Grid-Based Virtual Clinic for Medical Diagnosis Tutoring

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Abstract

Generally, new technologies enhance education and provide better services. The emerging grid-based technology is increasingly adopted, opening new way of teaching and learning. Learners, regardless of their different computer systems have access to knowledge across distributed sites. This is characterized all over the world, by the development of large scale tutoring systems.

Commonly, classical teaching tools are based on information transfer approach rather than a synergic approach focused on knowledge construction. In this paper, we propose a grid-based virtual clinic for medical diagnosis tutoring. The concept leans on the case base reasoning theory for operational competency sharing from experienced doctors to medical students in a virtual organization.

1. Introduction

The grid as a new software infrastructure for distributed computing of high performance is a challenge for researchers doing electronic or distance education. Using the grid for learning is considered as a major innovation, but the nature of learning services that are offered shall be clearly defined [1]. In medical studies particularly, current trends to technology enhanced learning reveals the need for tutoring systems with at least the connectivity performances offered by current networks and the requirement of services that may be used by medical school [2].

Medical diagnosis is a representative field with many challenges to be tackled. Indeed, patients are at the center of the process, but medical students don't have enough practical tools able to help them during practical training in hospitals where any judgment error can have irreversible effects. How to provide medical students with a system which generates true diagnosis cases and help them to master the lessons they have received?

To answer that question and solve related problems, this paper suggests a grid-based virtual clinic for medical diagnosis tutoring. The concept leans on the case based reasoning theory and personified agents to build an operational knowledge sharing system. Firstly we present the grid and its core concepts for learning. Secondly, we introduce the main theories guiding our proposal and give a brief review of related work. Finally, we present the basic architecture for the grid-based virtual clinic.

2. Grid Core Concepts for Learning

2.1. General View

The concept of grid finds its origins in researches aiming the development of infrastructure for distributed computing of high performance [3].

Many strands have emerged and with all the current interest in Grid computing, there are many directions on exactly what it is. Commonly, it is admitted that grid computing is an approach to processing that let you organize widespread, diverse collections of resources (computer, data, application) into a virtual supercomputer or reusable libraries of components (file system). It makes this virtual grid of resources accessible to multiple users simultaneously [4].

Currently, the associated technologies are developed in order to share the latent calculation power of connected computers. So, the grid can be seen as an aggregation of computers providing the opportunity to share knowledge distributed on a local or wide area network independently of technological choices.

2.2. Learning Services Technologies

Considerations about Grid Learning Services have been initiated by a collective of researchers to tackle that matter [5].

The analysis of papers from previous workshop on Grid Learning Services [4][5] shows that many trends have been raised for a new generation of learning services. Suggestions made by participants can be classified in semantic and ontological view on the one hand, agents and networking on the other hand. Finally, services may be targeted from these technologies according to each specific field.

2.2.1. Semantic and Ontological Views. Many points of view were raised concerning semantic and ontological aspects of the grid: a) the need for a service-oriented model [6] deeply intertwined with the use of semantic web technologies; b) the design of structured knowledge to be shared and reusable between tools and agents in the Grid [7]; c) the description of the field knowledge for easy dissemination or retrieval, customization and personalize learning services [8]. Another aspect related to the semantic web techniques was students' characteristics and content categorization along dimensions that are important to learners and teachers.

Finally, it appears that: a) semantic Grid as a basis for e-learning expands collaboration in existing collaborative environments, b) ontologies plays prominent roles likely to exchange structure and promote enhanced process tracking from learners' knowledge related to the its behavior model. Perspectives on which ontology has been proposed focused on the need to define methodologies for knowledge representation and modeling through adequate knowledge structures.

2.2.2. Agents and Networking Issues. Many contributions have stated the capacities for agents' technologies to respond to dynamic aspects for the generation of services on the grid. It has been emphasized that autonomous and intelligent agents can carry out sophisticated tasks for learners by proposing different types of learning objects with different characteristics to tutor students in acquiring new concepts.

The use of multiagent systems to perform training, and cognitive monitoring has been increased; we also noticed the use of agent-based communication model for a social approach of interaction, dynamic generation of services [9] and management of the computer-grid communication through specific devices [10].

Therefore, we have perceived the need of agents layer to meet the deployment deals to build cognitive environments as a structure of partners grouped in a virtual organization.

3. Medical Diagnosis Tutoring

3.1. Trends and Limits

Medical diagnosis tutoring is a complex process consisting on the identification of a disease from a set of symptoms, signs, laboratory results and body imaging results. The ability to set a good diagnosis is fundamental to take care of sick persons. In general, a physician acquires good diagnosis mastery after a long period of working activities. In fact, when a patient meets a medical doctor at the hospital, his worry is to regain his health. This will happen by the tracking of his illness from a set of characterizing indications.

The task is not really easy for medical students who should solve clinical problems from basic knowledge associated to hypothesis and strategies. When doing practice shift in hospitals, the stay in a department is generally brief and it is scarce to meet the multiple facets of an illness and any error can be fatal for patients. Meanwhile, a tool enabling practical learning of medical diagnosis from real cases will permit to benefit from professionals who have spent several years on the field. During the last decade, the use of computers for human training has increased. The maturity of artificial intelligence tools has strongly influenced the development of tutorial systems to which more intelligent agents are integrated to improve knowledge acquisition with convivial human-machine interfaces.

The literature review reveals that many systems for medical diagnosis have been proposed with the aim to provide a simple and built-in tool for designing diagnosis applications. Milho proposed a user-friendly tool based on Bayesian Networks [2]. Rajaram designed an animated pedagogical agent using knowledge about causal relationships between symptoms and disease states, represented as a Bayesian network, to dynamically generate a diagnostic process [11]. Beverly Park suggested a tutoring system where students are in fact immersed in a problem-based case. They are guided through patient interview to gather signs and symptoms, to perform examination and order laboratory tests or imaging studies [12].

Actually, those approaches to medical diagnosis are based on Internet protocols, web pages are used

as interfaces to interact with the users and the main limit is that cases are generated or simulated, not real. We intend to use Grid technologies to build a virtual clinic that gathers real patient cases from participating hospitals for medicine schools or institutes who will use them later for training purpose.

3.2. New Tutoring Techniques

Many cases studies have pointed out the challenges of current researches on tutoring systems scaling up real world learning scenarios, such as constructing theories or performing experiments. Even though, learners seem to have an active and central role in the learning process, learning activities are not possible without knowledge to be acquired. Therefore, services should be shaped according to teachers and learners needs.

On a pedagogical point of view, knowledge construction occurs through direct experiences where concepts are understood from their manifestation in realistic contexts (access to real world data) [13]. Higher level services such as those emerging from semantically rich domains should be implemented through Grid-enabled interfaces. The new generation of learning services needs to fit the new learning vision. We suggest that services should be built, according to users' needs with core layers designed to provide answers to the requests made by any user anywhere on the Grid.

Therefore, tutoring in medical studies can be design as a set of services offered in a collaborative space like a virtual clinic for medical diagnosis on distributed patient. That is our approach and targeted services that we present later on are the virtualization of patient, the pedagogical tutoring, and the decision support tool.

4. Grid-based Virtual Clinic

4.1. System Overview

The Grid as a network is a transparent to its users. Its anatomy facilitates the building of scalable virtual organizations which are dynamic collection of users, resources and services sharing common activities among others [14]. Many other views of a virtual organization have been proposed and it is currently admitted that its members may have common general interest or goal and come from many different institutions [15].

Medical diagnosis is a multidisciplinary process dealing with many actors coming together to heal patients. As far as tutoring is concerned, hospitals can be considered as structures with a lot of patient data resources that may be shared to medical schools or institutes who accept to access a common grid network. They delineate a virtual organization that we call a virtual clinic. It brings together real sick persons information from participating hospitals and medical students from implicated schools or institutions.

The expression virtual clinic is not really new [16] but our approach is unique by the fact that it builds a national or international infrastructure based on the Grid with real (not simulated) data. Those records are used to build virtual patients (virtualization) who are presented to medical students (coming and going over time.). The examination process and tests are carry out in a cabinet which is a laboratory space generated on demand (scenarization) by the system from experienced doctors settings.

The medical diagnosis tutoring is based on symptoms, signs and images registered by hospitals. It is done by a tutor (pedagogical agent) acting with a decision support tool and a case based reasoning system using a set of specific technologies that we have developed [17][18]. The system should respond to explicit security constraints, therefore access should be controlled and authorization only granted to users who are authenticated from a list of members.

4.2. Structural Design and Components

An overview of the system architecture (figure 1) show the main components and their relations explained below.

– *Patients Virtualization*. Several convergent studies acknowledge that the use of agents improves interaction in systems built for training [19]. The application of these studies led us to the production of virtual patients by a matching process of symptoms and signs characteristic with related virtualized images defining physiologic models. We define virtualization as the incorporation of embodied agents in users' interfaces to simulate human behaviors using agent and virtual reality technologies [19].

Building a tool for medical diagnosis on the Grid requires the representation of the domain with a set of concepts that are meaningful for adequate representation of patient or diseases and relation between related notions [20]. The inputs of the patient virtualization procedure are based on the ontological and semantical specification of the sickness case. The identified properties enable the description of representations' primitives that formalize knowledge according to the interpretation of medical paradigms. Those data are finally aggregated in an XML file that unfolds the real patient attributes collected from distributed hospitals. They will be recorded in the system as clinical cases

linked to the virtual patient by a set of investigation questions.

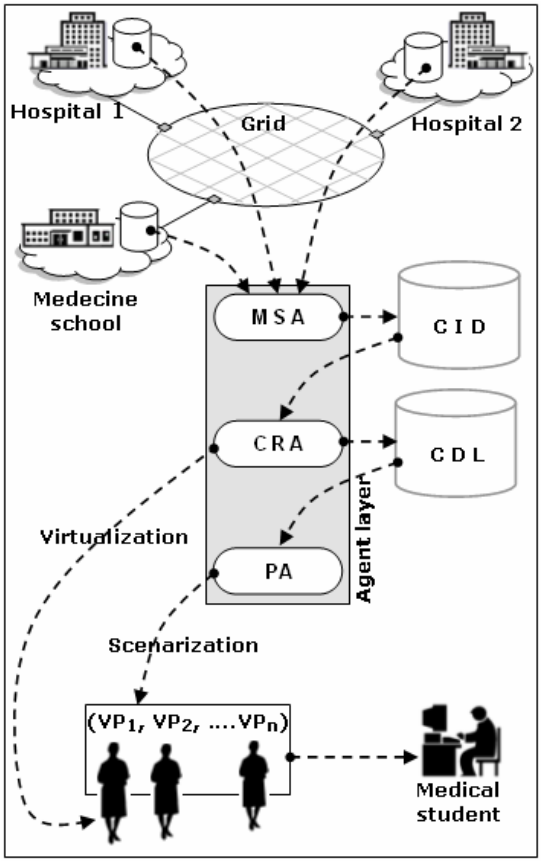

Figure 1. Grid-based virtual clinic architecture

– *Pedagogical Agent (PA)*. The knowledge of the field is given to the pedagogical agent by qualified physicians. Hence, diagnosis tutoring is based on descriptive models from algorithms made up of questionnaires related to the virtual patient records. It can be seen as a problem based on the recognition of model. The factors that complicate the diagnosis come from the great number of possibilities associable with a model.

Regardless of the number and the variety of diseases, it is always possible to classify them while following specific features of characters. Many complementary techniques are used and according to the clinical cases the challenges are related to the five types of quoted diagnoses: positive, differential, etiologic, of gravity and topographic. The pedagogical agent supervises the medical student, detecting its weaknesses and setting the strategies that may help him to solve the problems.

The process leans on the cognitive state from the learner model and suggests complementary knowledge that he needs. To provide this functionality, we build our tutoring strategy on the scenarization of virtual patients in area of expertise depending of the medical student specialization. The pedagogical agent will scrutinize the data provided by the CDL and return the cases that may be used to create the medical student cabinet, a waiting room produced from professionals' settings. It generates experimental condition for medical students' activities. When he starts to learn, the system automatically select relevant material, from his profile updated according to his specialization. Finally a decision support related to the case based reasoning theory is guides the interactions.

– *Decision support tool*. The expansion of clinical diagnostic decision support systems in medicine began with the development of particular clinical algorithms. Clinical databanks were used in conjunction with certain analytic functions or mathematical models to build small systems dedicated to a narrowly-focused medical diagnosis [21]. Later on, several tools to support decision in medicine have been developed with resolution support technologies like Bayesian models, neural networks, and cognitive models.

Currently, knowledge-based systems are becoming increasingly accepted as part of clinical decision support tools. The use of case based reasoning has been particularly successful in applications such as matching cases. The idea is for the system to imitate a physician's approach in "remembering similar past cases". A case is indexed to make it possible to be found from relevant or discriminatory characteristics that we called indices. The acquisition of cases is based on the ontology of the field, comprising a whole of concepts: disease, symptoms, examinations, antecedents, context social, and treatment.

We use case based reasoning to refine the result of tutoring investigation. As an extension to Frize idea, we expect that the interconnection of several databases through the Grid provides more cases to consider. Therefore, the virtual clinic allows physicians to retrieve and analyze information of 'similar' patients from anywhere.

4.3. Grid Knowledge Management

Efficient Grid information retrieval is one of the paradigms associated with knowledge management for the virtual clinic. The solution we propose is divided into three steps:

– In the first step we construct ontology of terms and expressions specific to each topic/category of disease. The criteria, on which an artifact will be classified in order to be correct, are defined initially by experienced physicians.

– Secondly, for the query to match the scenarization request, we use an inbuilt meta-search engine to retrieve the most adequate results from members' databases, and then proceed to validate or disqualify

them, based on content correctness. This is determined with respect to the related ontology and expert classification criteria.

– Thirdly, if conditions for correctness are verified, data are classified and identified into the local knowledge base. Therefore, the next time a similar query is launched, the system will first explore the local knowledge base. If the information is found there, there will be no need to do a Grid search.

All the dynamic view of the system is supported by intelligent agents. The cognitive architecture of agent is generally built on three levels characterizing its autonomy. We present below the dynamic scheme of the main agents related to the description above.

– *The Meta-Search Agent* (MSA) is the component that reviews the virtual community on the Grid and extracts any related patient case it encounters. This is done by a set of filter looking to metadata's identifiers stored in participating hospitals databases. From specific criteria defined by the professionals, a text classification is made and data extracted are stored in the Case Index Database (CID).

– *The Case Retrieval Agent (CRA)* automatically constructs the content digital libraries (CDL), as part of a knowledge network, from classification criteria based on web semantic techniques [22] [23]. Cases are built from ontology design to replicate medical diagnosis. These kinds of libraries are interesting in the sense that they make possible the storage of diagnosis related metadata, specific to specialized field and requirements. The retrieval technique concentrate on the matching of queries to results and the content correctness of the documents retrieved.

Present implementations of this on going work are running on Windows. Due to the limitation of the windows version of Globus toolkit we used the JINI API of Sun Microsystem. Agents were implemented as extension of Java thread running separated processes. Communications between agents were performed using blackboard techniques to drive messages addressed to agents. Each message has a field which specifies its recipients. They examine the new fact and engage suitable actions. In order to facilitate the interoperability with other databases management systems such as MySQL, we have decided to manage our data with the Protegé 2000's database. Grid architectures are not yet industrial; therefore, we have simulated a wide area network with local area network belonging to the virtual community members.

5. Conclusion

The aim of this work was to capitalize the advantages given by the Grid with the proposal of learning services for medicine schools or medical institutes. We have designed a system from concepts raised by recent researches on grid learning services (Ontologies, semantics, agents and services). Through this paper we show that Grid technologies can be of great interest for education when medical structures accept to collaborate and to be grouped in virtual communities.

The Grid-based virtual clinic for medical diagnosis tutoring that we propose is an integration of concepts aiming to bring into educational practice new types of medical tutors that may be used in medical curriculum for clinical activities training.

Medical students may now give out their opinion safely on the health state of a virtual patient submitted to their appraisal without fear, where a hazardous decision could have turned out to be fatal. They can quickly improve their performance, benefiting of a reduce time of real experiences that are stored.

Works in progress concern the neonatology diagnosis process and primary health care. Meanwhile, the generalization of this approach can be considered to capitalize experiences from various medicine specializations. The challenge we are facing is to build metadata for adequate queries and generic ontologies to cover several domains. With the satisfactory growth of grid network, a foreseeable perspective is to do tele-diagnosis for distant hospitals with low rate of professional employees.

The projected tests and evaluations of components already implemented will help to improve the prototype reliability taking into account specific requirements of medicine schools, medicine students and professionals for a better access to operational health expertise.

6. References

[1] Allison, C., Cerri, S.A., Gaeta, M., Ritrovato, P. and Salerno, S., "Human Learning as a Global Challenge: European Learning Grid Infrastructure", *in Varis, T., Utsumi, T. and Klemm, W. eds. Global Peace Through the Global University System*, 2003, pp. 465-488.

[2] Isabel Milho, Ana Fred, "A User-Friendly Development Tool for Medical Diagnosis Based on Bayesian Networks", *Proceedings of the Second International Conference on Enterprise Information Systems*, Stafford, UK, July 4-7, 2000, pp 176-180.

[3] Foster I., Kesselman C, *The Grid: Blueprint for a new Computing Infrastructure*, Morgan Kaufmann Publishers, ISBN 1-55860-475-8, 1999.

[4] Rob Bjornson, Andrew Sherman, *Grid Computing and the Linda Programming Model: An alternative to Web-services interfaces,* Dr. Dobb's Journal, Boulder, vol 29, n°.9, Sept.2004, pp.16-24.

[5] R. Nkambou, G. Gouardères, B. P. Woolf., "Toward Learning Grid Infrastructures". *Applied Artificial*

Intelligence : An international journal, Vol 19, No. 10, pp. 1-14. Taylor & Francis Group, 2005.

[6] Colin Allison, Stefano A. Cerri, Matteo Gaeta, Pierluigi Ritrovato, "Services, Semantics and Standards: Elements of a Learning Grid Infrastructure", *Grid Learning Service Workshop, Seventh International Conference on Intelligent Tutoring Systems*, Maceio, Alagoas, Brasil, 2004.

[7] Michelle Bachler and al., "Collaboration in the Semantic Grid: a Basis for e-Learning"*, Grid Learning Service Workshop, Seventh International Conference on Intelligent Tutoring Systems*, Maceio, Alagoas, Brasil, 2004.

[8] Bernard Lefebvre, Gilles Gauthier, Serge Tadié, and al., "Competence Ontology for Domain Knowledge Dissemination and Retrieval", *Grid Learning Service Workshop, Seventh International Conference on Intelligent Tutoring Systems*, Maceio, Alagoas, Brasil, 2004.

[9] Clement Jonquet and Stefano A. Cerri, "Agents Communicating for Dynamic Service Generation", *Grid Learning Service Workshop, Seventh International Conference on Intelligent Tutoring Systems*, Maceio, Alagoas, Brasil, 2004.

[10] Roland Yatchou, Guy Gouardères, Roger. Nkambou, "Ubiquitous Knowledge Prosthesis for Grid Learning Services: The Grid-e-Card", *Grid Learning Service Workshop, Seventh International Conference on Intelligent Tutoring Systems*, Maceio, Alagoas, Brazil, 2004.

[11] Rajaram Ganeshan, Lewis Johnson, Erin Shaw and al., "Tutoring Diagnostic Problem Solving", *Lecture Notes In Computer Science; Vol. 1839, Proceedings of the 5th International Conference on Intelligent Tutoring Systems*, Springer ISBN:3-540-67655-4, 2000, pp 33-42.

[12] Beverly Park Woolf, John Reid, Neil Stillings & al., "A General Platform for Inquiry Learning", *Proceedings of the International Conference on Intelligent Tutoring Systems*, Biarritz, France, 2002.

[13] Colin Allison, Stefano A. Cerri, Matteo Gaeta, and al., "Services, Semantics and Standards: Elements of a Learning Grid Infrastructure", *Grid Learning Service Workshop, Seventh International Conference on Intelligent Tutoring Systems*, Maceio, Alagoas, Brasil, 2004.

[14] Ian Foster, Carl Kesselman, and Steve Tuecke, "The Anatomy of the Grid: Enabling Scalable Virtual Organizations", *International Journal of Supercomputer Applications*, 2001, vol 15, n°3.

[15] Hoschek, W., Jaen-Martinez, J., Samar, A. and al., "Data Management in an International Data Grid Project", *Proceedings. 1st IEEE/ACM International Workshop on Grid Computing*, Springer Verlag Press, 2000.

[16] Scott Shepard, "Virtual Clinic Software has Virtually Endless Possibilities", *Memphis Business Journal* December 25, 2000.

[17] Roger. Nkambou, Yan Laporte, Roland Yatchou and al., "Embodied Emotional Agent and Intelligent Training System". In: Abraham, A., Jain, L., & Kacprzyk, J. (Eds), "*Recent Advances in Intelligent Paradigms and Applications*", Springer-Verlag, Berlin. ISBN: 3-7908-1538-1, Nov. 2002. Chapter 11, pp. 233-253.

[18] Laporte Yan, Nkambou Roger, Yatchou Roland, "Prototypage d'un agent émotionnel d'interface pour les laboratoires virtuels", *Technologies de l'Information et de la Connaissance dans l'Enseignement Supérieur et l'Industrie*, Compiègne : Université de Technologie de Compiègne, Oct. 2004, pp 198-204.

[19] Rebecca Voelker, "Virtual Patients Help Medical Students Link Basic Science With Clinical Care", *The Journal of the American Medical Association*, 290 (13), , 2003, pp 1700-1701.

[20] Sure Y., Staab S., & Angele J., "Ontoedit: Guiding ontology development by methodology and inferencing", *In International Conference on Ontologies,Databases and Applications of Semantics*, Irvine, USA, 2002

[21] Frize M., Solven F.G., Stevenson M., Nickerson B. G., and al., "Computer-Assisted Decision-support Systems for Patient Management in an Intensive Care Unit", *Proceedings Medinfo '95*, Vancouver, 1995, pp 1009-1012.

[22] M. Lalmas, "A Model for Retrieving Heterogenous Structured Documents based on Evidential Reasoning", *The Computer Journal*, 1999, vol. 42, n° 7, pp 547-568.

[23] Hervé Donfack, Roland Yatchou and Claude Tangha, "Application des agents de veille technologique à la formation sur Internet"*, Proceedings of CARI*, 2002.