GEODATA PROCESSING AND WEB MAPPING IN VISTULA LAGOON ECOSYSTEM MANAGEMENT

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ABSTRACT:

WEB mapping and processing of GIS-type data (geodata) through the Internet becomes the newest technology applied in geosciences and live sciences. Research project entitled "*System of the environmental and spatial information as the background for the sustainable management of the Vistula Lagoon ecosystem (VISLA)*, carried out at the University of Warmia and Mazury in Olsztyn, consisting in implementation of the innovative internet service for the management of environmental resources is presented in this paper. The main aim of the project is joint exploitation of several geodatabases, connecting land information systems (territory adjacent to the lagoon) with water quality information (in situ measurements), including remote sensing technology and finally the use of mathematical modeling to ecological processes analyses. Data models, modes of data acquisitions, integration and presentation of the results in the form of Internet map services are described. Different aspects of project organization and management linked to VISLA system architecture, software resources and procedures leading to web mapping of the results are shown. Specificity of system components and their mutual connections demanding high degree of formalism is presented in the form of UML diagrams and flowcharts. Adopted solutions and results are presented by some examples of thematic services.

1. INTRODUCTION

Presented project aims at the implementation of the innovative internet service for the management of environmental resources and the space of Vistula Lagoon. Precise and repetitive diagnostic of the status of this area by the use of marine research, satellite remote sensing and mathematical modeling should be an obligatory requirement for carrying out of any investment or revalorization activity in such a complex ecosystem. Vistula Lagoon is a specific part of Southern Baltic Sea. It represents a type of large (838 km2 area, including 328 km2 in Polish border) and shallow (2.6 m in average) lagoon with narrow connection with open sea. Its hydrological regime is dependent from the inflow of sea waters. Even 80% of water is coming from Baltic Sea by Baltyisk Strait. The major phenomenon causing permanent disturbance of ecosystem balance is an excessive primary productivity of phytoplankton, particularly regular harmful algae blooms. The main sources of nutrients are originating from unmanaged properly water treatment in the catchment area and from the resuspension from bottom sediment.

Last years showed that efficient management of this ecosystem requires: integration of multisource databases on land and water characteristics, use GIS driven approach in its processing, integration of remote sensing data and implementation of WEB mapping technologies permitting wide-spread access to information and in consequence better understanding of ecosystem functioning by local and regional decision makers, researchers and other interested parties.

2. WEB GIS BASED COLLABORATIVE FRAMEWORK

2.1 Project mock-up and project repository

The project is carrying out as an interdisciplinary task of the diffused workgroup in the frame of the WEB GIS based collaborative framework *(S. Dragicevic, S. Balram 2004)*. The schema of the framework used in VISLA project is shown in the figure 1where it is possible to distinguish four areas presented further in 4 detailed schemas: GIS, Remote Sensing, Ecology and Internet service. Project repository has been established according to mock-ups and its processes. An access to this repository is allowed by ftp protocol. Registered users as project's actors can read and write data and documents stored in corresponding directories. Another way to use the data stored in repository is remote access to the server via MS Windows Remote Desktop Connection with appropriate user privileges and running specific GIS and Remote Sensing software installed there. To develop and implement this framework the structural analysis and UML notation were used. GIS tools play

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role of analytic and computing environment in the VISLA Project. “GIS Area” is a platform of gathering and integration of external and internal data. External data were acquired from official and administrative datasets like geodesy and cartography centers, Ministry of Environment (NATURA 2000), hydrography and meteorology institutes. Internal data were produced as a results of field campaigns and in-situ measurement. All these data were integrated in the form of personal geo-database (ESRI nomenclature) stored on Geo-server being a part of the “Internet area”. Figure 3 shows interactions and data exchange links between GIS and ECO areas. “GIS area” task is to process data and to prepare geo-databases and maps. “ECO area” provides in situ measured data needed for water parameters extraction and inherent optical parameters of water column. All “eco” data (biological, chemical, hydrologic, etc) acquired in-situ are recorded in the form of simple spreadsheets comporting original values and converted into Geo-database as well. All collected data are stored in the formats easily readable by GEMSS system – a set of software modules permitting mathematical modeling of ecosystem components interactions. GEMSS is an integrated system of 3-D hydrodynamic and transport models, geographic information (GIS) and ecological data. The system includes grid generator and editor, control file generator, 2-d and 3-d post processing viewers and additional tools that include meteorological data processor, as well as flow data processor to support 3-D modeling. Figure 5 shows Internet area mock-up with 3 main components:

- Geo-server including computer, data and shared GIS functionality and mechanisms,
- Administrator tasks concerned users accounts and ftp protocol administration,
- Service as a set of activities used for map services preparing and publication.

Map services were composed on the base of personal Geo-databases prepared in ArcGIS Desktop environment.

2.2 Visla server resources

Geo-server architecture is shown on figure 6. Geo-server is the quad computer with Windows 2008 operating system. Internal elements of that system are http and ftp protocols. As a supplement of the system can be ArcGIS Desktop and ArcGIS Server 9.3. ArcGIS Desktop is the core of the Geo-server. All data, external and internal, are prepared and managed by ArcGIS Desktop. ArcGIS Server plays different role concerning GIS functionality sharing for thin client by, for example, Internet Explorer.

3. DATA SOURCES AND PROCESSING

GIS Data

For Vistula Lagoon Area Of Interest (VL AOI) there are many different databases, generally branch specific, organized or not as GIS maps or layers. Some of them cover only land areas, others cover whole territory including water bodies and rivers. The spatial information system (GIS) for the Vistula Lagoon environment has been built mainly on the official thematic databases available in Poland created in the framework of Spatial Data Infrastructure National Programme. These are namely:

- Regional Spatial Information System (RSIS) managed by geodesy and cartography regional offices
- sozologic and hydrologic(MPHP) maps in paper, digital raster or vector form,
- Corine Land Cover 2006,
- maps of NATURA 2000 areas,
- Geochemical atlas of Vistula Lagoon,
- Bathymetry and Digital Terrain Models.

The cartographic data were purchased from both Pomerania and Warmia & Mazury Voivodship Geodesy and Cartography Offices. All datasets have been checked for their consistency and formats, harmonized and converted into final formats – geodatabase. Simultaneously the maps presented RSIS resources were done. Redundancy and semantic incompatibility of data have been resolved.

Remote Sensing data

Satellite images acquired during last three years were registered by several systems like ENVISAT/MERIS, CHRIS/PROBA, Landsat5 TM, SPOT XS, DMCII NiSAT. Those data were used to land cover maps updating and water parameters extraction. Satellite data were especially useful on the Russian side of the lagoon. Georeferenced and processed to reflectance images are stored in data repository on Geo-server and they can be easily retrieved as an input for water parameters extraction based on physical or empirical models. The extent of water body and the needs of study were the main factors influencing the choice of satellite systems and sensors used for observing lagoon and surrounding land areas. ENVISAT/MERIS and CHRIS/PROBA served as source of information on water parameters, others like Landsat5 TM, SPOT XS, DMCII, both for water body inspection and surrounding land areas mapping.

ECO data

In order to create a model of the basin’s water quality once a month campaign for in situ data collection was planned during two first years of the study (2008-2009). The investigations were conducted during vegetation season and episodically in dormant season. Five constant and from ten to fifteen changeable (depending on satellite acquisition area) stations for data collection were planned in various characteristic locations on the Polish part of the Vistula Lagoon. The locations of

sampling stations are presented in the figure 8. There exist also numerous ecological databases, official, administrative, governmental, often offering long time series of parameters' values concerning water quality in lakes, rivers and streams. But these measurement results (e.g. sediment transport, salinity, temperature, chemical and biological components) are often stored in simple alphanumerical tables or in the spreadsheets in different institutions. The appropriate agreements for exchange data between adjacent administrative units or their purchase are needed also.

4. GEODATABASES AND MAP SERVICES CONSTRUCTION

As mentioned before external data were acquired from official databases and some integration procedures was needed. Data coming from in situ measurements and observations are managed in RDBMS environment. The most essential part of E-R diagram concerning measurements in-situ is shown in the figure 7. It was recorded about 70 water quality parameters and their multitemporal values. Personal Geo-database composed from that data allows making synthetic queries, which results could be presented as maps and charts on internet map service.

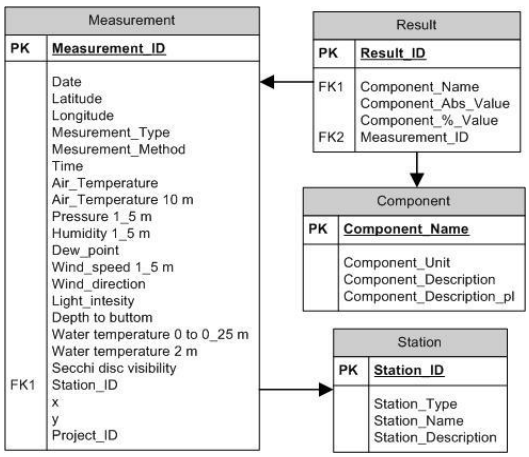

Figure 7. E-R diagram concerning measurements in-situ

Internet map service prepared using ArcGIS Server environment assumes to take advantage of GIS functionality shared as Internet service. That service can be used by simply explorer as Internet Explorer, Opera and so on. Internet map service construction consists in several activities leaded to receive the set of directories and files (Map Document) contained vector, raster and tables data organized as GIS resources shared by ArcGIS Server. The general rule of Internet Map Service construction using ArcGIS Server is shown in the figure 8.

The most important benefits followed that application are:

- Source data separation from end users
- Possibility of use the wide range GIS functionality shared for thin clients
- Possibility of project results (maps, charts, measurement data) dissemination in the Internet.

Internet mapping mechanism delivered by ArcGIS Server has been used for several sets of data publication. That data relates to following kind of products:

- General set of topographic data concerning roads, cities, lakes, forests, NATURE 200, railways, rivers, hypsometry, administration borders, and so on, delivered from official databases,
- Thematic maps elaborated as synthetic data compiled from above and other statistical data presenting social and natural phenomena,
- Satellite data prepared as geo-referenced images contained current land cover, extracted water parameters, coastal vegetation and colour compositions for photo-interpretation,
- Results of GEMMS modelling contained state of the water in the lagoon and prediction of its future changes.

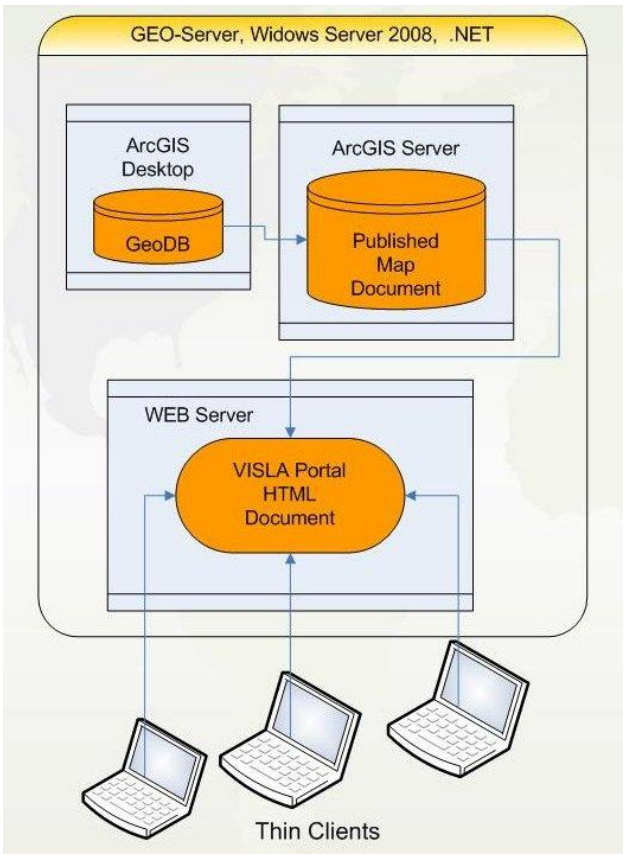

Figure 8. The general rule of Internet Map Service construction using ArcGIS Server (ESRI).

An example of map service is presented also in the figure 9 showing satellite image MERIS of the Polish part of the Vistula Lagoon.

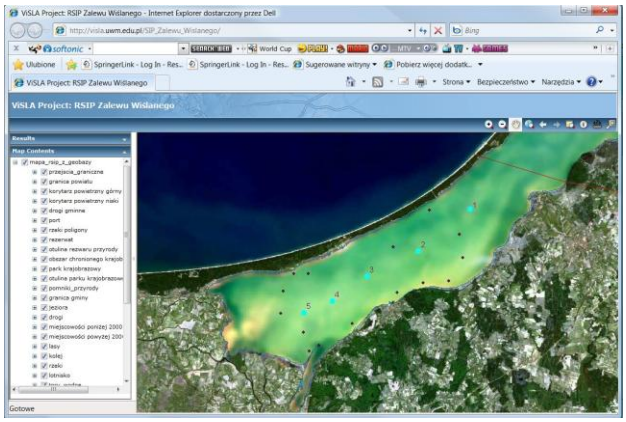

Figure 9. Polish part of VISTUA LAGOON presented on internet map service.

5. CONCLUSIONS

All presented issues, datasets, methods and procedures leading to establishing an Internet service helping scientific and administrative community to better understand Vistula Lagoon ecosystem and its behavior are still under development and integration. Each interested person is invited to visit our Web site at http://visla.uwm.edu.pl and to express own remarks, questions and comments about the methods, results and usefulness of WEB services. The authors hope that after second year of satellite data collection and GEMSS model running the repository of the project will have an important database reflecting the specificity of the Vistula Lagoon and showing "mathematically" confirmed complexity of its ecosystem.

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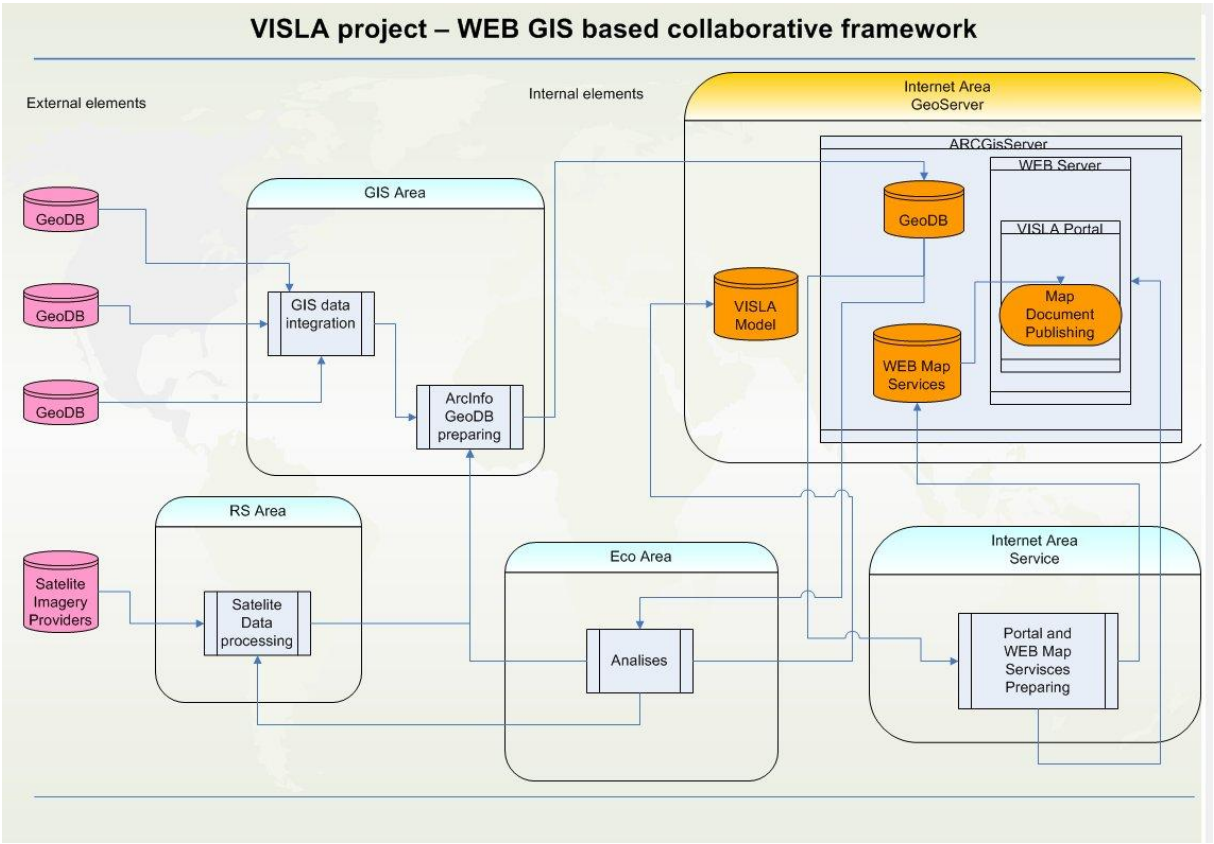

Figure 1. VISLA project – WEB based collaborative framework.

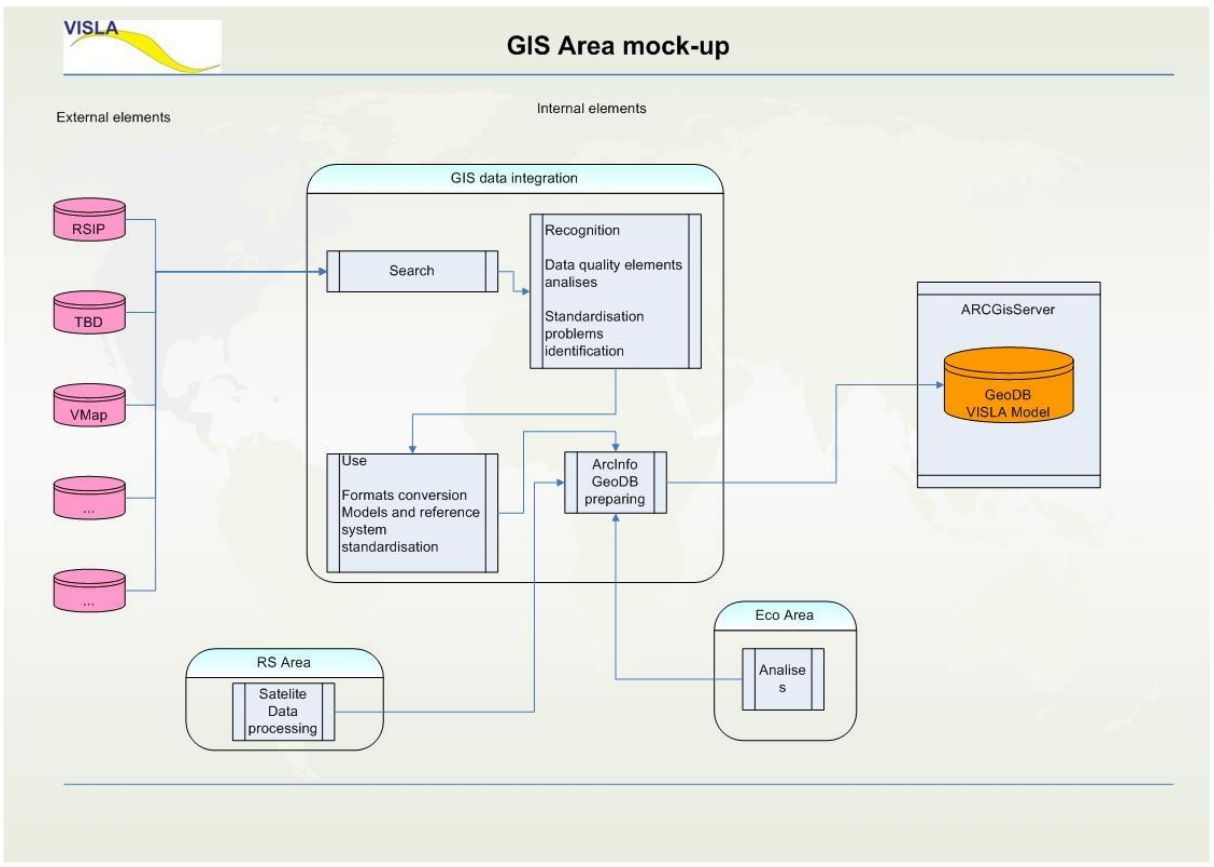

Figure 2. VISLA project – GIS Area mock-up.

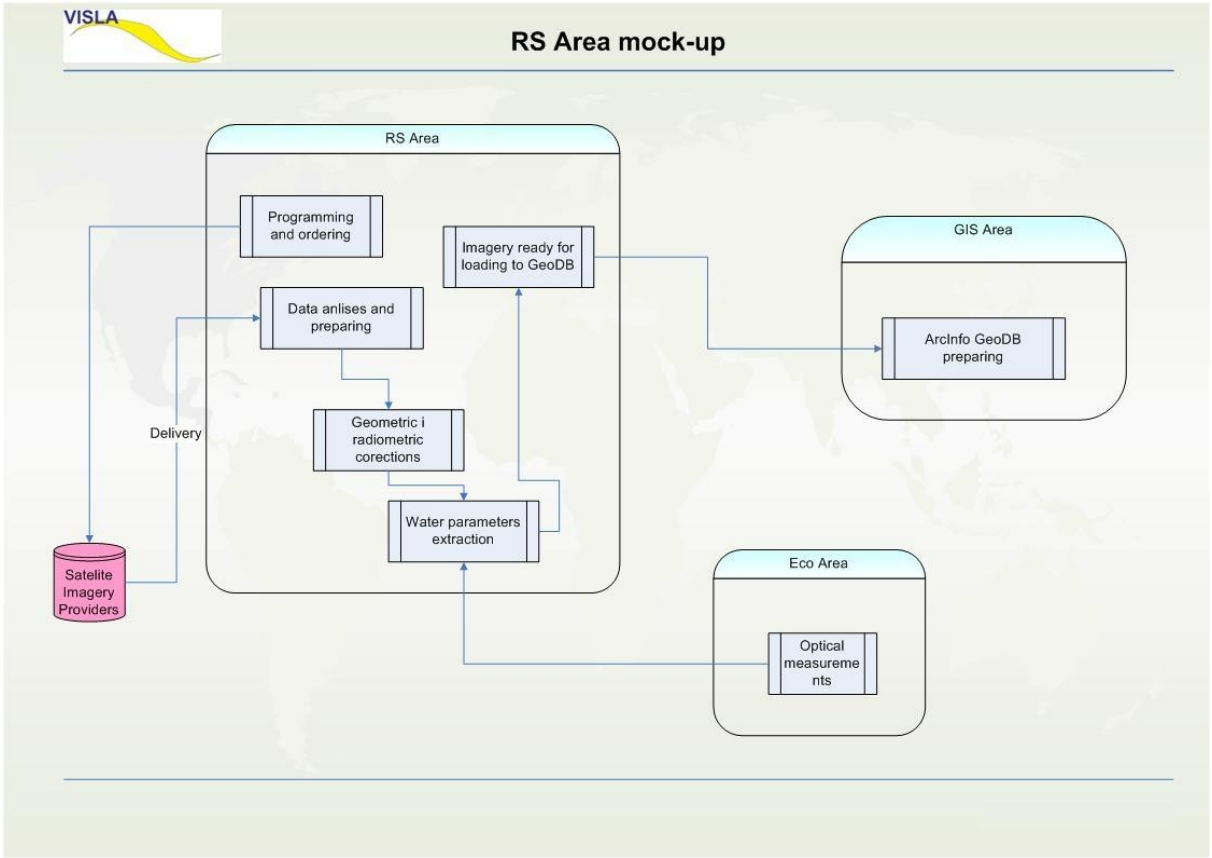

Figure 3. VISLA project – RS Area mock-up.

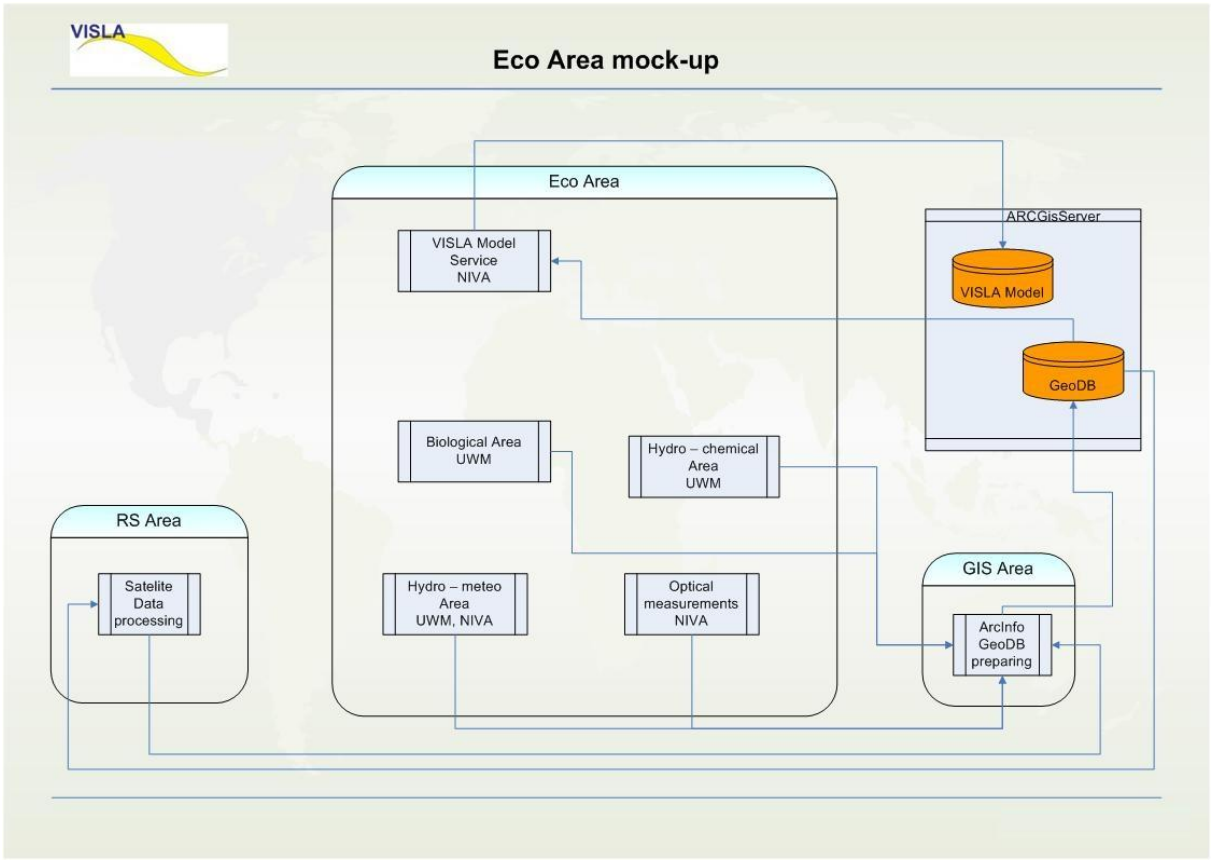

Figure 4. VISLA project – ECO Area mock-up.

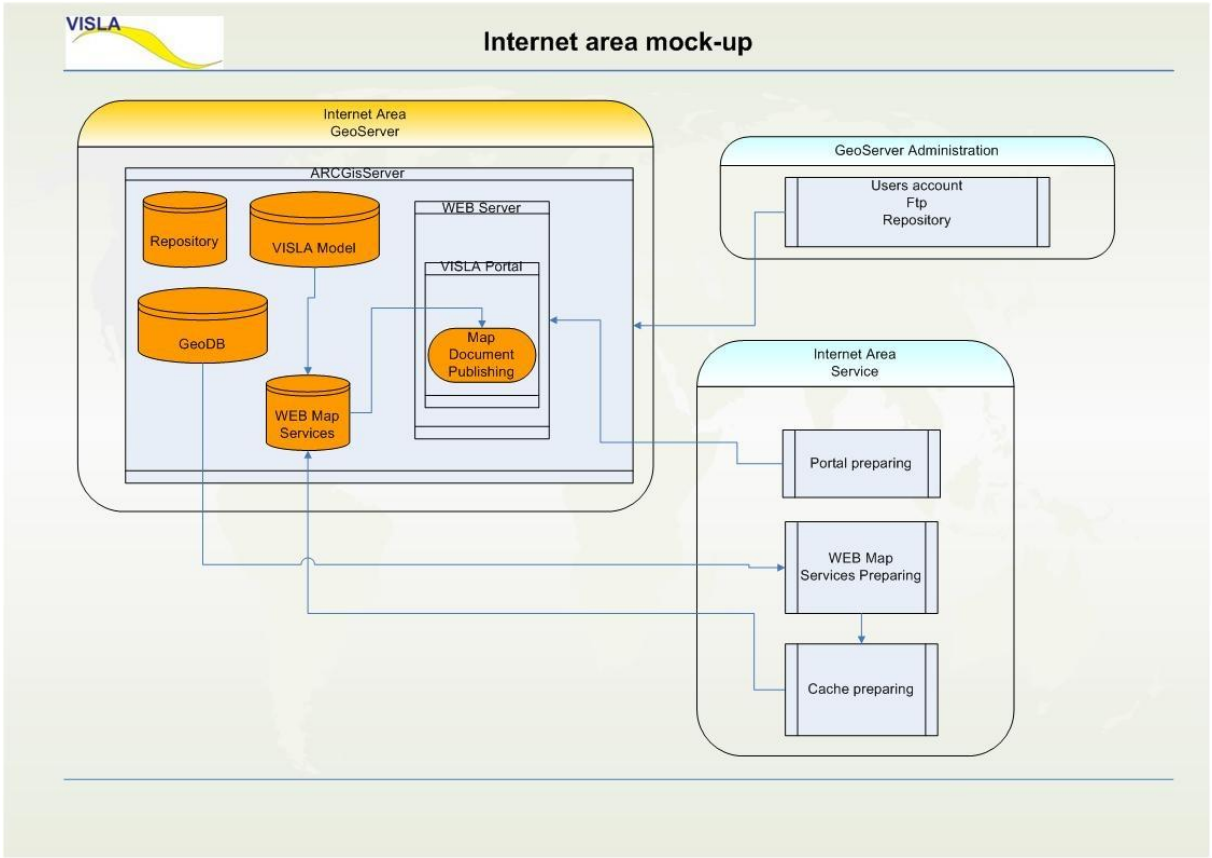

Figure 5. VISLA project – Internet Area mock-up.

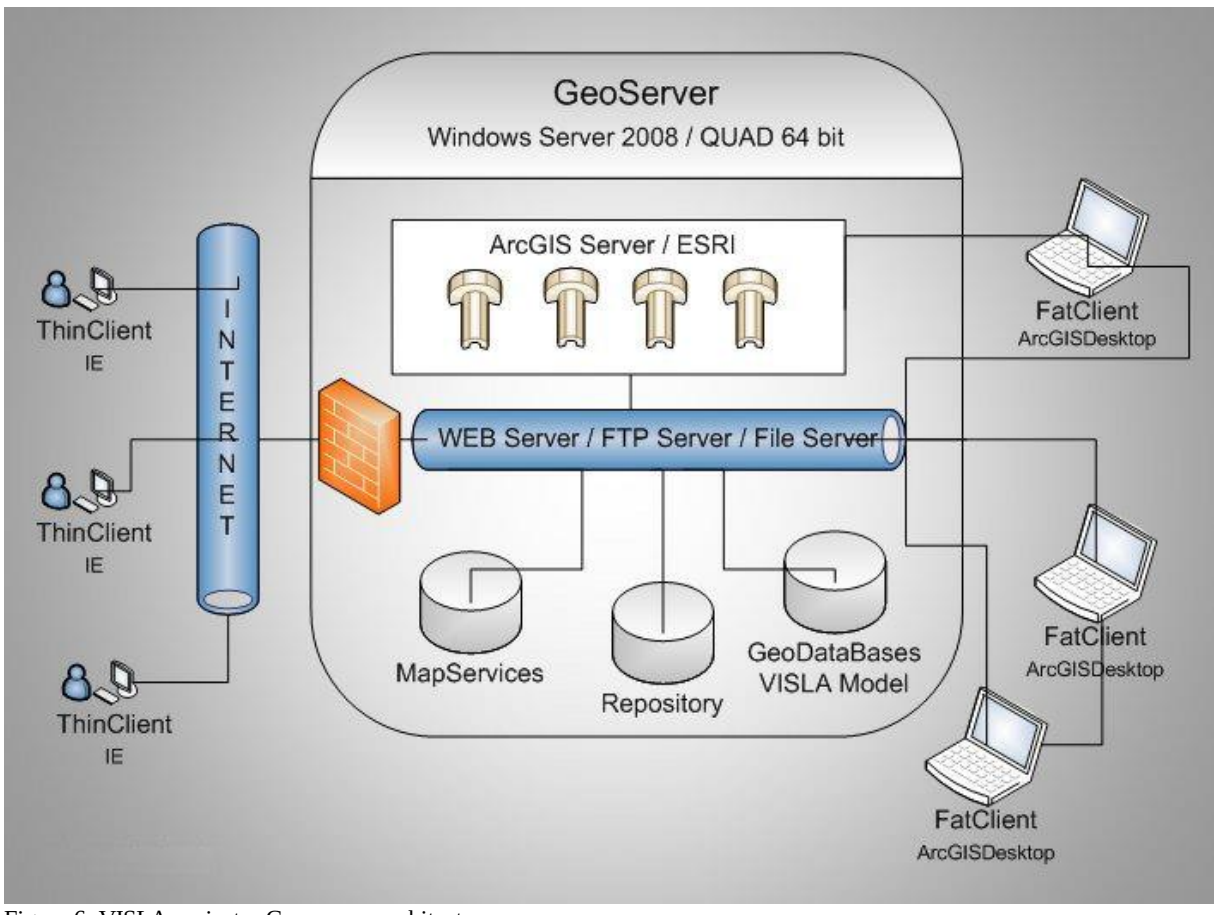

Figure 6. VISLA project – Geo-server architecture.