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GIMMI: GEOGRAPHIC INFORMATION AND MATHEMATICAL MODELS INTER-OPERABILITY. THE INNOVATION OF GEOGRAPHIC INFORMATION.

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1. ABSTRACT

The presence of an inter-operable network of Geographic Information (GI) and GI-based web-services in the environmental domain is going to become more and more important, as Europe is aiming to define common frame-works and rules for environmental protection. One of the most relevant topics in the environmental protection is the *Pesticide Impact Assessment* to ground and surface waters (ruled by the Registration Directive 91/414/EEC).

GIMMI (Geographic Information and Mathematical Models Inter-operability – IST-2001-34245, FP5-CPA V.1.3 Use) is a project started in April 2002 and aims at bridging the existing communication 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 Final Users (agronomists, consultants and even citizens in the street). GIMMI allows elaborating simulation-based vulnerability maps identifying the most critical areas for pesticide environmental impact. This can be achieved by allowing the inter-operability via Web of GI environmental protection services physically distributed and locally managed by their own generators, by providing the proper IT structures to represent and manage temporal knowledge inside a GI system, and by integrating the IT infrastructure state-of-the-art legacy systems for document management and report generation.

Partners of the project are TXT e-Solutions SpA (Co-ordinators) (Italy), FHG-AIS – Fraunhofer Institute for Autonomous Systems (Germany), EIG Environmental Informatics Group (Germany), URS CAVEA/ LABSITA University of Rome La Sapienza (Italy), ERSAF – Lombardia Region Agency for Agriculture and Forest (Italy), SARA – Ministry of Agriculture in Catalonia (Spain), INHAMI – National Meteorological and Hydrological Service (Ecuador).

It's also relevant to know that it will contribute and support the creation of a vertical Pesticide Leaching SDI at European level (one of the so-called Thematic Components in DG ENV E-ESDI initiative).

Some key challenges will be addressed by the project, such as:

- Inter-operability of GI systems based on different technologies and different technical as well as semantic standards: GIMMI will directly interface remotely distributed databases, belonging to different data providers;
- Integration of GI with legacy code from mathematical models;
- Integration of model results and GI with advanced visual tools;
- Use of e-Commerce and workflow engines for scientists, practitioners, managers and citizens;

- Integration of all above mentioned tools with easy-to-use metadata and data access networks.

The main result of GIMMI will be 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 distributed in different formats and in different sites; this information can be original GI or may be derived from studies and simulations already performed with GIMMI or other tools. GIMMI will support users to locate information of interest without the need to deal with or even to know the systems of data suppliers.
- **On-Line Simulations**: if the amount of data involved and the processing time required allow to run the integrated assessment in an on-line environment, GIMMI will support end users in direct, web-based interaction with GIMMI tools like model and GI engines. In this case, input data may be provided by the user himself or come from a GIMMI data source.
- **Off-Line Studies**: if a service requires huge amounts of data to be inter-operated, long time or the attendance of human experts, GIMMI instantiates a work-flow agent which will conduct the study process on behalf of the user and make results available for download or later on-line inspection of final results, e.g. a report.

The project will be validated in two distinct pilot areas, characterised by different real life scenarios and sited in Northern Italy (Lombardy) and Spain (Catalonia), and a technology observatory shall be set up in Ecuador (Guayaquil gulf).

2. SCENARIO

The validation scenario chosen for GIMMI is the field of Pesticides Impact Assessment in agriculture practices and Land Protection, by the adoption of four alternative EC-validated *pesticide leaching models.*

Crop protection is essential to maintain agricultural yields to a level able to cover food needs of a continuously increasing world population. In this context pesticides are essential elements in modern agriculture. The extensive use of pesticides in agriculture can entail risks for the human health, the environment and the non-target organisms. Hence the need to assess the nature and degree of the risk and at the same time to take preventive measures aimed at minimising possible damages.

These demands generated on one hand a detailed set of laws containing procedures to formalise the pesticide registration and on the other hand a high number of researches addressed to the water protection fields.

Leaching is an important effect associated with pesticide usage. Consequently the evaluation of the pesticide leaching to groundwater gets more and more attention both at the European level and at the individual member states level.

Different pesticide leaching models have been developed by scientists to simulate the pesticide fate in the environment; traditionally all pesticide leaching models have been applied locally at field scale, without any reference to spatial information. One of the most recent trends of the application research in this field has been to apply such mathematical models (by nature mono-dimensional) at spatial scale, by defining on the territory some homogeneous areas where the application scenario (meteorology, soil, agronomy and pesticide, basically) could be considered unchanged.

3. GIMMI AND GEOGRAPHIC INFORMATION

In this context and in order to achieve the main items, GIMMI is addressed to obtain the following tasks:

- **GI Inter-operability**: systems based on different technologies and different technical as well as semantic standards. GIMMI intend to contribute to the creation of an ontology (concepts, relations, semantics) for Agricultural Pesticides Management which could help identifying and developing a *Vertical SDI*. The aim is a direct interface with remotely distributed databases, belonging to different data providers. These DB will contain data in different formats and are currently described according to different semantic standards. This will be possible thanks to the use of Metadata language, that in GIMMI will have an addendum: it will cover not only GI data, but mainly *GI services* related to Pesticide Impact Assessment
- **Common Access to GI**: GIMMI will improve the existing *Common GIS sw* architecture by improving the display and the interactivity of geographic maps and by adding to it data-mining and geo-statistics capability. Inter-operability solves the problem of merging several data sources into a coherent new data set that can be viewed on a computer screen. It is necessary to enable the users to apply the available functions in a way that reasonably supports their goal of analysis or decision-making. One goal of the project is to enable more interested users to actively use the tools for own analysis and exploration. Enabling end users, including casual and non-expert users, to utilise the GIS tools to some degree of hitherto unforeseen proficiency is what we mean with “common access to GI”. The users will be guided in applying pesticide leaching models on a wide number of spatial distributed datasets and in analysing results with the most innovative spatial analysis tools. Moreover, they can access to various kinds of information and geo-datasets.
- **GI and Temporal Information**: how GI is connected with temporal knowledge typically coming from monitoring and simulation systems. In this project is very important to consider the GI in a dynamic and evolving world. Proper *meta-data structures* will be developed to consider time-varying GI and cross-mapping models identified to pass from one model to another one. Another important aspect is to design a proper interactive and web-based GUI which will be able to conveniently show GI varying along time (animations).
- **GI Integration with Legacy Systems**: a tight integration of GI with mathematical models is required in order to guide end users in the complex process of prepare simulations input data. Usually GI systems are considered as fully isolated from other software tools implementing the day-by-day life of an organisation, mainly belonging to Public Administration (e-government). GIMMI project will realise an XML-based integration between different applications in use: GI systems, mathematical models, decision support systems, geo-statistical packages, office automation systems, workflow management systems and e-commerce environments.
- **GI Application to Pesticide Environmental Impact Assessment**. Traditionally, pesticide leaching models have been applied locally at field scale, without any reference to spatial information. One of the most recent trends of the application research in this field has been instead to apply such mathematical models (by nature mono-dimensional) at spatial scale, by defining on the territory some homogeneous areas where the application scenario (meteorology, soil, agronomy and pesticide, basically) could be considered unchanged. Simulation results as well as complex data analysis are strictly depending on GI. GIMMI will integrate GIS tools in order to follow in a dynamic way simulation outputs and its spatial-temporal analysis.

4. GIMMI ARCHITECTURE

GIMMI will be a web application, but it needs to interface to remote provider’s sites, in order to be able to retrieve data held locally.

The architecture is mainly divided on “three tiers”:

- GIMMI web server where are deployed all user interface;
- GIMMI Application Server where has run all business logic component. Inside of it there’s the module of Fast Risk Assessment which will be an “a-priory” analysis to be performed on raw data without launching a long, time-consuming simulation;
- and finally, the GIMMI DB Server that contains all data.

The basic assumption of the GIMMI system is that both data and models are kept by their own providers, who are distributed in the Net and are able to communicate through a generic inter-operable architecture (middleware). In these scenario, the data are store locally on data provider site, and the system retrieves them only when the user requests it (ex: to execute a simulation). The GIMMI DB Server stores only the description of the data and of the services available on the net, via a proper meta-data and meta-service neutral language (XML-based).

In addition, other components are required:

- Provider’s sites components, in order to ensure connectivity with remote databases
- GIMMI external application, such as G-CLIPS required in order to set up the system

The following picture represents how the components are distributed on the various servers:

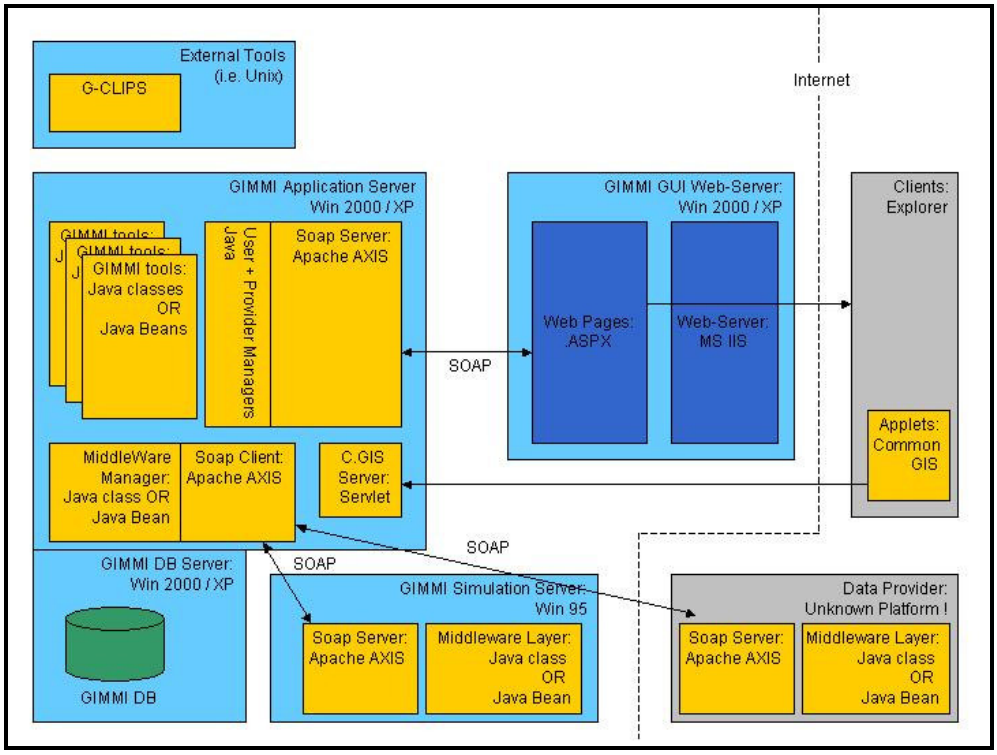

Fig. 1 System architecture.

As indicated before, the information about soil and meteo data are distributed on the various data provider. These data are referred to homogeneous “land unit” called plot, defined by unique combinations of different thematic layers such as land use, climatic

regions, soil units. To guarantee the correct execution is necessary to optimize the data which will be processed. Another relevant point is the necessity to have the data without errors and anomalies for the optimization of running processes.

In order to solve all these problem GIMMI use an artificial intelligence tools called GClips, a rule based language based on CLIPS (NASA). GClips will be used in order to optimise geographic information (i.e. polygons) for simulation preparation and for better on-line analysis, for example by removing those very small polygons created by bad intersection between lines.

The poster will provide images and text showing the main aspects of the project.

5. REFERENCES

GIMMI website: http://services.txt.it/gimmi/