

Configured software integrating application data-servers, performing horizontal altitudinal layer selection out of the 3D data models and adapting data from different GIS maps – deliverable under the form of computer operational software and configuration information.

## 1. Introduction

The AIRAWARE on-line Open GIS system was designed following a distributed architecture. All the partners and end-users are able to access the system using a thin web client (via a simple web browser like Internet Explorer or Mozilla Firefox) or a thick desktop client to store, display, query, analyze and retrieve Bucharest air quality related information's (Figure 1).

The main functions of the system are:

- acquisition, validation, storage, spatial analysis and data interpretation;
- management and exchange of raster and vector graphic information, and also of related attribute data for the air quality monitoring activities;
- handling and preparation for a data rapid access;
- information updating (temporal modification);
- data restoring, including the elaboration of thematic documents;
- generation of value-added information;
- distribution of the derived products to the interested authorities, media, etc.

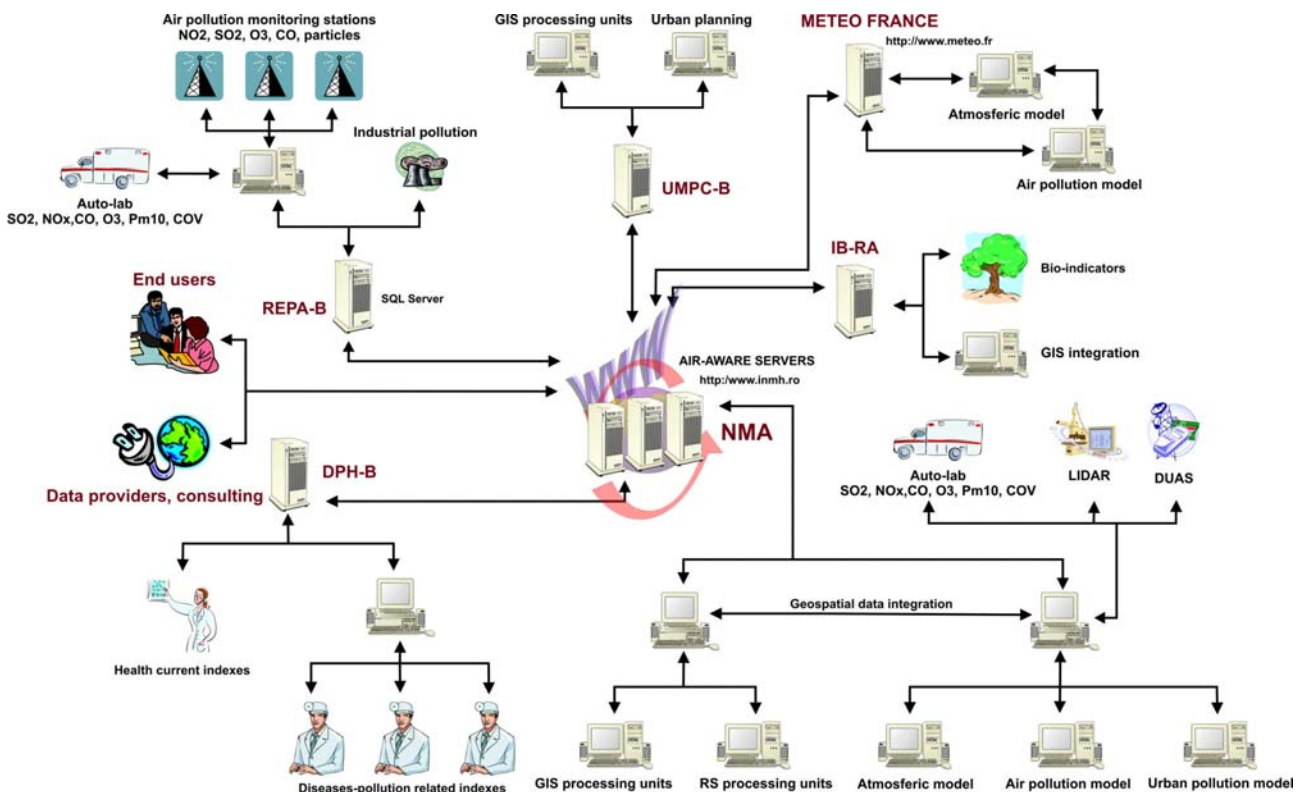


Figure 1. AIR-AWARE on-line Open GIS system flowchart.

## 2. System key components

In order to achieve the above functionality a complex system was designed and developed. The system has a modular and distributed architecture. The main components of the system

are represented in Figure 2 and described below.

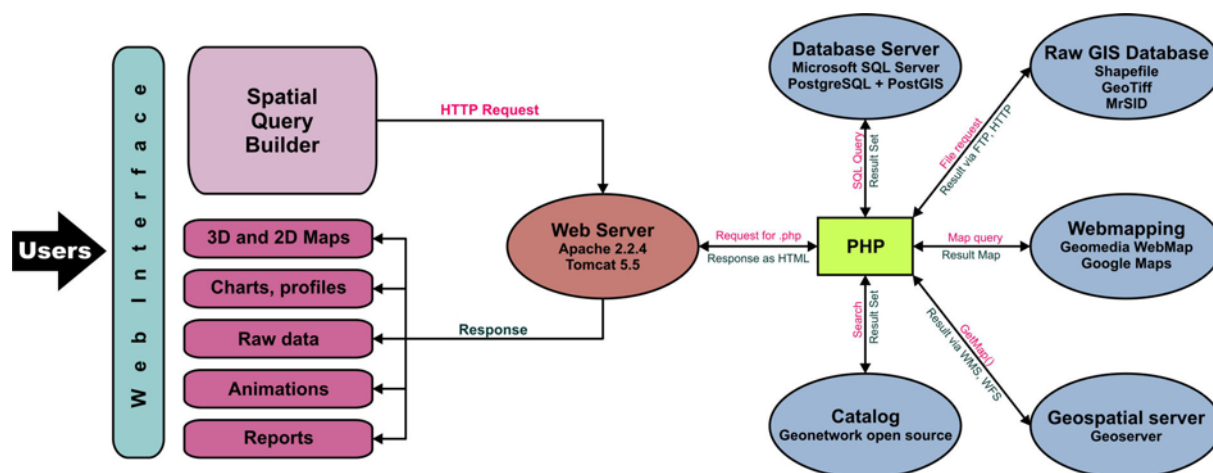


Figure 2. AIR-AWARE system key componens.

## 2.1. Core Server

Is the core component of the system since it handles the interactions between the various modules, the end-users management, the display, analysis and manipulation of data. The server-side of the system is composed from: Hardware components (Server, Rack mount, Peripherals), Operating System (OS), HTTP Server, Java Platform, Java Servlet Container, server-side scripting language, geospatial catalog application and Map Server.

### 2.1.1. Server

Consist in a powerful, 64-bit, multi-processor computer. The machine configuration was chosen according with the computing power requested by the software components of AIR-AWARE on-line system.

### 2.1.2. Operating System

Is the software that manages the sharing of the resources of the computer server and provides programmers with an interface used to access those resources. The AIR-AWARE system is using the Linux Red Hat Enterprise Premium Edition operation system. This operating system has proved compatible with the classical server side applications (HTTP server, Servlet Container, PHP), geospatial applications (Geoserver, Geonetwork) and the air quality forecast mathematical models.

### 2.1.3. HTTP Server

The HTTP (web) Server is powerful server-side software that handles the information to be distributed over the web on request from one or many clients by HTTP protocol. The AIR-AWARE system is using Apache as HTTP Server. Apache HTTP server is a very popular, scalable, open source web server. Apache supports a variety of features, many implemented as compiled modules which extend the core functionality. These can range from server-side programming language support to authentication schemes.

### 2.1.4. Java Platform

Is a standard platform for developing application software and deploying it in a cross-platform environment. Some of the geospatial applications used by the AIR-AWARE system (Geoserver, Geonetwork Opensource) were build in the Java programming language and require the presence of Java Platform to run.



#### 2.1.5. Java Servlet Container

The AIR-AWARE system is using the Apache Tomcat to provide an environment for Java based applications to run in cooperation with a web server. Tomcat implements the Java Servlet and the JavaServer Pages (JSP) specifications.

#### 2.1.6. Server-side scripting language

In order to be able to generate dynamic HTML pages and to provide an interactive link to database and geospatial modules, the AIR-AWARE on-line system required a server-side programming language. The solution of choice was PHP: Hypertext Processor (PHP), another open source technology that can run with Apache Server and provide the ability to highly customize the response based on the user's requirements, access rights, or queries into data stores.

#### 2.1.7. Geospatial Catalog Service

The AIR-AWARE system integrates data from multiple sources. When the volume and diversity of data increase, the rapid and intuitive retrieve of specific information from the system (by a user or a client application) becomes a challenge. In order to comply with this challenge a geospatial catalog service was implemented. Catalogue services are the key technology for locating, managing and maintaining distributed geo-resources. With a catalogue service the client applications are capable of searching for geo-resources in a standardized way (i.e. through standardized interfaces and operations) and retrieve back relevant information's. The solution of choice for AIR-AWARE system was a Java based web application called GeoNetwork Opensource. GeoNetwork is fully compliant with Open Geospatial Consortium (OGC) catalog specifications.

#### 2.1.8. Map Server

Represent one of the main components of the system and is bringing GIS functionality into the web environment. The Map Server application helps the users to access and display the GIS database and to perform layer selection, different queries and spatial analysis. Map Server works the web server application. The web server receives requests for maps and passes them to Map Server to create. MapServer generates the requested map image and hands it to the web server, which transmits it back to the user. Figure 3 shows how the user interacts with the web server which, in turn, makes requests to the MapServer program inside the AIR-AWARE system.



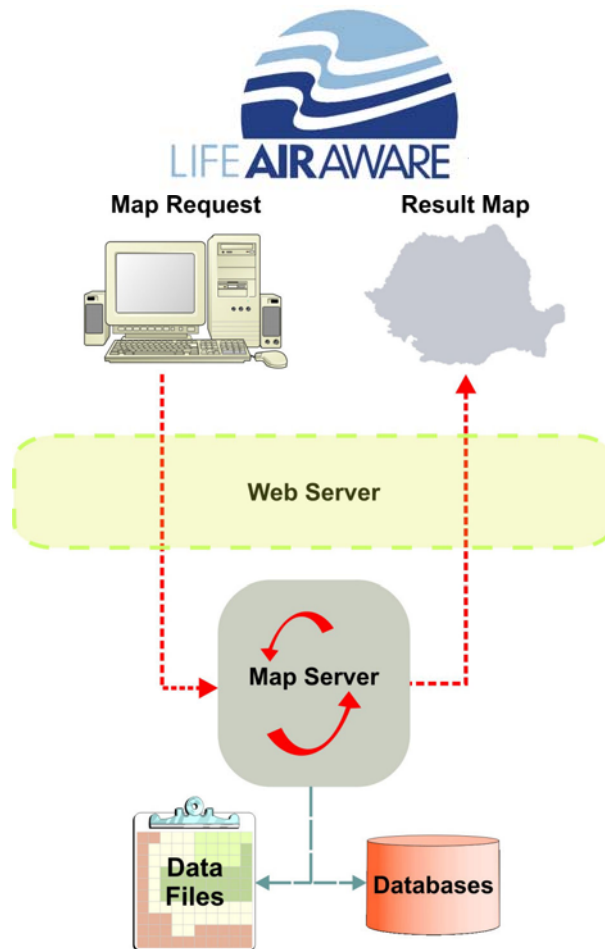


Figure 3. AIR-AWARE Map Server operation flow-chart.

The Map Server functionality within AIR-AWARE system is provided by Geoserver. GeoServer is a Java (J2EE) implementation of the OGC's Web Feature Server specification. It is free software, available under the GPL 2.0 license. GeoServer supports efficient publishing of geospatial data to a numerous types of formats, including: KML (Keyhole Markup Language), GML (Geographic Markup Language), Shapefile, GeoRSS, PDF (Portable Document Format), GeoJSON, JPEG, GIF, SVG (Scalable Vector Graphics), PNG.

The maps served by Geoserver can represent different pollutant concentrations, wind forecast, city features (streets, buildings, point of interest, hydrological network) etc.

## 2.2. Database Server

Is the second server of the AIR-AWARE system architecture. Its purpose is to store all the data collected within the AIR-AWARE project and to deliver that content on request basis. The database management software is deployed on a dedicated machine, scaled up to serve hundred of simultaneous requests. The chosen operating system was Microsoft Server 2003. The AIR-AWARE database server hosts the two ORDBMS (object-relational database management system) applications described bellow.

### 2.2.1. Microsoft SQL

The Microsoft SQL database instance store all the data related to air quality monitoring and climatology. It's closely linked with the NAM main climatological database.

### 2.2.1. PostgreSQL+PostGIS

Is used to store and serve the all the geospatial data from the AIR-AWARE project. PostgreSQL is an ORDBMS released under a BSD-style open source license. The geospatial support in PosgreSQL is provided by the PostGIS extension, allowing it to be used as a backend spatial database for geographic information systems. PostGIS isn't simply a data storage repository, but also an environment for interacting with spatial data by implementing the SFSQL (Simple



Features Specification for SQL) published by OGC.

## 2.3. System clients

The user access to AIR-AWARE system functionality is achieved via specially developed software clients. The clients were designed according with the users in order to achieve the AIR-AWARE project objectives. The

### 2.3.1. Web client

Is the most important client of the AIR-AWARE system. All the users can access this client using only a simple web browser and an Internet connection. For the geospatial support the web client is build around a custom version of Geomedia Webmap application. Geomedia Webmap is on of the most important application in the field. The native formats can include those used by different commercial vendors. In cooperation with Geoserver other nonproprietary formats can be used as well, including the OGC standards for Geography Markup Language (GML), Web Map Server (WMS), Web Feature Server (WFS), PostGIS and other databases. Geomedia Webmap is also able to deal with the different coordinate systems used within the AIRAWARE project: Stereographic 1970 – official Romanian coordinate system, Gauss-Kruger, UTM – Universal Transverse Mercator. The ability to have simultaneous access to diverse data formats on the fly without conversion makes Geomedia Webmap one of the top applications available. The use of Geomedia Webmap as webmapping platform ensure the compatibility between all the AIRAWARE participants as they all use Intergraph and OGC compatible products for GIS activities.

The Geomedia Webmap architecture incorporates a processing model that uses many components working in cooperation to run simultaneously and create map data for delivery by the Web server. Components, communicating using standard protocols, can be distributed anywhere on the network while the components remain synchronized. Each host computer's operating system controls the execution of Geomedia Webmap processes and manages memory.

From the user's perspective, a button is clicked, an operation is performed, and a result appears on the screen. This summarizes a complex process of communication between the viewer and the server. What actually occurs when the user clicks a button is that an XML request is sent from the viewer to the Application Server. The Application Server directs the request to the appropriate Geomedia webmap function type (and to the correct host server, if different servers are used for services and the viewer), then returns the response to the viewer (Figure 4).

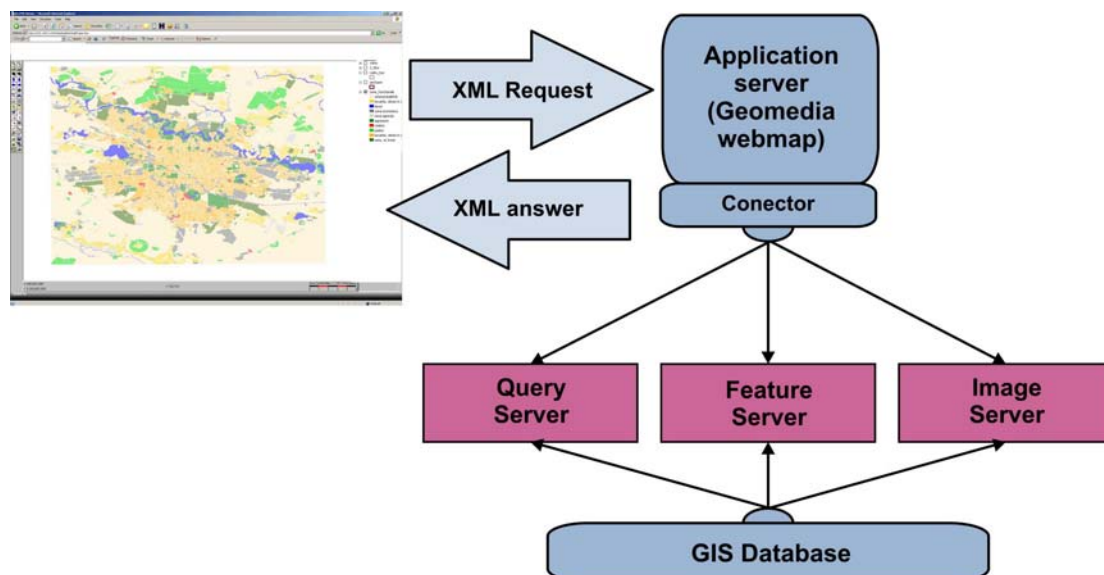


Figure 4. Geomedia Webmap flowchart.

The client webmapping interface contains several key functional areas:

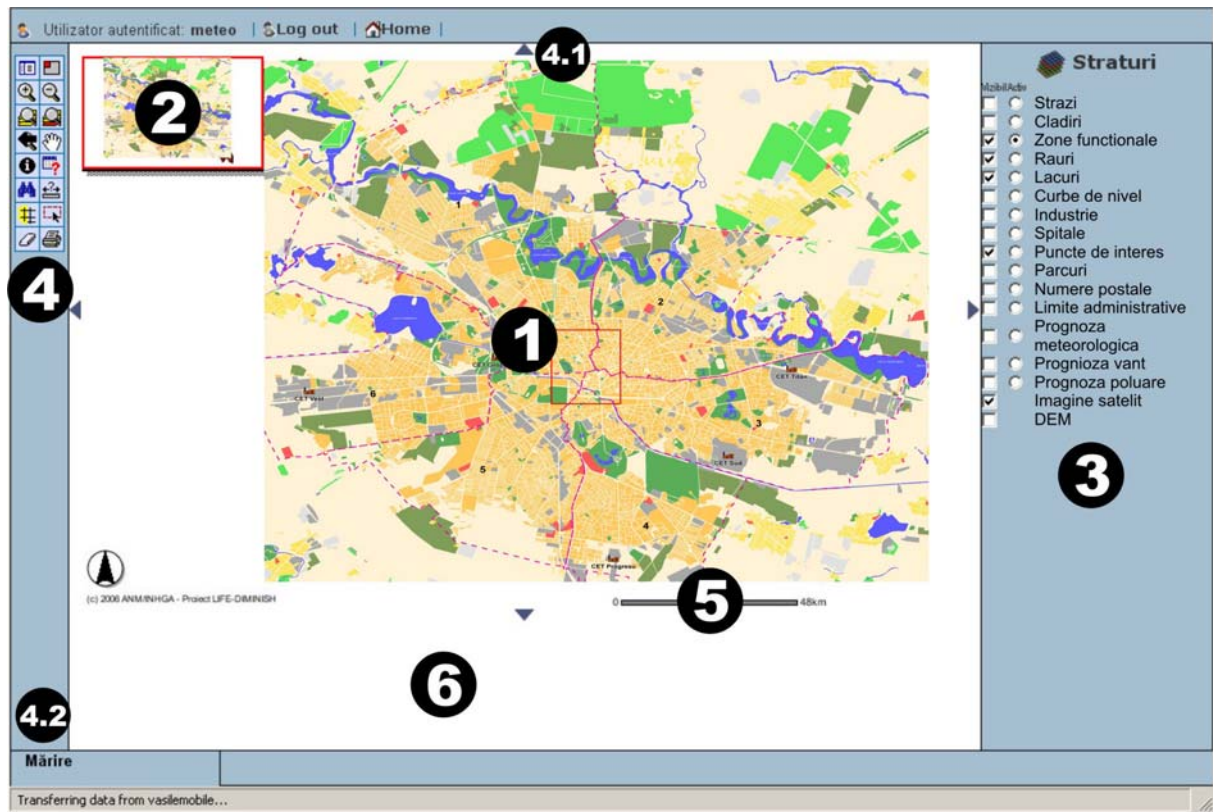


Figure 5. AIR-AWARE system webmapping interface functional areas.

<b>Zone 1</b>	The central map contains the cartographic representation of the spatial data stored in the GIS database;
<b>Zone 2</b>	The overview map facilitates the user orientation inside the map;
<b>Zone 3</b>	The list of the spatial layers which can be represented in the map;
<b>Zone 4</b>	The toolbar contains all the needed instruments for map interaction;
<b>Zone 4.1</b>	Shifts the map on one of the four cardinal directions;
<b>Zone 4.2</b>	Display the name of the selected instrument;
<b>Zone 5</b>	The graphic scale of the map;
<b>Zone 6</b>	The output area for the query results.

#### *The map*

The central map contains the cartographic representation of the spatial data stored in the GIS database. Both Raster and Vector (points, lines or polygons) data can be displayed in this area. The map can also include labels for the represented spatial entities, generated based on the related database attributes. The cartographic symbols and labels are automatically adjusted according with the representation scale. The map is refreshed after each action performed by the user.

#### *The overview map*

The overview map facilitates the user orientation and provides a mechanism for interactively re-centering the main map to a point selected with a simple mouse click.



### The layer list

The layers list is used to determine the way the map is composed and displayed. Each layer has two associated input boxes. First is a checkbox, allowing the user to control the map composition by turning on and off the layer visibility. Second is a radio box, allowing the user to select the active layer. The active layer can be selected, queried and analyzed using the instruments from the toolbar. The 3D model output data may be used for queries and different analysis, based both on spatial location and attribute database. The list contains the following vector layers: communication network, buildings, parks, hydrographical network (rivers, lakes), administrative boundaries, points of interest (industrial objectives and other pollution sources, sensor location, medical facilities).

### The toolbar

The toolbar contains all the instruments needed for map navigation, database search, feature selection, buffer creation. The functionality of these tools is very similar with the one contained in every GIS desktop application.

	Toggle between layers list and layers legend;
	Toggle the overview map;
	Zoom in the map. The user can use this instrument interactively, by drawing a rectangle on the interested area;
	Zoom out. Is the opposite of the previous instrument;
	Display the map at the maximum layers extend;
	Display the map at the maximum extend of the selected layer;
	Returns to the previous extend of the map;
	Pan - is one of the most used instruments for map navigation. The user controls the displayed part of the map by interactively dragging the map with the mouse.
	Identify - allow the user to interactively select and query elements from the active layer
	Query – allow the users to select elements from the active layer based on the attributes stored in the database.
	Search the attribute database;
	Measure distances on the map;
	Create a buffer with fix radius (defined by the user) around the selected entity;
	Interactively selects elements from the active layer by drawing a rectangle on the map;
	Deselects all the selected elements;
	Creates a printing version of the map.

The access to the AIR-AWARE system is done via a secure webpage, using a predefined username and a password. Only the registered users are able to pass forward to the Start (Home) page and have access to the system functions. The web interface was designed according to end-users' needs. The goal is to obtain a simple and friendly environment for spatial data management. Users with appropriate privileges can access the AIR-AWARE interface through the web browser and perform queries, and retrieve different products useful in order to:

- process these data for specific computations (health, bio and urban planning indicators);
- to integrate the multi-source processed information in Decision-Analysis-Matrixes in order to better understand the impact of the pollution on humans and environment; upgrade the result in a Decision-Analysis common access space of the GIS Server;
- provide the right, both short and long term, decisions.

At this stage, the compatibility of the AIR-AWARE system web client was successfully tested on Windows platforms (2000, Xp, 2003 Server), using Internet Explorer, Mozilla Firefox and Opera browsers. The minimum recommended screen resolution to use the system is 1024x768. The browser should also allow pop-up windows, Javascript programs and Cascade Style Sheets formatting.

### 2.3.2. Desktop clients





The users with who require more advanced GIS functionality or want to use their own data processing algorithms can access the AIR-AWARE system content using a desktop (thick) client. This is possible due to the standard data access protocols and methods implemented on the AIR-AWARE server-side. Also, the users with poor or zero GIS knowledge are able to access some of the AIR-AWARE products within popular, easy to use, applications like Google Earth.

