Modeling Services for the Semantic Grid ⋆

Extended Abstract

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The Grid has emerged as a new distributed computing infrastructure for advanced science and engineering aiming at enabling sharing of resources and information towards coordinated problem solving in dynamic environments. Research in Grid Computing and Web Services has recently converged in what is known as the Web Service Resource Framework. While Web Service technologies and standards such as SOAP and WSDL provide the syntactical basis for communication in this framework, a service oriented grid architecture for communication has been defined in the Open Grid Service architecture. Wide agreement that a flexible service Grid is not possible without support by Semantic technologies has lead to the term "Semantic Grid" which is at the moment only vaguely defined. In our ongoing work on the Web Service Modeling Ontology (WSMO) we so far concentrated on the semantic description of Web services with respect to applications in Enterprise Application Integration and B2B integration scenarios. Although the typical application areas of Semantic Web services have slightly different requirements than the typical application scenarios in the Grid a big overlap justifies the assumption that most research results in the Semantic Web Services area can be similarly applied in the Semantic Grid.

The present abstract summarizes the authors view on how to fruitfully integrate Semantic Web service technologies around WSMO/WSML and WSMX and Grid technologies in a Semantic Service Grid and gives an outlook on further possible directions and research.

The reminder of this abstract is structured as follows. After giving a short overview of the current Grid Service architecture and its particular requirements, we shortly review the basic usage tasks for Semantic Web services. We then point out how these crucial tasks of Semantic Web services are to be addressed by WSMO. In turn, we try to analyze which special requirements for Semantic Web Services arise with respect to the Grid.

We conclude by giving an outlook on the limitations of current Semantic Web services technologies and how we plan to address these in the future in a common Framework for Semantic Grid services.

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1 Grid Services

The Grid has emerged as a new distributed computing infrastructure technology for advanced science and engineering aiming at enabling resource sharing and coordinated problem solving in dynamic multi-institutional Virtual Organizations [5], [7]. Grids are used to join various geographically distributed computational and data resources, and deliver these resources to heterogeneous user communities. However, the term "Grid" doesn't have a unique interpretation - different communities have different understandings [10], [9]. The definition of Grid that we consider in this paper is provided by Open Grid Services Architecture [7].

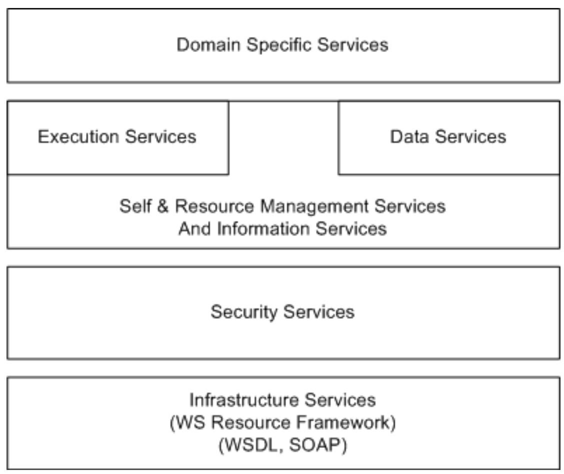

Fig. 1. Open Grid Services Architecture

The Grid provides the protocols, services and software development kits needed to enable flexible, controlled resource sharing on a large scale. Sharing in Grid is, necessarily, highly controlled, with resource providers and consumers defining clearly and carefully just what is shared, who is allowed to share, and the conditions under which sharing occurs. At the heart of the Grid is the concept of Virtual Organizations [7]. A Virtual Organization is a dynamic collection of individuals, institutions and resources bundled together in order to share resources as they tackle common goals.

The Open Grid Services Architecture(OGSA) [6] provides a conceptual framework for Grid systems based on Web services concepts and technologies. Figure 1 presents the overall OGSA architecture. OGSA provides different types of services that are required in Grid environment. These includes: (1) *Infrastructure services* which leverage Web services machinery to structure OGSA based systems according to the design principle of Service-Oriented Architecture to better design Grid systems; (2) *Security Services* which provide controlled access to resources which can be in various administrative domains with different access and security policies; (3) *Execution Management Services* which deal with the problems of task initiation and management; (4)*Data Services* which are responsible for efficient data access, data consistency, data persistency, data integration and data location management; (5) *Resource Management Services* which allow the management of individual resource itself, management of resources in Grid (i.e. resource reservation, monitoring and control) and monitoring of Grid infrastructure; (6) *Self-Management Services* which includes SLA, policies and service level manager models and finally (7) *Information Services* which provide access and manipulate information about applications, resources and services in the Grid environment.

While defining a clear architecture for how resource and service collaboration and distribution work together in the Grid environment, this current architecture accounts for semantic heterogeneities only to a limited extent and descriptions of resources and services are generally rather simple. Description and matching of resources is achieved upon simple attribute/value pairs with limited flexibility of what can be described. In Condor [15] for example requesters and providers advertise their characteristics and requirements in *classified advertisements* (ClassAds). Characteristics are expressed in a attribute/value style. An example is given below:

```
Disk = 10; //gigabytes
Memory = 512; //megabytes
```

Obviously, richer semantic descriptions and recognition of matching on a semantic level such as provided by Semantic Web technologies are needed to achieve a more flexible Grid environment.

Moreover, workflows describing complex tasks to be solved on the Grid are mainly encoded in proprietary languages and the Grid part is mainly concerned with distributing these workflows over the available resources based on the above-mentioned simple matching. Approaches for scientific workflow execution in a Grid environment have been described and discussed in this workshop, as KEPLER[1]. The need for re-use, replacement, querying, and semi-automatic composition of such workflows has been issued but concrete solutions in the Grid context seem not have been addressed so far. These goals can only be achieved if the underlying formalism to define workflows and complex processes to be executed in a grid environment can be defined in a language with a well-defined uniform formal semantics.

2 The Web Service Modeling Ontology (WSMO)

Not developed in a Grid context, the Web Service Modeling Ontology (WSMO) [16, 18] and the area of Semantic Web Services [14] in general still cover a lot

[1] http://kepler-project.org/

of the requirements which are needed in a fully semantically enabled Service Grid infrastructure: The goal of semantic service description frameworks such as WSMO or OWL-S [1] is the provision of a methodology and language to describe all relevant aspects of services and information resources in general in order to enable the automation of tasks such as selection, composition and monitoring of complex services in order to fulfill user requests, called goals in WSMO.

This explicit notion of goals is missing in Grid architectures so far, but essential in our point of view. WSMO inherits its main concepts from its foundation in the Web Service Modeling Framework (WSMF) [4].

Also originating from WSMF, WSMO defines a notion of strong decoupling by mediation between all components in order to resolve data, process and heterogeneities and relies on formal ontologies and ontology mediation for solving such problems. This allows matching and interoperability beyond simple attribute/value matching in current Grid environments: The use of resources and services via mediators becomes possible despite slight heterogeneities or the combination of services can be chosen in order to resolve a goal. By means of the Web Service Modeling Language (WSML), WSMO provides a formal language to describe and annotate all relevant aspects of services.

Combinations of services can be described formally in the form of services offering a complex choreography interface and/or the interoperation of other services and goals in the orchestration interface. Both these aspects choreography and orchestration) of a service or goal are described formally by means of abstract state machines [11]. We plan to provide a more easily usable language for such interface descriptions which also allows for graphical modeling of complex services and goals but equally bases its semantics formally in ASMs in future versions of WSMO and WSML.

Besides the conceptual model (WSMO) and language (WSML) the WSMO framework offers a reference implementation and architecture with the Web Service Execution Environment (WSMX). There is already work in progress to align and converge this architecture model with the reference architecture models and frameworks in the Grid (OGSA and WSRF).

3 Are Web Services the right means for a Semantic Grid service infrastructure?

Although WSMO and the current Grid Service architecture proposals show significant convergence already, there is one more point open to mention around Semantic Web services which will in our opinion also crucially influence Semantic Grid Services. In [3] we point out that current message-based Web service technologies are in fact not really applying Web principles. It is rather an XML message exchange protocol (SOAP) and interface definition (WSDL) using Web protocols (http) but the usage of the http protocol alone does not justify the "Web" in Web services.

Similar concerns particularly apply in Semantic Grid applications: What made the Web so successful for humans was the possibility for communication despite reference-,time-, and location-wise de-coupling of the communication by simply persistently publishing the information and requests to be conveyed in a global space. We believe such persistent loosely coupled is also possible (and even necessary) in a flexible machine-usable application collaboration infra/structure. By combination of Semantic Web technologies around RDF[12] and WSML with the ideas of coordination and collaboration systems often called tuple space[8] we aim making the vision of semantic Web Services come true. Details and first results of this approach can be found at [13, 2] and in the recently started Austrian national funded TSC project[17].

4 Requirements for Semantic Web Services in Grid applications

As opposed to Semantic Web service scenarios, the Grid applications might have tighter performance constraints on semantic descriptions and matching. The level of expressivity and matching methods need to be chosen carefully. A description with language with efficient matching properties such as WSML Core or OWL Light might address these requirement best, finding the necessary trade-off between expressivity and efficiency.

We will need to investigate the current approach of WSMO for describing complex service interfaces on the one hand and goals on the other hand in terms of choreography and orchestration interfaces. We believe that it is possible to base a suitable description framework for Grid applications and complex goals formulated as workflows on WSMO. Grid Services probably will have special requirements on the decomposability of such goals and interfaces to be distributed among the available services and resources in the Grid, focusing on the orchestration part of service and goal descriptions.

Although the current Grid service architecture defined by OGSA is based on WSDL and SOAP, we have several concerns on whether these technologies are sufficiently flexible for asynchronous collaborations in a Grid environment with distributed services and Data resources. We believe that TripleSpaces as a new semantically enabled Web service infrastructure based on Web principles allowing for stateful communication via persistent publication will be a second complementary pillar in a complete Semantic Grid service infrastructure.

5 Conclusion

Summarizing, we believe that the research results in Semantic Web services in general WSMO in particular provide a solid basis for an integrated Semantic Grid Services with OGSA and a Grid oriented version of WSMX as architectural building blocks and using WSML as description language. Furthermore we emphasize that existing Web Services techniques around WSDL and SOAP which mostly rely on synchronous message exchange should not be the single basis for a flexible service and collaboration infrastructure such as required by the Semantic Grid. We thus currently work on the definition of more flexible Semantic middleware as an alternative Semantic Web service communication infrastructure which we call the TripleSpace. Combining these building blocks in a new standardized framework which will be the kernel of the Semantic Grid is a big endeavor which we aim to tackle in several running and upcoming research projects within DERI and in collaboration with several European and international partners.

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