy and fast, but the system would have gone over budget, so using these tools was not considered.

Part of the information in the mining department is public, it can be accessed by anyone. The World Wide Web provides a convenient method for accessing to this information, so the information system had to deal with the fact that part of it should be accessible through the web. Another part of the information is of potential interest to other departments in the regional government so it should be shared through its intranet.

The possibility of accessing to the information over the Internet and over the regional government's intranet suggested Java as the technology to implement the information system. Portability issues and the possibility of using RMI, instead of the more complex CORBA, as the mechanism to communicate remote applications when needed, definitely pointed to this language.

---

<sup>1</sup> **Acknowledges:** The basic technology for this work was partially supported by the *Comisión Interministerial de Ciencia y Tecnología* (CICYT) of Spain through the project TIC98-0587.

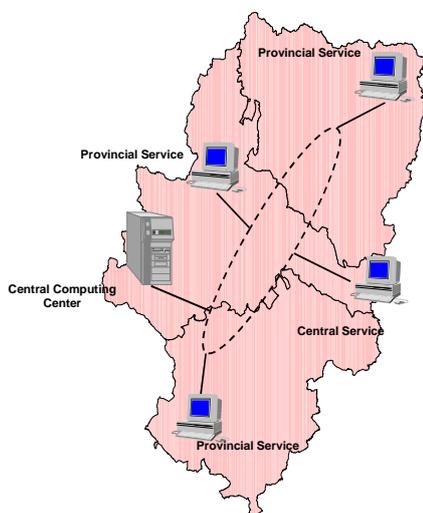
Our approach to the information system was determined by its needs: a distributed and public accessible system had to be constructed while keeping a low cost. The administrative database and the mining coverages were going to be accessed in different ways, and from different places, so it made sense to keep them in a central server. For the provincial and central services, a Java application was developed, consisting of several components. Some of them were developed from scratch to access the tabular information in the system, and others, as the GIS component or the user control, tailored from generic components to meet the requirements for this application.

The internet and intranet access to the information would be implemented as Java applets, that would be developed from the application used in the mining department services. This task is easy because of the use of Java, and the fact that this applets provide less functionality than the application. The biggest work for giving intranet and internet access to the information system would be the development of server programs to provide the applets with adequate data taken from the information system.

In this paper, a brief description of the geologic-mining information system is presented first. Then the system architecture is described, to give a global overview of the system. The next section describes the application developed for the mining department services, focusing on its main components. A brief discussion of several technical aspects of the concurrent remote access to the information system comes next. The final two sections describe the technical issues of the intranet and internet access to the system.

## A geologic-mining information system

A regional public administration mining department is in charge of franchising the exploitation of mineral deposits in a certain area to individuals or companies according to mining regulations. It is also responsible for keeping the information related to the granted franchises (classified into mining concessions, authorisations and permits) and other mining elements, such as active mines, treatment plants or deposit traces. This information includes the characteristics of the mining rights granted for each franchise, the administrative and bureaucratic records kept for each element in different type of support and the in situ obtained information for the main mines, plants or traces. It also includes the geographical data referring both to each element geographical location and to geologic and cartographic information from the region.



**Fig. 1.** Autonomous Regional Government Mining Department Structure.

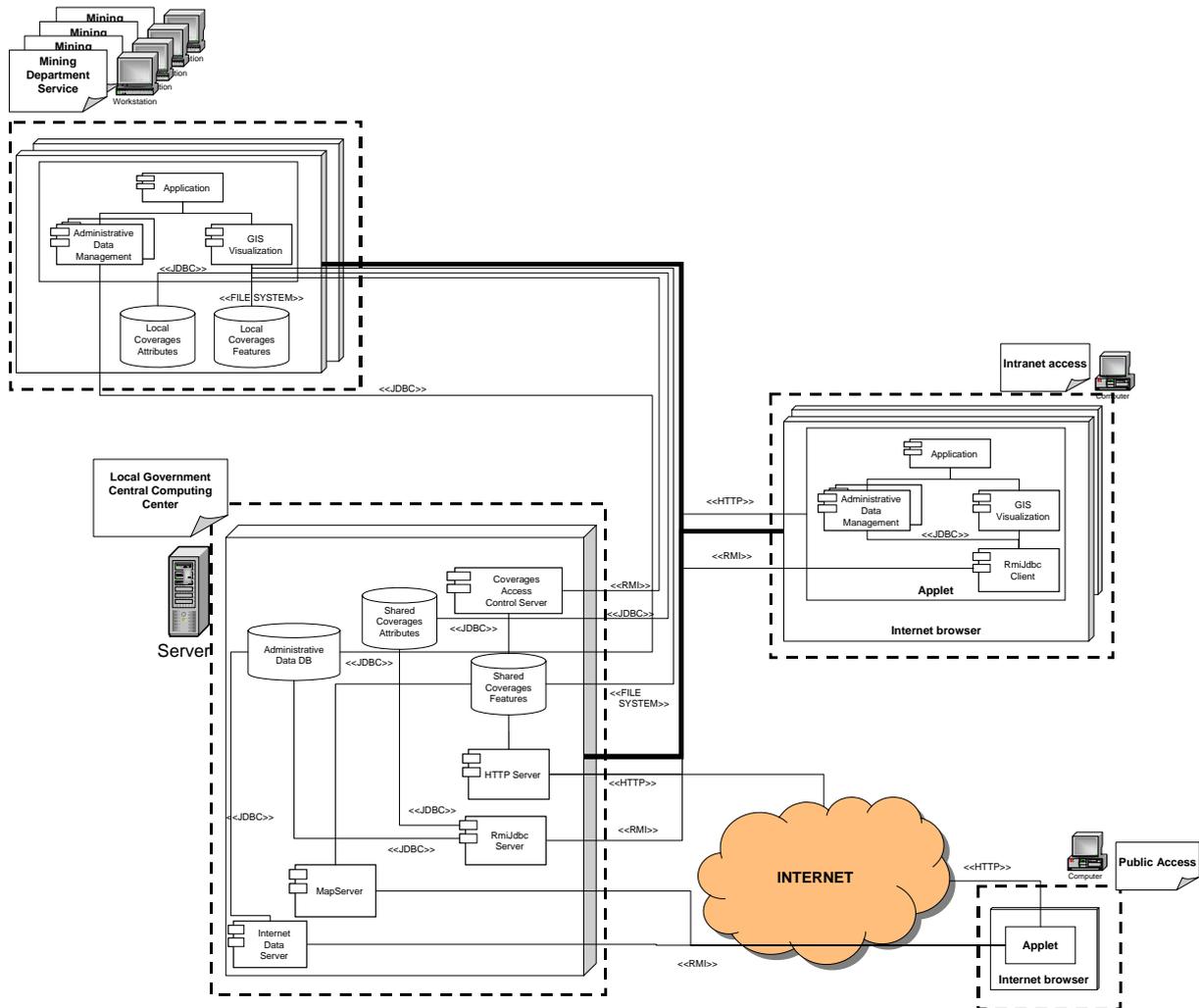
The software development described in this paper is intended to integrate all the tabular and geographic information into a single information system. The information system has been designed to be used by a regional Spanish government mining department organised in the form of a Central Mining Service that coordinates the activity of several Provincial Mining Services (**Fig. 1.**). Each Provincial Service has access to all the information in the system, but it can just modify the data concerning its province. On the other hand, the Central Mining Service is supposed to be able to access and modify the data concerning all the Provincial Services.

Both tabular and geographical information should be accessible for reading by any Department in the regional public administration interested in it, such as the treasury, the agriculture or the environment departments. Finally, part of the information is public, so any person interested in mining information can access it with

certain limitations and restrictions. The Mining Department is responsible for both protecting the private data from been accessed by a third party and for providing access to the public information. The Internet provides an excellent way to provide this access.

## Geologic-mining information system architecture

The architecture of the geologic-mining information system is shown in **Fig. 2.**, which shows the different ways of accessing the data in the information system.



**Fig. 2.** Run-time architecture.

The people that work daily with the information system in the central and provincial mining services access remotely to the mining data using an application developed in Java. This application is composed of several components, that provide the administrative data management and GIS visualization capabilities required by the system. From every mining service, the application access remotely to the administrative information database and the mining coverages, located in a server. The access to several geographic coverages representing non-mining data that is not supposed to change such as rivers or roads, is made locally, replicating these coverages in every mining service, in order to improve performance.

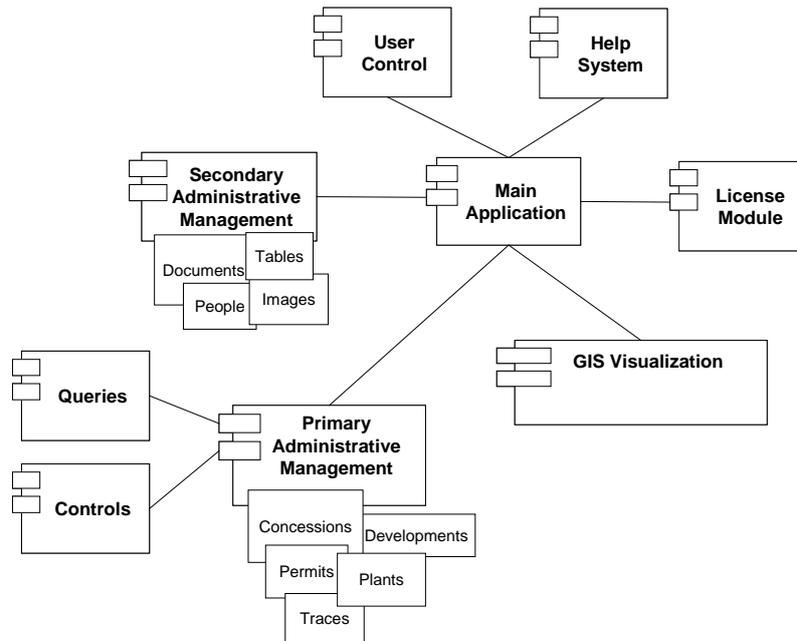
Other departments in the local government may need access to the information system. They should not be allowed to modify information, but they should be able to read most of the data in the system. This service can be provided through an applet in a web page served in the local government intranet.

Making some of the data public is other interest of the local government. The internet provides a perfect solution for the publication of this information. A small applet, in order to keep the download times short, can be embedded in a web page for internet access, providing some geographical data, such as mining development locations, and some administrative data on them.

The most important point about this architecture is the fact that there is only one information system, but it can be accessed in different ways to cover specific needs.

### Application to access the geologic-mining information system

The application is formed by several components as shown in **Fig. 3**. All of them are assembled around the main application component. This component acts as a container for the different components and allows the communication between them. The application graphic user interface is shown in **Fig. 4**.



**Fig. 3.** The components in the application.

The primary administrative management component handles the tabular information about the mining features while the secondary administrative management component is responsible for the elements in the system that, though related to mining information, are not mining features.

Query and Control components allow the user to make searches in the administrative data. While the query component is intended for general searches, the control component is meant to make searches too, but predefined and quite specific, as they are frequently used queries always related to dates.

User control establishes levels of access to the application, the help system provides help to the users, and the license module manages the use licenses of the application.

The GIS Visualization component is in charge of representing and managing the geographical information in the system.

### Tabular geologic-mining data management subsystem

The mining administrative elements that are relevant to the Public Administration are categorised into five different groups: concessions and authorisations, permits, working mines, deposit traces and treatment plants. Concessions, authorisations and permits refer to mining rights, that is, land areas given to either an individual or a company to exploit the deposits of a certain mineral. The differences among them refer mainly to the object of the exploitation, the regulations they must observe and the information of interest to the administration. Concessions, authorisations and permissions had associated one work plan per year, which includes detailed information on the mining exploitation. In the case of concessions and authorisations, each work plan may include the related working mines used in it. All of the mining administrative elements include not only tabular information but also geographical data. Concessions, authorisations and permits are represented as polygons, while working mines, deposit traces and treatment plants are considered as single points.

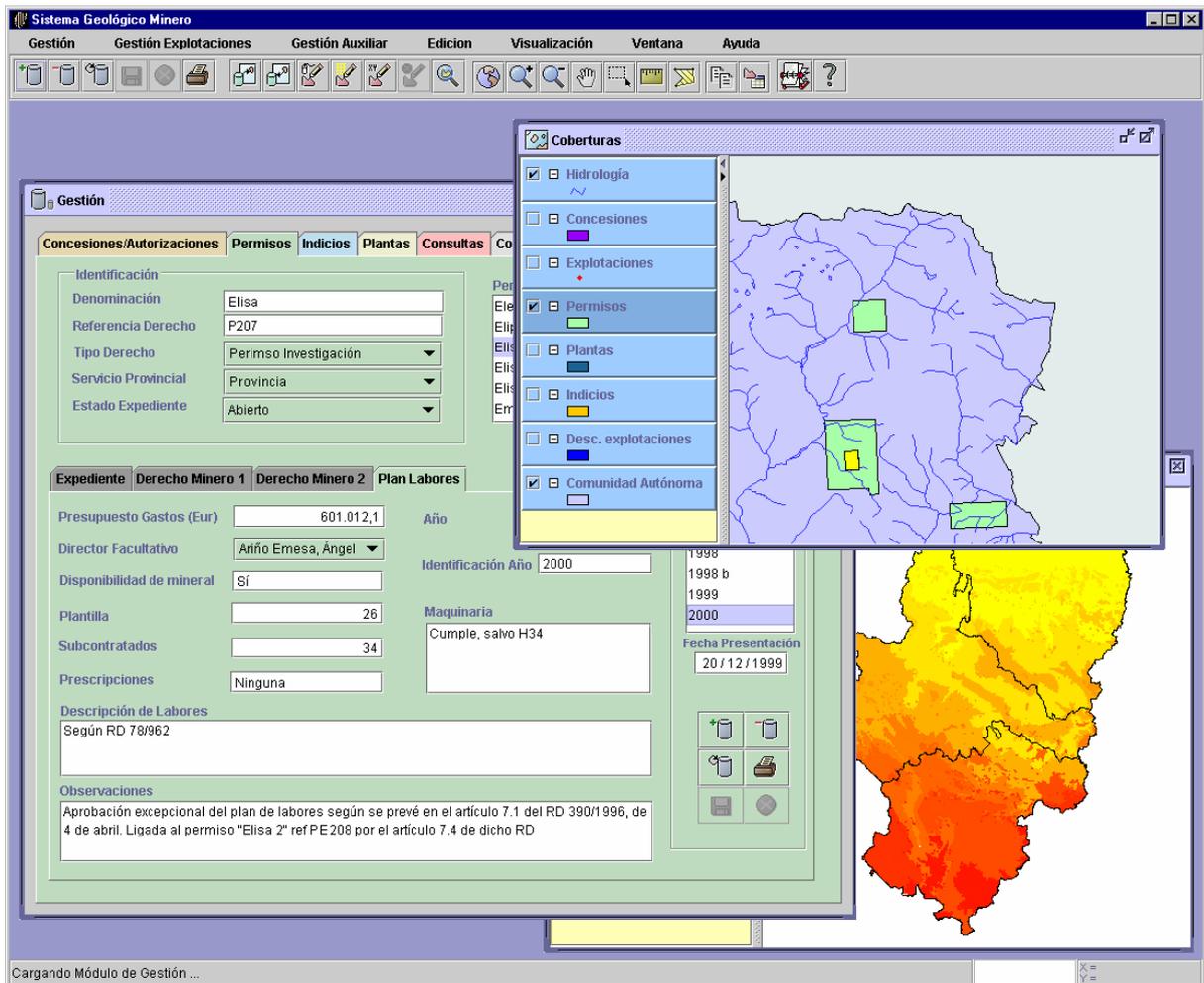


Fig. 4. Geologic-mining information system GUI.

The tabular geologic-mining data management subsystem is in charge of handling the information about the mining administrative elements. It is divided into three different components: primary administrative management component, secondary administrative management component and query and control component.

The primary administrative management component handles the information about the mining elements. It is organised into five different modules, one for each kind of mining element: concessions and authorisations, permissions, working mines, treatment plants and deposit traces. Each module of this component allows the user to consult and change (by adding a new item or deleting or modifying an existing one) the information concerning a single element. The five modules present a similar graphic interface. The permits module interface is shown in Fig. 4. All the available elements are shown in a list, and the user can choose the element whose information he or she wants to work with by clicking on it in the list. Any item in any of these modules may have geographical information associated to it, which can be shown and edited in the GIS visualisation component, as described below.

The secondary administrative management component is responsible for the elements in the system that, though related to mining information, are not mining elements and are not related to geographic data. These data are also organised in different modules, which include the person directory module, the document reference module, the image module or the auxiliary option table module. They follow the same graphic user interface style than the primary modules and can be managed in the same way.

Finally, the query module allows the user to make searches through the mining administrative elements. The user can set restrictions on the value of the selected attributes. When the query involves work plans information, basic statistics about the result elements can also be obtained and shown. The controls component is used to perform searches too though, in this case, they are predefined searches, related to deadlines or administrative expirations. The result of both a query and a control is shown in a table by default, but the geographical information linked to the result can also be shown in the GIS visualization subsystem.

## **GIS visualization subsystem**

The application to access the geologic-mining information system has several GIS visualization needs. Some of them are common to most applications that use GIS but there are several particular ones, to provide the special functionality required by the mining department.

Among the normal GIS visualization capabilities, several can be highlighted:

- The application can provide the administrative information about a feature in one of the mining coverages, and can select the geographical feature associated with a particular tabular information.
- Several coverages, with geographical information such as rivers, roads and municipal boundaries, can be shown, in any order and with different renderers.
- The user has the typical tools for map handling such as zoom or panning, besides a tool for measuring distances and other for measuring areas.

The special needs of the application come from the fact that one of the most important tasks that the information system allows is adding new mining concessions, developments, permits, traces and processing plants, as well as to maintain the old ones. This implies that the application must let the user insert and modify features in the mining coverages. This can be done in several ways:

- The user can insert directly the coordinates of the new feature in a dialog, and the feature is created in the selected coverage. As the coordinates in the coverages are in the UTM system in the zone 30, and the region administered by the mining department is between zones 30 and 31, the coordinates are automatically converted if the user decides to use geographic coordinates or UTM coordinates referred to the zone 31.
- The user can draw with the mouse the shape of the feature he or she is inserting. Except for the development locations, that are points, all features are polygons.
- Finally, the user can make use of the mining grid, that is an imaginary grid that covers Spain every 20 seconds in latitude and longitude, and can be used to define the mining features represented as polygons in a normalized way. In this case, the grid is painted over the coverage where the user is making the modification. If the user is modifying an existing feature, the squares of the grid corresponding to that feature are highlighted. Then the user can select and deselect squares on the mining grid to define the new polygon. The application will take the squares selected and will convert them into a polygon to store it in the corresponding shapefile.

The GIS visualization capabilities of the application are based on the generic component described in next section and some of these capabilities were customizations of this component as described in the section *Customizing GIS visualization by adding domain behaviour*.

### **A general purpose Java visualization component for GIS**

The Java visualization component is a piece of software developed to provide an application with GIS capabilities. It was designed to make it easier and faster to develop this kind of applications by providing a reusable set of GIS functionality. Thus, it can be used immediately in any Java application that needs to show and manage geographical information but can be used too for developing more complex and specific solutions using the capabilities provided as a base. Besides, it is possible to use it as a standalone viewer, because it has its own reusable GUI.

Here is a brief list of its main features:

- It is pure Java, so it is easily portable.
- It works with raster and vectorial coverages.
- It allows the drawing of vectorial coverages with different renderers in order to present the information in the most appropriate way to the user.
- It has tools to select and modify features and attributes in vectorial coverages.
- It lets the user modify coverages as it provides simple tools for inserting and editing features.

### **Customizing GIS visualization by adding domain behaviour**

The GIS functionality of the geologic-mining information system is built on top of the Java visualization component described in the previous section. This component provides most of the capabilities required by the system, but it was necessary to add several domain-specific ones.

As it is described in the section *GIS visualization subsystem*, the application to access the geologic-mining information system allows the insertion and modification of features in the mining coverages:

- Mouse insertions can be done directly by the Java visualization component, so it did not need customization.
- It was necessary to add coordinate conversion to allow the insertion of coordinates in the systems used by the mining department.

- The operations requiring the mining grid were implemented making use of the selection tools provided by the Java component for the interaction with the user, and creating algorithms for converting mining grid selections into polygons and vice versa.

### **Interoperating GIS visualization and tabular data management components**

The GIS visualization component provides an interface that is used by the primary administrative management component to handle the geographical information associated with the mining features. It makes possible to:

- Display the geographical features associated with a single record of administrative data or a group of them.
- Insert, modify and delete features associated with the administrative information.
- Show the administrative information associated with a geographical feature.

### **Dealing with multiple access**

The Mining Department consists of several mining department provincial services and a central service, as it have been previously shown in **Fig. 1.** Every service has several client PC's, and there is a Sun station server in the local government central computing centre. The services are connected by the local government intranet that uses a wide area network connecting the different provinces, and several local area networks in each province. The run-time architecture diagram is shown in **Fig. 2.**

The Microsoft Access database with the administrative information, and the mining coverages, in ESRI's shapefile format [1], are stored in the server. All the information in the server, geographical and non-geographical can be accessed and modified from the applications in the mining services, with certain restrictions in the case of provincial services and full access for the central one. The coverages that are not directly related to mining, such as rivers or roads, are replicated in every service to improve performance, as they rarely change.

The access to the server database is made using the JDBC-ODBC bridge [2] with the Access drivers. The same technology, with the adequate driver, is used to access the attributes of the mining coverages stored in the server and the attributes of the local coverages stored in every client, as they are stored in dBase files along with the shapefiles.

The access to the shapefiles is, in almost every aspect, a local access, because the directory in the server that contains these files is mapped to a local drive in the computers of the mining services. However, there is a problem because the mining coverages are regularly updated from the different services and two updates are not allowed simultaneously. To solve this problem, a little Java program was implemented to control the access to the shapefiles. This program is always running in the server. When a user wants to update a shapefile, the application connects to this program through RMI, and asks permission to access the file. If there is another application accessing the requested file, the permission is denied and the application must wait until the file is released; in other case, the user asking is allowed to edit the file and following requests will be denied until the file is released.

### **Intranet access**

As it has been told previously, reading access to the geologic-mining information system should be possible from any point at any department of the regional public administration through its intranet. The Treasury Department may want to contrast a mining company profit with the economical data stored in the work plans of that company. The Environment Department will also be interested in knowing about the state of mining industry in areas close to nature reserves or controlling what is done with the waste of treatment plants. This kind of access should be provided with no need of installing the application or copying coverages data and taking full advantage of the bandwidth the regional government intranet provides.

Just two little changes are made to the architecture to accomplish this requirement:

- First, the client application is transformed into an applet [6] that can be stored in the client browser as a plug-in [7]. As a result, the client can be executed on a web browser with built-in or plugged-in JDK 1.2 support, providing access to the mining and geological data through the same application that is used by Central and Provincial Mining Services. Since the Mining Department doesn't want to provide writing access to other Departments, a new kind of user with no writing permission is created for intranet access users, and interface options such as add, delete or modify elements are completely removed from the interface.

- Second, a client/server JDBC driver based on Java RMI [5] is introduced between the intranet client applet and the database, due to the fact that ODBC access is limited to local data sources. This new driver allows remote access to the databases without changing the client communication mechanism, since the driver offers a complete JDBC interface to it. This driver makes component reuse easier to the developer and removes the necessity of any kind of installation and configuration to the intranet user, who can access the information system by just clicking on his/her web browser.

For an Intranet user, the installation process merely consists in downloading the applet from the server with a web browser. The geologic-mining data management subsystem and the GIS visualization component will be available to the user, together with all its capabilities (except for the writing and modifying ones). The only price the user should pay for a non-permanent installation is the loss in performance due to the additional JdbcRmi client/server pair that is introduced, plus an increase in the time of access to the system the first time, as the applet has to be download and *plugged in* the browser.

## Internet access

It has been explained in the section *A geologic-mining information system* that part of the information that the mining department holds is public. The Mining Department wants to provide electronic access to this information through the Internet. The purpose of Internet access is then clearly different from the Intranet access: to provide general public reading access to certain geographic or tabular information and to provide specific access to certain individuals without requiring high bandwidth or speed connections on the client side.

The Internet user is supposed to send his/her requests and receive the requested data through a web browser, so a typical client-server architecture is used and incorporated in the whole architecture, as shown in **Fig. 2.** A Java applet embedded in a web page will be the vehicle for the user to access to the information requested [6].

On the server side, three different servers are running: an HTTP server, which provides the html pages containing the applet to the client web browser, an Internet data server and a map server.

The map server is a reusable Java component in charge of generating GIF images from coverage files or databases. It expands the general purpose Java visualization component for GIS functionality by being able to generate these images [4, 8]. The Java Internet Data Server is used to attend and process the requests coming from the client applet. To access the tabular data, the Internet data server uses a JDBC connection. When geographic information is demanded, the map sever component generates an image and sends it to the applet.

On the client side a light Java applet running in the user web browser is used. The web browser downloads the html page that contains the applet. It presents to the user a form that must be fill in. In case of a general user, the form have a similar appearance to the query component of the application. The user can fill it in to specify the kind of data he or she wants to get (type of data: tabular or geographical and type of elements: concessions, authorisations, permissions and so on), the fields of his or her interest and the restrictions that the requested data must fulfil. When the user identifies him or herself as a member of a certain group, such as the owner of mining rights, the form allows him or her to access data on the elements whose rights he or she owns, such as each concession annual working plan. The applet is in charge of collecting this request of data from the user, making the request itself to the Internet data server in the regional government central computing centre and formatting the requested data when is received form the server. Depending on the request, the received data can be both tabular and geographical. When alphanumerical data is requested, the Internet data server will send a range of data rows to the applet, which will show them to the user as a table. When the requested information is geographic, the applet will send a request to the map server to obtain a GIF image.

The internet access architecture easily allows future improvements of the information system by making possible to the individuals or companies that holds mining rights to provide the administrative data on line or by allowing the mining inspectors to check in situ the correctness and accuracy of the stored data [9].

## Conclusions

The case of a Spanish regional public administration mining department has been presented, as it has been presented our approach to the information system too. It has been determined by its needs: a distributed and public accessible system had to be constructed while keeping a low cost. The administrative database and the mining coverages are kept a central server, a Java application, consisting of several components allow the central and provincial services access the information. Internet and intranet access to the information through Java applets has been presented too.

Using Java in the development of the information system has made its development easier in several aspects:

- Implementing the control of the shared coverages in the server was quite easy. The operating system in the server was not a concern, because of the use of Java, and RMI could be used instead of developing a more complex solution using another distributed infrastructure like CORBA [3].
- If the server or the computers in the provincial services are changed, the application will not need major modifications, since Java is a crossplatform language.
- Thanks to Java, other ways to access the information system are available with minor changes to the code, for instance the developing of an applet for accessing the information from other departments in the local government intranet, as described in the *Intranet access* section.
- Since most web browsers interpret it, it is a good solution to Internet access
- Using JDBC allows the use of any database that supports this standard technology to store the administrative information in the server and the attributes of the coverages. Thus the application is not bound up with any database.

The main disadvantage of Java comes partially from one of its major advantages: to be a crossplatform language. It causes Java to be an interpreted language, being slower and more memory-consuming than other non-interpreted languages at run-time. However, this is becoming less a problem, since new optimizing tools are appearing into scene [6].

The information system is being tested at the moment by the Mining Services. The server infrastructure needed by the Services (the administrative database, the shared coverage features and the coverage access control server) is already set up in the Local Government Central Computing Center. The client application is installed in the Central Service and in one Provincial Service to be tested by end users. The complete installation in the rest of the Provincial Services will take place when the testing phase finishes. The implementation of both intranet and internet access will then be started too.

## References

1. Environmental System Research Institute. "ESRI Shapefile Technical Description." *ESRI White Paper*, July 1998
2. Sun Microsystems, Inc. "JDBC API Documentation."
3. R. Orfali, D. Harkey. "Client/Server Programming with Java and CORBA." *Wiley Computer Publishing*, 1998.
4. Alexandre Sorokine, and Irina Merzliakova. "Interactive map applet for illustrative purposes." *Proceedings of the 6th international symposium on Advances in geographic information systems*, 1998, Pages 46-51.
5. Gibello Pierre-Yves. "A client/server JDBC Driver based on Java RMI."  
<http://dyade.inrialpes.fr/mediation/download/RmiJdbc/RmiJdbc.html>
6. Eckel, Bruce. "Thinking in Java." *Prentice Hall PTR*, 1998.
7. Jasnowski, Mike. "Installing Java with the browser." *Java Developer's Journal*, March 2000, pages 22-30.
8. Davis, Frank G. F. et al. "Wyoming Geological Database: an Internet Map Server Application." *ESRI International User Conference*, 1998
9. Hillman, Barry. "Integration of Real-Time Survey, Mine Planning Software, GIS and Machine Control GPS for Mining Operations Management." *ESRI User Conference*, 1998.