Enhancing Grid Usage through Semantic Metadata

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***Abstract*— The coordinated sharing of resources to address computational problems is a central issue in environments of Grid computing. Two important scenarios arise from this issue. First, as the amount of installed applications increases, the difficulty of finding an explicitly desired application for reuse also grows. Simultaneously, the possibilities of suitable replacement of software pieces in response to user requirements increase too. Second, an efficient mechanism to answer user requirements for applications could enhance the grid resource usage, since the new raised possibilities also increase the application requirement spectrum. This paper describes an extensible semantic grid knowledge base (KB) and a prototypical matching that explores the KB, enhancing the grid content and the grid resource usage.**

I. Introduction

The coordinated sharing of resources for the solution of computational problems is a central issue in Grid computing environments. Most of Grid resource management systems, to our best known, are based on approaches to match appropriate grid resources with application requirements, whose focus is put only on the resource description.

However, as a grid structure grows with an increasing amount of installed applications, the difficulty of finding a desired application for reuse also becomes a relevant problem, although, it also raises the possibility of substitution or interchange of software pieces in response to a user application requirement. Indeed, this above scenario could enhance the grid resource usage, since the new raised possibilities also increase the application requirement spectrum.

Ontology is defined by Swartout and Tate [6] as an explicit representation of domain concepts that provides a basic structure around which KBs can be built. Ontologies, according to [3], can improve the quality of information about grid software and resource and this can help to increase the efficiency of software and resource management on the grid.

In this paper, we exploit a set of related ontologies to answer a wide variety of questions regarding the management of grid software and resources. We claim that this approach will improve the reuse, sharing, and integration of software and computational resources on the grid.

Our ontologies are based on OWL-DL, a sublanguage of OWL, a W3C-recommended ontology language[1]. Ontologies in OWL-DL can be processed by a *reasoner* to meet different goals. In reasoning, conclusions not explicitly present in the KB can be inferred from axioms in this base.

[1]`http://www.w3.org/2004/OWL`

The InteGrade, an opportunistic grid middleware [4], will be used as the base for a prototype implementation of our approach. At the moment, the InteGrade middleware focus mostly on to take advantage of idle computational resources on grids. An extensible KB about applications and grid resources could enhance InteGrade to allow management and effective reuse of software and resources on grids.

This paper is organized as follows: Section II presents a set of ontologies and their relation mechanisms on the KB. Section III discuss the reasoners work to infer knowledge from inserted incomplete assertions and how to explore the KB through inference and querying mechanisms. Section IV shows some related works, while Section V presents our conclusions and describes the next steps of this work.

II. The Knowledge Base

We started our KB definition rethinking the grid system ontology described in [7]. In order to improve the KB maintainance and scalability, we separate the original ontology in a set of related ontologies, connected between them through the OWL import mechanism. This resultant set consists of three types of ontologies: upper-level ontologies, ancillary ontologies containing domain specific concepts, and more concrete grid ontologies, which extend the upper-level ontologies to describe specific grid concepts as reusing these top ontologies.

In our KB prototype[2], we have one upper-level ontology, which is called the *Grid Base Ontology*, one ancillary ontology, the *Platform Ontology*, and one more specific grid ontology, the *Grid Software Management Ontology*. We used the Protégé-OWL tool[3] to enter the new proposed set of ontologies. Reasoning tasks, such as consistency check and class hierarchy inference, were performed through a connected Pellet [5] reasoning tool.

An *upper-level ontology* or *top-level ontology*, as defined in [3], is an "ontology that describes knowledge at higher levels of generality". In our grid KB, the *Grid Base Ontology* contains concepts, properties and axioms which can be considered common to grid domain application and users. Figure 1 shows the Protégé-OWL GUI with the asserted and the inferred class hierarchies of the *Grid Base Ontology*. The class hierarchy is based on two root concepts: *Grid Software Concepts* and *Grid Resource Concepts*. The former encompasses concepts,

[2]download at `http://www.deinf.ufma.br/~vidal/GO/`
[3]`http://protege.stanford.edu/plugins/owl`

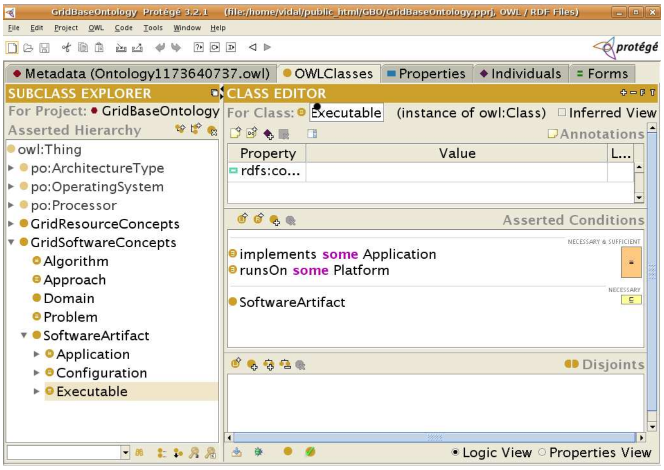

Fig. 1. Upper Level Grid Ontology

such as *Domain*, *Problem*, *Approach*, and so on. The latter encompasses concepts related to grid computational resources such as *Computer*, *Cluster*, and *Platform*. The upper-level ontology imports the *Platform Ontology*.

The *Platform Ontology* contains a short class hierarchy and related properties, on the computational platform domain (e.g. operating systems, architectures and processors).

The *Grid Management Ontology* imports the top-level ontology showed in Figure 1. In our example, its software branch describes concepts related to a specific domain (*Data Mining Domain*), such as *Classification Approaches*, which are derived from the *Grid Base Ontology* concepts.

III. The Semantic Grid System

The proposed set of ontologies were produced as result of our exploratory effort to create a generic an extensible grid KB, initially aimed to support the InteGrade middleware requirements for metadata.

After defining the top ontology and its necessary ancillary ontologies, we can explore their uses in different scenarios. The grid base ontology initially act as a fundamental taxonomy encompassing the main concepts related to grid systems.

A strong appeal of the semantic model is the interesting possibility of inference knowledge from previously defined axioms and incomplete information. For example, subsumption inference can be designed to be produced in advance, in conformance with an intelligent policy.

However, yet is possible to explore the reasoner engines in other interesting way through query languages and mechanisms. Using these ontologies, the KB, query languages, and inference engines embedded in the middleware, a grid user or the middleware itself can pose a question such as “Are there equivalent methods for a specific task ?”. The query results in the Semantic Grid should be interpreted under the assumption that we are asking about what is known. In this context, the use of query languages, e.g., SPARQL, may be fruitful.

IV. Related Work

Generic ontology-based grid systems are not a common subject. The Core Grid Ontology (CGO), described in [9], [8] provides a common KB about grid systems. In this sense, our approach is similar to that of CGO. However, it is not clear how they intend to explore reasoning and querying tasks.

Cannataro describes in [2] the Data Mining for Grid Programming project which uses an ontology (DAMON) for the data mining domain. We propose a multi domain approach to the management of grid content and resources .

Brook et al. [1] propose an ontology-based matching of task requirements and grid resource policies. Our work aims to integrate application search problem and the matching of application and grid resources within a comprehensive perspective.

V. Conclusion and Ongoing Work

In this work, we took a basic taxonomic grid ontology, refactored it, and investigated different manners to explore it. Then, we extended the concepts defined in the upper level ontology to create cluster specific ontologies, describing grid concepts related to specific software domains and computational resources registered and connected to some cluster. In this context we infered subsumed hierarchies to obtain new inferred knowledge. Ontology-based applications can be built around the KB to cover different domain problems. This approach can help grid users to obtain more efficient query results from inferred class hierarchies, and even to increase the spectrum of application and grid resource matching, as discribed in Section III. The necessary implementation tasks to provide user interfaces for querying and for KB maintainance, and to easy scalability, represent our ongoing and future work.

References

[1] J. Brooke, D. Fellows, K. Garwood, and C. Goble. Semantic matching of grid resource descriptions. In *AxGrids 2004*, volume 3165, pages 240–249, January 2004.

[2] M. Cannataro and C. Comito. A data mining ontology for grid programming. In *In Workshop on Semantics in Peer-to-Peer and Grid Computing (in conj. with WWW2003)*, pages 113–134, Budapest, Hungary, 2003.

[3] B. Chandrasekaran, J. Josephson, and V. Benjamins. What are ontologies, and why do we need them? *Intelligent Systems and Their Applications, IEEE*, 14:20–26, jan 1999.

[4] A. Goldchleger, F. Kon, A. Goldman, M. Finger, and G. C. Bezerra. InteGrade: Object-Oriented Grid Middleware Leveraging Idle Computing Power of Desktop Machines. *Concurrency and Computation: Practice and Experience*, 16:449–59, March 2004.

[5] E. Sirin, B. Parsia, B. C. Grau, A. Kalyanpur, and Y. Katz. Pellet: A practical owl-dl reasoner. Technical Report 2005-68, Maryland, USA, 2005.

[6] W. Swartout and A. Tate. Guest editors’ introduction: Ontologies. *IEEE Intelligent Systems*, 14(1):18–19, 1999.

[7] A. C. T. Vidal, J. Jose de R. P. Braga, F. Kon, and S. T. Kofuji. Defining and exploring a grid system ontology. In *MCG ’06: Proceedings of the 4th international workshop on Middleware for grid computing*, page 16, New York, NY, USA, 2006. ACM Press.

[8] W. Xing, M. D. Dikaiakos, and R. Sakellariou. A core grid ontology for the semantic grid. In *CCGrid 2006*, pages 178–184, Singapore, May 2006. IEEE Computer Society.

[9] W. Xing, M. D. Dikaiakos, R. Sakellariou, S. Orlando, and D. Laforenza. Design and development of a core grid ontology. In *CoreGRID Integration Workshop 2005*, pages 21–31, Pisa, Italy, November 2005. S. Gorlatch and M. Danelutto (Eds.).