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A SEMANTIC SERVICE COMPOSITION MODEL FOR HEALTH GIS APPLICATIONS DEVELOPMENT

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Abstract. In the development of large scale distributed health applications, the need for adopting new technologies, such as multimedia or GIS, became more and more important. This paper describes a model for the composition of medical web services, by means of a SOA ontology, in which information is combined and process in a semantic approach. The visualization of the resulting data sets is placed on a GIS architecture, which is used for the support of decisions for health services development. In this paper we propose a Semantic Web GIS architecture using SWS technologies together with details about its practical usage and future work. The vast amount of heterogeneous data sources that a GIS practitioner have to cope with to find appropriate resources for special situations has led to a new approach in GIS application research and development. To fill the gap in discovery and share of information we need a semantic layer in GIS framework to give machine understandable meaning to services and web content. Using Semantic Web Services (SWS) we can add higher semantic level to GIS framework improving interoperability and reasoning for better matching responses.

1. INTRODUCTION

The development of distributed applications which implement geographical mapping and routing methods became an important toping for researchers and practitioners.

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It is essential to have appropriate information about healthcare data collected from the population from different geographical areas, so as to control and improve the medical system.

Many scientific events took place in the last five years, being focused on the application of GIS technologies in medicine and healthcare.

Our paper brings into light the development process of GIS architecture which integrates semantic web services, for the assurance of medical information from distributed and heterogeneous data sources.

GIS applications bring an essential contribution to the collection, processing and sharing medical knowledge, through the development of web service ontology, which mix data regarding:

- SWS description;
- web services functionalities, described in WSDL;
- semantic annotations mechanisms for service discovery, composition and invocation;
- SWS relationships;
- categories and domains, such as geospatial data and medical knowledge.

Semantic web standards used for GIS applications provide levels reusability and productivity in software development, by the automation of the processes of data discovery, integration, refinement and evolution. The standards for semantic web services have been described in papers such as [3] and [9].

The creation of automatic machine readable and usable data with minimum human intervention is based on semantic annotation and specification of services by means of ontological data structures. It is desired that data is extracted from various sources, based on the meaning and with further processing to become accessible to heterogeneous types of client software, such as web sites, mobile or desktop applications.

In this situation, the extraction and combination of data gains a higher level of accuracy and the errors are minimized, while the effort of programming interoperable applications is also reduced due to the common set of specifications and language patterns based on XML and OWL-S.

2. SEMANTIC WEB SERVICES AND GIS IN HEALTH APPLICATIONS

Ontologies provide a formal and machine-readable conceptualization of a domain, by means of a unified terminology and semantic inter-relations. The use of semantic layers in GIS, which is in process of development and establishment, started to be investigated in late 90's [2], [5] and [7]

Almost ten years later, enabling the dynamic integration of geospatial data and geo processing functions and resources over heterogeneous systems and platforms through the cutting-edge technology of semantic Web service (SWS), was still subject of doctoral theses, research projects and conference subjects [9]. Numerous GIS applications have proved that the implementation of semantics could bring many advantages.

In supply chain management, for example, knowledge dynamics and knowledge sharing between partners is facilitated [10] by semi-automatic combining individual services into more complex systems.

In [11] a practical e-Government application for Emergency Management consists in a decision support system based on Semantic Web Services (SWS) technology, which assists the emergency officer in "retrieving, processing, displaying, and interacting with only emergency relevant information, more quickly and accurately".

Having ontologies describing a Spatial-Related Data (SRD) repository and its functionalities is believed to enhance cooperation with other systems [10] and to better match user needs- and abstract web services, corresponding to a group of services that accomplishes a specific functionality could be used as a mean of assuring better system reliability [4].

Many semantic similarity computation paradigms have been proposed both as general-purpose solutions or framed in concrete fields such as biomedicine. Ontology- based approaches have proven their efficiency, scalability, lack of constraints and thanks to the availability of large and consensus ontologies [8].

From the health GIS perspective, a wide range of studies try to define the impact of various variables involved in health system: from understanding the pattern of geographic distribution of Psychiatric Mental Health Advanced Practice Nurses (PMH-APRNs) and describe rural-urban differences in the distribution of PMH-APRNs [6], to the fact that the geometry and orientation of roadways may influence fatal injury in adolescents [1].

3. HEALTH GIS ARCHITECTURE

The objective of the Health GIS Architecture we developed is to create a suitable framework which contributes to a better health information management, and includes the following categories of elements:

- different client applications, which are installed on dedicated servers, on client machines or on mobile devices, to which the users directly interact for the accomplishment of their objectives;
- GIS frameworks, services and APIs, offered by companies such as ESRI ArcGIS and Microsoft;
- mapping services, which provide geospatial data, layers and geo processing functionalities;
- semantic web service composition ontologies;

- application layers, in which the semantic services are integrated and subjected to composition by ontologies and annotation mechanisms;
- data access services, which include queries and transactions on the databases;
- databases, built on different technologies, accessible by means of web services.

In *figure 1* the main components of the Health GIS architecture are presented.

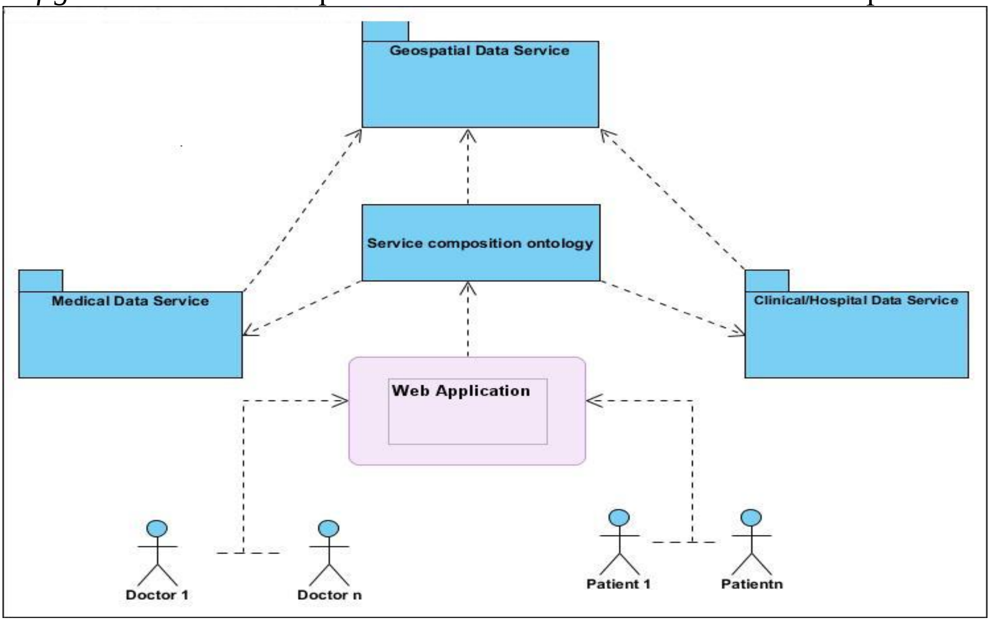

Figure 1. Proposed Medical GIS Application Architecture

The architecture will significantly contribute to the new GIS applications engineering process. The resulting applications will offer the following types of information:

- geographical localization of medical centres, medical facilities and hospitals;
- medical departments and specialities, with corresponding statistics and ratings regarding the successful medical procedures for specific categories of diseases;
- health maps,
- patient reviews about the quality of medical services in medical centres and hospitals;
- premedication for medical procedures;
- costs and expenses;
- routing services based on ArcGIS and Bing Maps routing functionalities;

The architecture consists in five modules, which interact mediated by the service composition ontology, presented in *figure 2.*

It is important to take into account the both categories of final users. The distributed GIS application is useful for bringing heterogeneous information to the patients and to the doctors, in order to improve the quality of medical services.

The web applications refer the service ontology. The service composition ontology has access to the medical web services through endpoints and WSDL files, in which the endpoints are described in.

The doctors interact with the GIS app by means of a friendly user interface, in order to upload and update clinical information. This clinical information will later become available for patients as datasets. Any private information will only be available to the authenticated and authorized users, depending on their rights. The data entered by users is stored in distributed relational databases and which communicate to the data access medical services. Each service collects corresponding data in order to be accessible in the GIS interface through the ontology.

The Ontology permits semantic identification of services for a better matching between user queries and the received answers.

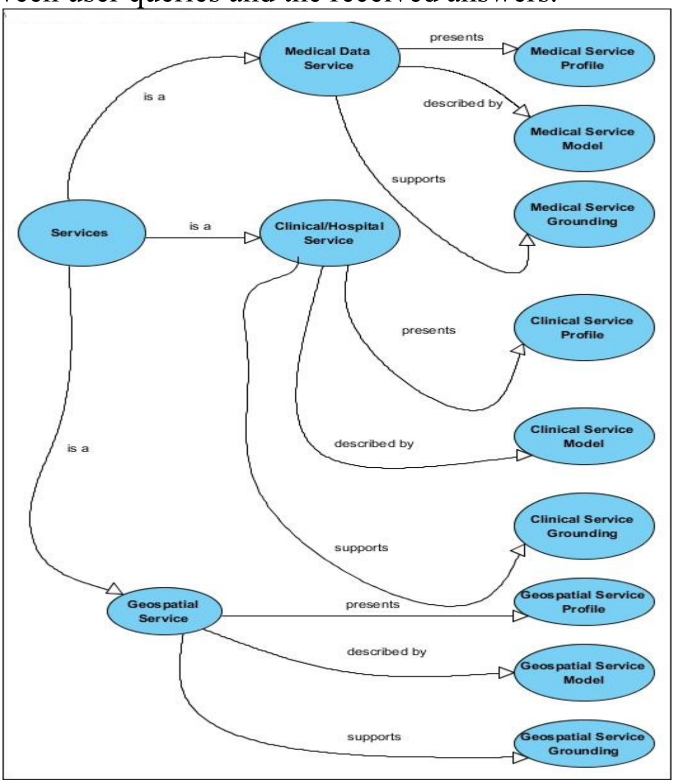

Figure 2. Semantic web service composition ontology

The web application finally collects the answers from the services and presents them to the users by means of data tables and tuples and graphical elements on health maps.

In this way, each patient is able to find the appropriate information about the geographical distribution of health services as well as the quality of health services and procedures. The *figure 3* presents the way in which the requested hospital location appears on map. In order to find the answer two web services were invoked: Geospatial Data Service and Clinical Data Service (figure 1.).

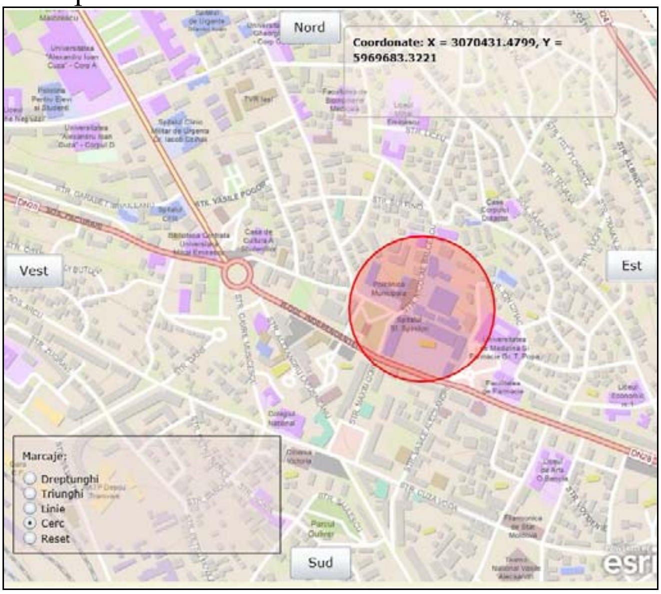

Figure 3. Identification of Hospital "Sf. Spiridon" from Iasi

The map control is developed by ArcGIS and the service for spatial images display is based on the topographic map from Esri ArcGIS.

4. CONCLUSIONS

This paper introduces a health care GIS architecture, which combines the power and functionality of a GIS application with a semantic service composition model in order to track the medical data that users requested.

In this way geospatial related medical data gathered from multiple sources are filtered through these semantic services and the results are displayed in friendly user interfaces which ensure the efficiency of human computer interaction in GIS.

This architecture is in an early stage of development, which is intended to evolve in a standard model for health GIS applications development.

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