Managing Semantic Metadata for Web/Grid Services

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ABSTRACT

Web/Grid services’ metadata and semantics are becoming increasingly important for service sharing and effective reuse. In this paper we present a generic framework for engineering and managing services’ Semantic Metadata (SMD) with the ultimate purpose of facilitating interoperability, automation, and knowledgeable reuse of services for problem solving. The framework addresses fundamental issues, approaches, and tools for the whole lifecycle of SMD management, in other words, those of acquiring, modeling, representing, publishing, and reusing services’ SMD. It adopts ontologies and the Semantic Web technologies as the enabling technologies by which services’ metadata are semantically enriched and made interoperable, understandable, and accessible on the Web/Grid for both humans and machines. In particular, mechanisms are proposed to make use of service SMD for service discovery and composition. The paper also describes a service SMD management system in the context of the UK e-Science project GEODISE. A suite of tools are developed, which forms the core of the SMD management infrastructure. We demonstrate the added value of the use of SMD through the integration of SMD management with GEODISE application systems.

Keywords: engineering design; knowledge management; metadata; ontology; Semantic Grid; Semantic Web; Web services

INTRODUCTION

The essence of Grid computing (Foster & Kesselman 2004) is the sharing and reuse of distributed heterogeneous resources for coordinated problem solving. Its success relies on the effective discovery, seamless aggregation and effective use of the “right” services for the “right” problem. Metadata is data that provide extra information about other data. For example, a photo can be described using the following metadata: <dateTaken> 12/09/2003 </dateTaken>, <placeTaken> seminar room </placeTaken> and <whatAbout> GEODISE project meeting </whatAbout>. Metadata is becoming increasingly critical in Web/Grid com-
puting because human users as well as software agents increasingly rely on metadata for service discovery, reuse, and expertise sharing.

Metadata exist at all levels of the Grid, ranging from low-level repositories of resource handles to upper-level application-related services. At the time of writing, the metadata of low-level hardware-related Grid services is stored and managed by core Grid services such as Globus MDS (www.globus.org/mds) and RGMA (www.r-gma.org). In the Open Grid Service Architecture (OGSA) (Foster, Kesselman, Nick, & Tuecke, 2002) application-level resources are wrapped as Web or Grid Services, and services’ metadata are associated with Web/Grid services, which are described in WSDL files (www.w3.org/TR/wsdl12), and published and stored in UDDI repositories (www.uddi.org).

The way that current service-oriented infrastructure handles and manages services’ metadata is not adequate and effective for metadata to help services discovery and knowledge sharing. First, there is no enough metadata about Web/Grid services. Services, in particular, legacy resources, are developed by service providers for their own use, without realising the role and importance of metadata this naturally leads to the lack of descriptive information for services. Second, metadata are unstructured. Web/Grid services are diverse; the types of metadata required for describing services in e-Science (Hey & Trefethen, 2003) vary greatly between individuals, organisations, and scientific communities. The use of different terminologies and the adoption of various metadata models such as using comments or annotations as metadata are inevitable. Unsurprisingly, this causes the problem of mutual understanding and service interoperability. Third, metadata lack semantics. XML- (www.w3.org/XML) based metadata modeling and representation as in WSDL and UDDI are incapable of capturing genuine semantics, relationships, or constraints. There are no problems for humans to understand XML-based metadata as described in the above photo example because we know the meaning of these English words. The question is: “can machines understand and consume them?” so that they can perform automated and automatic processing with regards to the use of Web/Grid services. Clearly without further assumptions, the answer will be no. Fourth, there are no dedicated metadata storage and associated query and reasoning facilities. UDDI is not supposed to deal with large amount of metadata. While it is possible to incorporate rich metadata into UDDI repositories, UDDI itself does not provide scalable storage mechanisms and rich capabilities for manipulating metadata, such as query and reasoning against metadata.

The Semantic Web (Berners-Lee, Hendler, & Lassila, 2001) and Semantic Grid (De Roure, Jennings, & Shadbolt, 2003; Zhuge, 2005) are extensions of the current Web/Grid in which information and services are given well-defined meaning, better enabling computers and people to work in cooperation. We believe that the first step towards the Semantic Web/Grid is to make the Web/Grid full of rich SMD, in other words, metadata with semantics. To achieve this objective, we argue that an integrated framework for SMD modelling and management is required so that service’s metadata are flexible and extensible, and metadata generated in such a way have explicit, conceptually consistent meaning. This framework ought to exploit knowledge engineering techniques in advanced knowledge technologies (Zhuge, 2004) (Goble, De Roure, Shadbolt, & Fernandes, 2004) (www.aktors.org/akt), the emerging infrastructure in the Semantic Web and Web/Grid services technologies (www.w3.org/2002/ws/) (www.globus.org/wsrf) communities in order to work with heterogeneous distributed services across dynamic virtual organisations.

This paper proposes a generic framework for SMD engineering and management, which can be applied to both Web Services and Grid services. Our contributions are threefold. Firstly the proposed framework provides a systematic, coordinated approach to SMD management, offering a new and deep understanding of SMD management as a crucial means for service-oriented computing. Secondly various methods and mechanisms are proposed to addresses
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