GECOSAN: a platform of tools and services for health knowledge management

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Abstract

Knowledge management in the medical domain has been recognized as a critical issue in development of medical systems in all western countries.

The increasing demand for health services is now facing the problematic aspect of delivering, organizing and saving resources in clinical contexts.

An Italian research project, titled GECOSAN, is currently being developed in order to realize a digital environment aimed both at helping in the dissemination of world wide clinical knowledge to medical practitioners and at collecting feedback by the same practitioners so that to increase the knowledge base.

The project focuses on the development and deployment of a SW platform based on the standards of "Web Services" so that to ensure full interoperability. This is then exploited to provide two basic services beyond any barrier of HW and SW diversity.

The first service consists of making widely available, to medical practitioners, operational guidelines stemming from all known and scientifically approved clinical trials that make up the Evidence Based Medicine (EBM).

The second service aims at supporting the efforts of Continuing Medical Education with events that are provided over the Web through the novel "Intelligent Tutoring System" technology, in order to eliminate the weaknesses of distance learning.

Keywords:

Health information systems, Evidence Based Medicine, Intelligent Tutoring Systems, Medical informatics, Web Services

1. Introduction

On may 2002, the Italian Department of Research approved the financing of the project named "GECOSAN - methods and tools for health knowledge management"; the project is coordinated by ENEA, one of the Italian major research institutions, and sees the participation of the Medical Department of the Second University of Naples, of San Filippo Neri - Hospital System, CRMPA (Center for Research in Applied and Pure Mathematics), CETMA (Center for Design and Research in Advanced Materials).

All partners co-finance the project, budgeted at about three million euros.

The project is engaged in the development and deployment of a platform, based on the "Web Services" technology, aimed at providing services of knowledge management to medical practitioners.

The platform includes two main building blocks:

- the CME part based on the Intelligent Tutoring System technology and devoted to providing e-learning events ;

- the EBM part devoted to the gathering, processing, dissemination and creation of EBM knowledge.

The following sections provide a picture of problems and proposed solutions for both parts as well as summary descriptions of the related SW architectures conceived within the project.

2. Intelligent Tutoring Systems in the GECOSAN Platform

A main requirement for panel doctors is to take training where it is immediately useful and applicable to real cases. This has always been the aim of "training-on-the-job", in models of apprenticeship [1]. Moreover they have to take training in order to quickly solve current problems. This is usually referred to as "just-in-time training".

When compared to traditional approaches, new training techniques utilizing computer networks can rapidly deliver effective training content directly to the desktop or work environment and the selection of the training content can be made quickly by learners themselves in response to their individual needs and the tasks at hand. These techniques create e-learning systems that can systematically address both just-in-time and on-the-job training within one integrated solution.

Within this context, the Intelligent Tutoring System (ITS) technology aims at recreating the ancient paradigm of teaching: a specific teaching process for each learner, just as a human tutor can do, but at the cost of any other on line learning event. In the context of ITS, "intelligent" refers to the specific functionalities that are the goals of ITS development [2,3].

Within GECOSAN, the CME service wants to integrate on-the-job and just-in-time training with the potentials of an ITS engine.

3. Management of Evidence Based Medicine's knowledge in the GECOSAN Platform

The Evidence Based Medicine (EBM) aims mainly at suggesting health care practices, based on a wide set of reliable data, in order to improve clinical outcomes for patients.

Notwithstanding its recent diffusion, EBM is still featured by sluggish adoption in health care systems; reason being, among others, difficulties in gathering and delivering structured information into the dynamics of health systems [4-6] as well as in presenting usable information for "real world" clinical contexts. Still EBM is referred to as capable of providing solid answers to problems of clinical interest as long as also the specific features of individual patients are taken into account [7].

The most recent orientation in clinical research methodology indicates a pragmatic approach in clinical trials as needed in order to find more realistic and applicable indications for clinicians. Many authors underlined the need of a more "close to reality" scientific effort and are suggesting several methods for filling the gap.

4. CME Architecture

The GECOSAN solution for the CME is based on a modular and innovative approach to the classical Intelligent Tutoring System with respect to technologies, methods and functionalities. Inside its environment, a panel doctor will be able to select a particular set of topics from an ontology of covered arguments and let the system arrange personalized

and self-adaptive courses about such topics (personalization is based on user profiling).

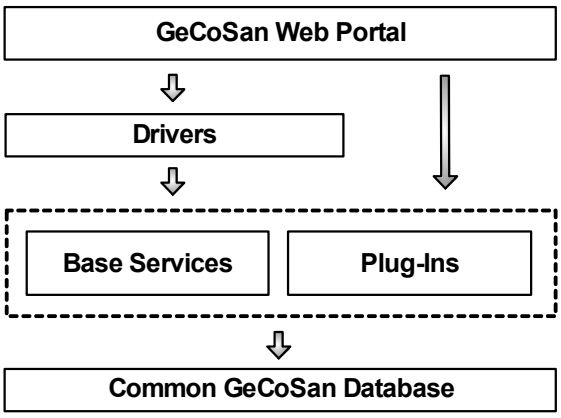
Course customization procedures will be based on the formal representation and management of the main entities involved in the e-learning process through the adoption of three different models: the Knowledge Model, the Student Model, and the Didactic Model.

- The Knowledge Model will be able to represent in a machine understandable way the information associated to available didactic material. Our solution will use metadata to describe Didactic Modules and ontologies to formalize cognitive domains through the definition of concepts and relations among concepts. This will allow, moreover, the automatic evaluation of the student and the customization of the didactic paths.
- The Student Model will be able to catch automatically the knowledge acquired by the student during learning activities and learning preferences shown (considered as cognitive abilities and perceptive capabilities) with respect to pedagogical parameters such as: media, didactical approach, interaction level, semantic density, etc.
- The Didactical Model will define the optimal transfer modalities of domain knowledge to the students according to the discipline (formalized with the knowledge model) and the characteristics of the student involved. Through that model the CME module will be able to customize the didactical experience on the basis of the previous knowledge of each student and its learning preferences. Several are the didactic models one may implement in such a way: intuitive, simulative, experiential, deductive, etc.

One of the principal concerns about the use of a distance learning platform in medicine derives from the enormous quantity of possible formats that a didactic material can assume in this field. Doctors' teaching, in fact, rarely relies only on textual material but, very often, includes the use of images, videos, simulative instruments etc.

To support any kind of didactic material, the CME module will realize a paradigm based on the "adapter" design pattern to allow the exploitation of a wide range of learning object types through software modules called drivers. Each driver will manage the creation, the delivery, the update, and the feedback for a given learning object category. Furthermore, "aggregate" drivers will provide functionalities for managing complex objects built on the aggregation of different learning objects. By exploiting drivers, the CME module can be extended in any moment with a particular learning object category by simply writing a driver capable to handle the new object.

The CME module will provide, also, extensibility and customizability at function and service level by allowing the user to add new ad hoc written components named plug-ins in conformity with some system specifications. Often, in fact, advanced learning objects like interactive simulations, virtual experiments, etc., requires advanced functions to be executed. The plug-in mechanism will solve this issue.



The resulting architecture of the system can be sketched as in the above.

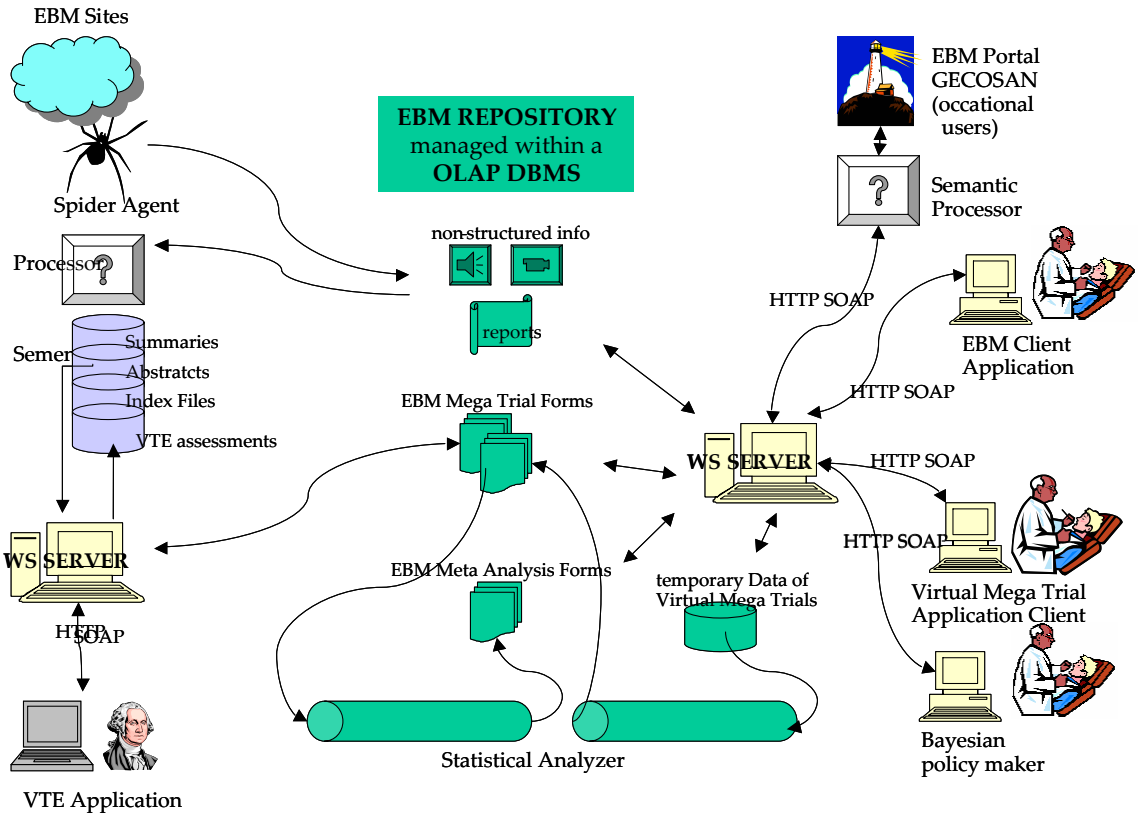
The following list describes briefly the main services included in the Base Services block.

- Content Management Services will provide common functions to manage didactic resources like lessons, video and audio clips, slides, tests, exercises, simulations, etc.
- Course Management Services will provide all functionalities to manage and deliver didactical courses in the CME module, where a course is conceived as an aggregation of learning objects managed by an aggregate driver. The CME will support static and adaptive courses.
- Collaboration and cooperation Services will allow teacher/student and student/student cooperation through the use of asynchronous (e-mail, discussion forums and instant messaging) and synchronous (chat and videoconferencing) communication tools.

5. EBM architecture

GECOSAN project is intended to build a digital environment in which the available Evidence Based medical knowledge can be provided, over the Web, to the medical practitioners but, at the same time, can also be newly created through the appropriate monitoring and processing of their daily operations.

The figure below shows the main components included in the architecture of the EBM platform and shortly described in the following .



- Virtual Team for Evidence (VTE). This is a human, non-software, essential component and consists of a pool of clinicians, from different backgrounds, who are assigned the duty of setting up and supervising the strategies of the GECOSAN services. The team is also in charge of assigning the available EBM resources to predefined classes of dependability/credibility, depending on the quality of the scientific investigations which are at the base of the same EBM resources. Moreover, the VTE has the function of identifying the topics of high medical relevance about which the GECOSAN platform should initiate and support a Virtual Mega-Trial (see below).
- Spider Agent. It is devoted to searching for EBM resources to be down-loaded from Web portals and sites (such as Crochane, PubMed, Best Evidence etc.). The web searching and down-loading is performed periodically and whenever a query got no answer from the system database. The agent is oriented on selected medical topics identified by domain experts (VTE).
- Semantic Processor. It is a SW component devoted to the analysis of the downloaded EBM resources; this feature aims at lightening the work of the VTE. Each EBM resource is analyzed so that to highlight the most EBM-significant basic concepts , facts and statements. Later on, the VTE member will only work with these segments, extracted by the original document, so that to focus on the core information of the downloaded document, with the purpose of assessing the EBM resource in the terms of dependability/credibility. This SW component is made available by the most advanced Knowledge Management platforms on the market.
- EBM Repository. It is essentially a DBMS environment in which the EBM resources are stored and from which they can be retrieved. These resources may come in multi-media forms, such as text, video clips, images, presentations, Virtual Reality simulations. EBM resources, stored as they are downloaded from the web, make up the non-structured section of the repository. However, resources that have been processed by the semantic processor and the VTE assessment, are turned into structured information, typically included in tables of a relational data base. The data included in the relational data base represent a summary of the basic message and operational guidance that each EBM piece of knowledge (such as mega trials, results of meta analyses) grants. This structured part of the repository ("EBM Mega Trial Forms" and "EBM Meta Analysis Forms", in the above figure) is build for safe, controlled, fast-easy-effective access, by the final user - i.e. by the medical practitioner, in order for him to find the guidance stored in the GECOSAN system.
- WS (Web Services) Server. It is the server part of the platform with the functions of receiving the request from the client components, of parsing it and of concocting the appropriate answer. This web and application server is driven by interfaces, between server and clients, built applying the standards included in the technology of the "Web Services", such as XML, SOAP, WSDL, UDDI, just to mention the most relevant. This choice has been determined by the willingness to provide the widest interoperability among the different SW and HW platforms which can be in usage by the medical practitioners.
- EBM GECOSAN Portal. It is a point of access for occasional users not endowed with the GECOSAN client components. They are allowed to place queries without comply with the Web Services standards. The semantic processor maps those queries to equivalent standard requests to the GECOSAN system. This component is provided to let users get into the system in order to explore its potentials before subscribing.
- Virtual Mega Trial. It is the component devoted to monitoring and processing the

operation of those medical practitioners which already enjoy the GECOSAN services and make the decision to provide, back to the GECOSAN system, information on the effects on patients of their daily operation. In practice the doctor, when visiting a patient, sends information on the diagnosis, the anamnesis, the prescribed therapy, the prognosis and relevant personal data of the patient (such as sex, age, relevant life conditions and the like). This information is processed by the GECOSAN system in the same fashion as in a mega trial and is added to the pool of EBM knowledge. These "virtual" mega trials have the advantages of low cost and times, afforded by resorting to the basic infrastructures of the GECOSAN system.

- Bayesian Policy Maker. It is the component that, exploiting the information about cost and effectiveness of medical treatments, and gathered through the Virtual Mega Trials, can support the decision making process of makers of public heath policies. In practice, the component is an application of Cost/Benefit analyses in conditions of uncertainties, as long as the mega trials provide statistical results.

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