Integration of Heterogeneous Software Components in a Pesticide Decision Support System

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Abstract : The paper presents a project called GIMMI (Geographical Information and Mathematical Model Inter-Operability), which is funded under the 5th European Framework Program. GIMMI will develop a middleware based system which is used for the pesticide impact assessment domain. This paper does neither look into the modelling aspects of the system nor into the GIS-related issues. It focusses entirely on an overview of the system architecture which has been developed during the first project year. The goal of this architecture is to make GIMMI available for different distributed environments, as they may occur in practice.

Keywords*: Environmental Decision Support Systems, Pesticide Models, Environmental Information Systems (EIS), EU FP, GIMMI*

1. ENVIRONMENTAL INFORMATION AND DECISION SUPPORT SYSTEMS

Environmental Information and Decision Support Systems (EIDSS) are information systems which facilitate environmental decisions by using a combination of various software tools (Swayne et al., 2000; Denzer, 1999). Key elements of EIDSS of these systems are:

- Complex, time and space related data which is often incomplete, fuzzy or of the wrong scale needed for a given task
- Complex software tools which may come from any domain of information technology
- Complex data management issues due to the variety of autonomous data providers and consumers
- The absence of *real* data and metadata standards for many domains
- The fact that for many problem solving issues, you need to bring different tools into one holistic solution for end users.

This paper presents a project which has the ambition of the latter point for the application domain of pesticide impact assessment.

2. GOALS OF GIMMI

GIMMI (Geographic Information and Mathematical Models Interoperability) is a project funded under the 5th EU framework program intended to bride the gap in the Pesticide Impact Assessment domain between Data Providers (soil, meteorology, agronomy, pesticide experts), Scientists (chemists, geologists, modellers and academic institutions), Service Providers (local and central governments, public administration bodies, private chemical industries manufacturing pesticides) and End Users (agronomists, consultants and even citizens in the street).

The main goal of GIMMI is to design and implement a Web brokerage system supporting different web services such as: On-Line Data Access (to seek and drill down into huge amount of distributed Geographic Information); On/Off-Line Simulations (allowing inter-relation of distributed databases to run mathematical models). The validation scenario chosen for GIMMI is the field of Pesticides Impact Assessment in agriculture practices and Land Protection, by the adoption of several alternative EC-validated pesticide leaching models.

GIMMI aims at bridging the gap in Pesticide Impact Assessment domain between data and service providers, scientists and end users: In particular:

- allowing the inter-operability via web of geographic information (GI) based environmental protection services physically distributed and locally managed and maintained by their own inventors and generators
- providing the proper IT structures to represent and manage temporal knowledge inside a GI system.

- integrating in the IT infrastructure state-of-the-art legacy systems for document management and report generation

GIMMI intends to implement 3 kinds of services:

- on-line data access, when the user seeks to "drill down" into the huge amount of GI distributed in different formats and in different sites
- on-line simulation, when the amount of data involved and the time required to answer allow it
- off-line study, when the requested services require huge amounts of data, long time or human experts

GIMMI is based on a distributed service concept integrating GIS, legacy models and data / metadata management and will also interface with other, existing services like E-commerce engines, data mining and workflow systems.

Table 1 shows the consortium partners. Pilot end users are the region of Lombardy and the Region of Catalonia.

Table 1. GIMMI Consortium

TXT e-Solutions	Italy	Software company
Fraunhofer AIS	Germany	Research Center
EIG	Germany	Academia (Saarbrücken)
LABSITA	Italy	Academia (Rome)
ERSAF	Italy	Region of Lombardy
SARA	Spain	Region of Catalonia
INAMHI	Ecuador	Meteo/hydro of Ecuador

The project is at the end of its first year (of a total of 30 months) and the first working prototype has just been finished. Various aspects of GIMMI have already been published. For an overview of the project, see Villa et al. (2003). This paper focusses on a high-level view of GIMMI software components and its architecture.

3. EIDSS TOOLS

In Denzer (2002), four main *building blocks* of typical EIDSS are discussed (figure 1)

- Models
- Geographical information systems (GIS)
- Decision support systems (DSS)
- Data management systems

Many EIDSS have a combination of at least two of these building blocks. Many others have only one building block (models, GIS or DSS), but should at least have a second one, namely a proper data management system. Those which only have one data management system (e.g. a typical environmental facts database like an emission inventory) are not of interest in this context.

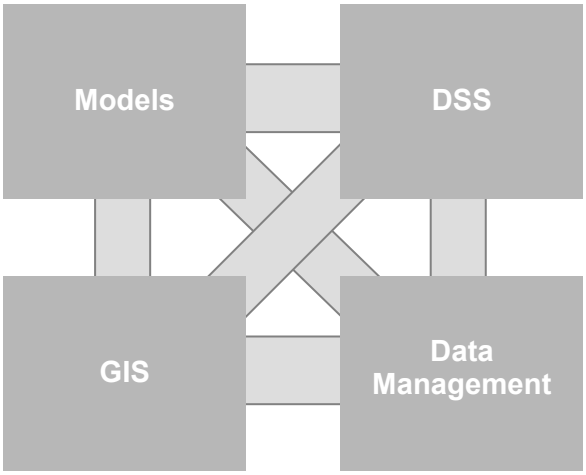

Figure 1. Building blocks of EIDSS

GIMMI is a good example of such an integrated system. It contains distributed data and metadata management, GIS, various models and a decision support component.

4. GIMMI COMPONENTS AND ARCHITECTURE

GIMMI serves both end users who wish to use the system (for analysis and simulation) and providers (data providers, model providers, ...) who wish to offer their services. Therefore, the business logic is present at various distributed sites. Figure 2 gives a high-level overview of this business logic. User access is entirely through a Web-based front-end.

The central business logic components in GIMMI are:

- Users Manager
  The main interface component for end users functionalities. It streams all requests from End-user user interfaces to the correct component and return results.

- Providers Manager
  This component has a similar role as the Users Manager for providers.

- Access Manager
  This component checks access rights and privileges.

- On-Line Analyser
  This component is in charge to implement the top-level functionalities for on-line data search

- Expert Module
  The expert module performs risk assessment analysis on data purchased by users. The idea is to have a preliminary evaluation on data without launching extensive simulation runs.

- Off-line Query Builder
  This component is the core component for preparing simulations. In particular it is able to query the Metadata Manager about available services and databases.

- Common GIS Server
  The back end of GIMMIs GIS capabilities.

- Metadata Manager
  This component is dedicated to the management of the metadata database and the execution of metadata-specific operations.

- Middleware Manager
  This component allows GIMMI to access remote data or service providers.

In addition to these core elements, a number of

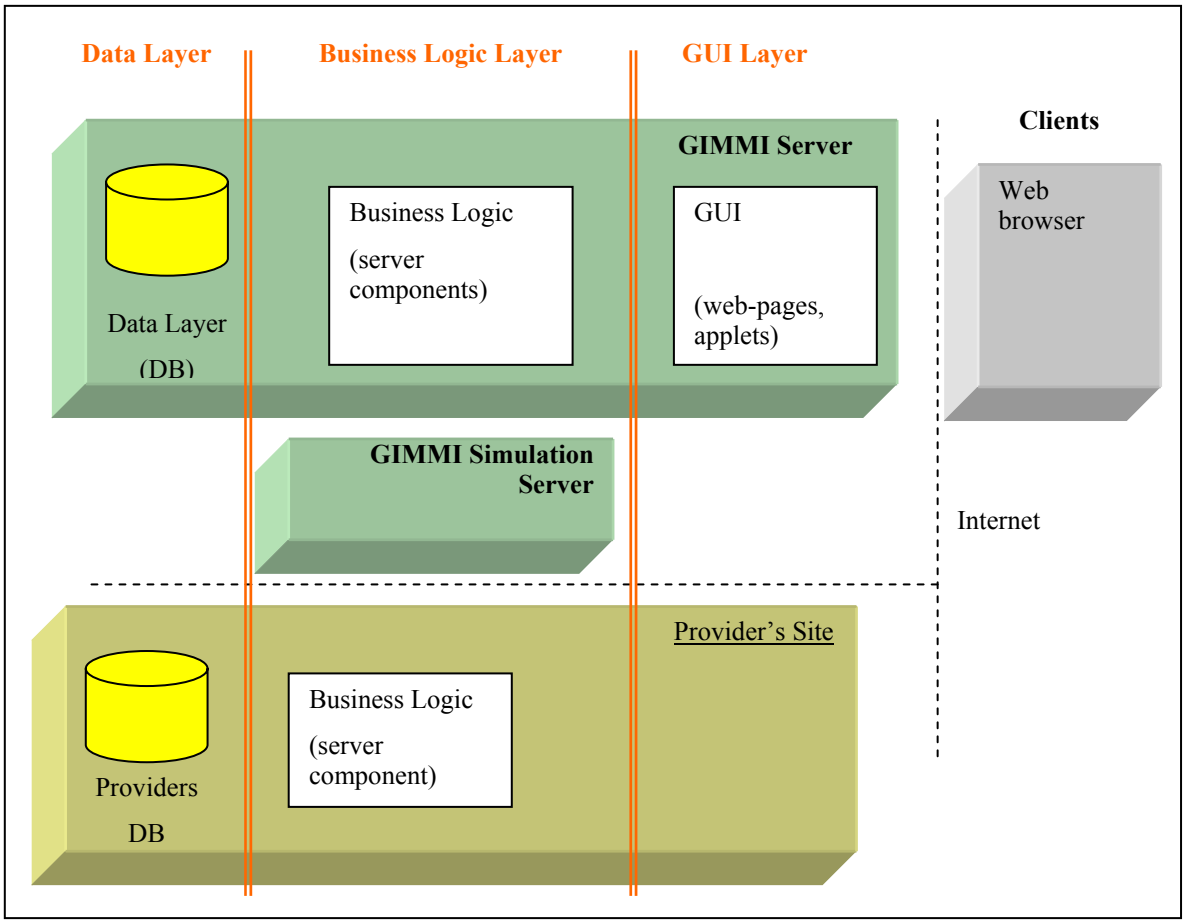

Figure 2. High level view of GIMMI Business Logic

external tools will be used for various purposes.

The layers shown in fig. 2 show the separation of these core business components (Business Logic Layer) from the Data Layer and the User Interface Layer.

All core components are distributed components, which allows to adapt GIMMI to different end user environments.

The data layer allows for storage within the GIMMI server as well as for keeping data stores with end users and data providers.

All user interfaces are web-based. They are either standard web pages, dynamically created web pages or Java objects which can run in a web-based environment.

5. GIMMI SYSTEM ARCHITECTURE

Figure 3 gives an overview about the overall architecture of the system. Users run GIMMI by accessing its web site through a standard web browser. Apart from standard Web technology, only one applet needs to be accessed from GIMMI, the CommonGIS applet which is the geographical user interface of the system.

5.1 GIMMI GUI Server

All user communication is services by a specialised GUI server, which dynamically creates the access pages to the GIMMI data and services. The GUI manager dynamically accesses the GIMMI Application server to create the web interface on the fly.

5.2 GIMMI Application Server

The application server offers the core business logic to all other GIMMI components, although it is mainly used by the GUS Server itself.

The server contains the main components

- Users and provider manager,
- Metadata manager,
- Query builder,
- Analyser and

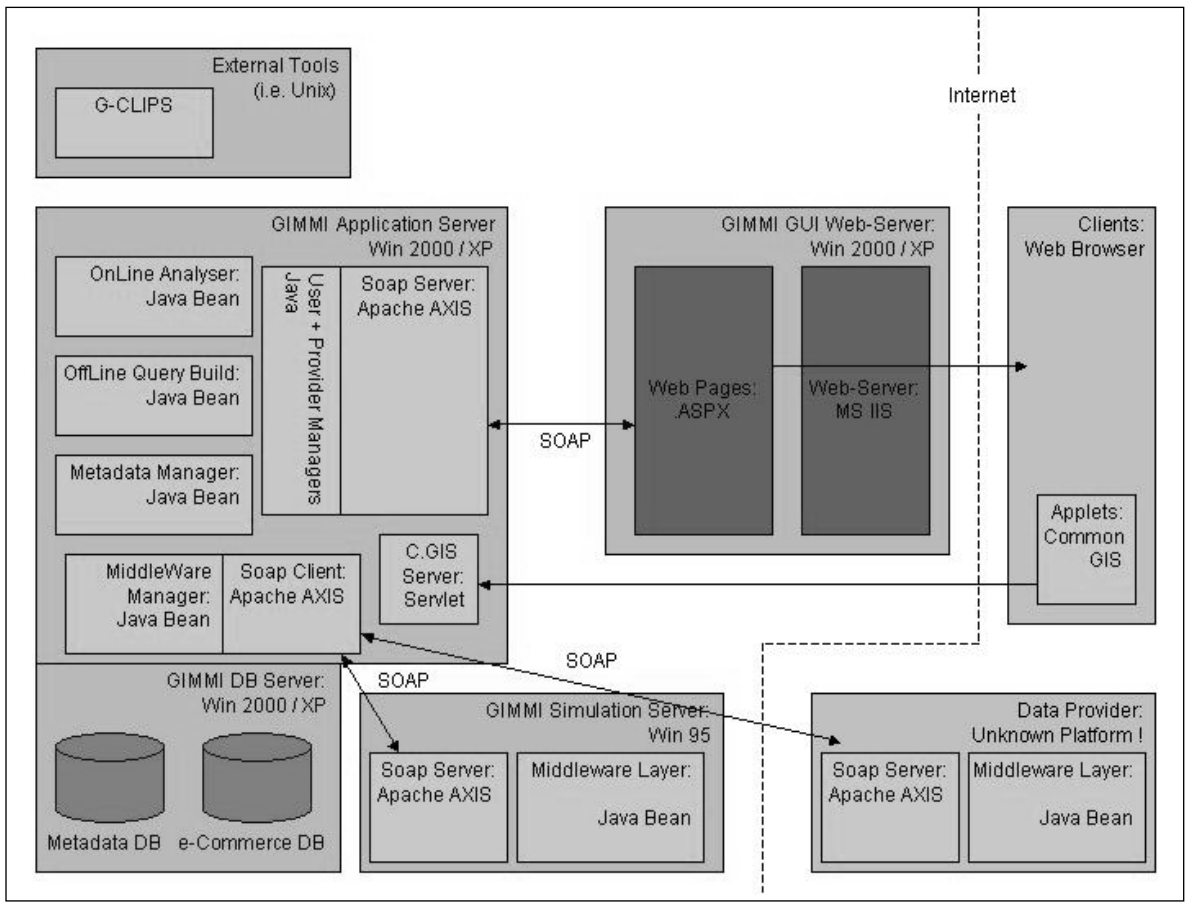

Figure 3. System Architecture Overview

- Middleware Manager,

as well as the central GIMMI data- and metadata bases.

5.3 GIMMI Simulation Server

The GIMMI Simulation Server wraps the numerical models and offers to run them across the network. The simulation server is a separate computer running Windows95, because most of the stand-alone legacy models can only run under this environment.

5.4 Data Provider Server

The Data Provider Service is used to make external data services available to GIMMI. These services can be run anywhere and are connected to the systen through the middleware layer.

6. SIMULATION EXECUTION

An important issue is how legacy stand-alone models can be incorporated in a flexible distributed system.

As can be seen in figure 3, all components communicate with SOAP as middleware layer.

This is also true for the communication between the GIMMI Application Server and the model execution component, the GIMMI Simulation Server.

Figure 4 shows the execution of one step of a simulation, the data query:

SOAP request going from the middleware manager to the middleware simulation server

- Run the query
- Package the results
- Send results back trough a result handler

This general procedure has to be done for every part of a simulation: data retrieval, invocation of the simulation, storage of results etc.

7. CONCLUSIONS

GIMMI is work in progress. At the time of presentation of this paper, the first integrated prototype has been implemented. GIMMI will go through a refinement stage during its second year

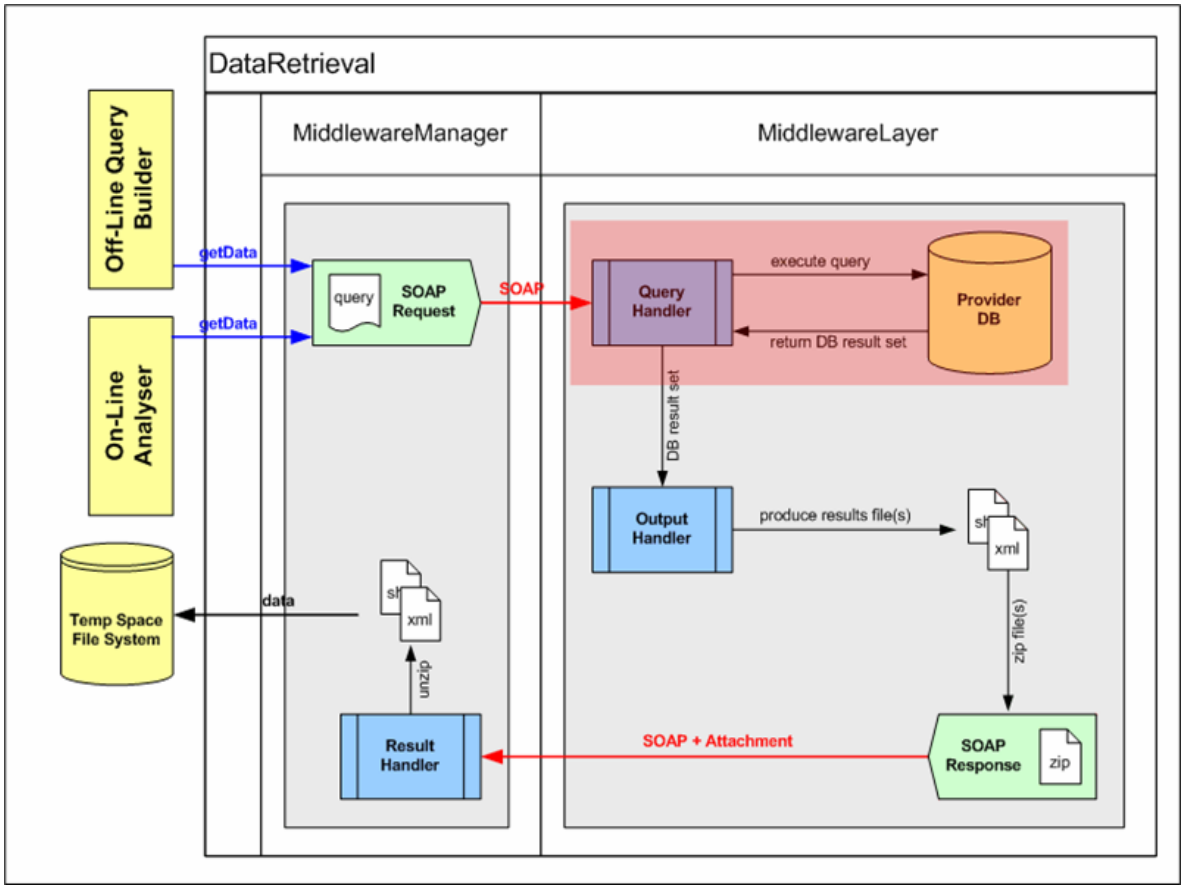

Figure 4. Simulation Execution

and will extensively be evaluated at the pilot sites. Further progress will be reported.

8. ACKNOWLEDGMENTS

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