Using Triple-Space Computing for communication and coordination in Semantic Grid

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Abstract: Triple Space Computing is a new communication and coordination paradigm for Semantic Web Services. It has been achieved by extending Tuple Space Computing to support RDF as Triple Space Computing and then use it for communication in Semantic Web Services. Similarly we want to use the emerging Triple Space Computing to enhance the communication of computation and information services of the Semantic Grid. This paper briefly describes how Triple Space Computing can be used for Semantic Web technologies, Web Services, Semantic Web Services and eventually the Semantic Grid.

1. Semantic Web Services

Web Services [1] are currently a widely used technology for applications and businesses integration. Their success is due to a shared view on how functionality and behavior should be exposed and invoked by different parties. Applications and resources can be provided as services moving the information society towards a service oriented world. The building blocks of Web Service technologies are protocols like WSDL and SOAP. Using such protocols, the automatization of different task in eWork and eCommerce can be achieved, but only to a very limited extent. A strong human support is needed in order to perform successful service related tasks like discovery, selection, composition, mediation, execution and monitoring. Semantic Web Services are a step forward in the realization of intelligent infrastructure that will enable previous mentioned tasks on services to be realized in a more and more human independent manner. Two technologies are used in realizing Semantic Web Services i.e. Semantic Web and Web Services. The combination of these two allows services to be described in a machine understandable way. The Web Service Modeling Ontology - WSMO is one initiative that provides a conceptual model for the description of various aspects of services towards such Semantic Web Services. Four basic elements are defined by WSMO:

- **Ontologies** - Ontologies [5] define a common agreed terminology by providing concepts and relationships among concepts. They are then further used in modeling all the other elements involved in Semantic Web Services descriptions.
- **Goals** - Goals are key modeling elements that capture the requester perspective and his/her requested functionality.
- **Web Service descriptions** - Web Service descriptions contains the specification of the service functionality, behavior and non-functional characteristics.
- **Mediators** - Mediators connect different WSMO elements and resolve heterogeneity in data representation, protocols and business processes.

By using WSMO semantic descriptions tasks like: discovery, selection, composition, mediation, execution, monitoring on Web Services could be realized in a semantic execution environment. The Web Services Execution Environment (WSMX) [3] is such an execution environment providing the reference implementation for WSMO. WSMX functionality could be summarized as performing discovery, mediation, selection and invocation of Web Services on receiving a user goal specified in WSML [4], the underlying formal language of WSMO.

2. Triple Space Computing

Tuple Space Computing is a communication paradigm in which communication is carried out by reading and writing the information to be exchanged in a shared space. Its semantic extension was proposed in [6] and is called as Triple Space Computing in which RDF [2] triples are used to read and write information than that of simple messages. RDF provides the natural link from the Tuple Space Computing paradigm into the Semantic Web. It provides a richer data model than interlinked triples that could also be used to model and retrieve information. The Triple Space shall offer an infrastructure that scales conceptually on an Internet level. Like Web servers publish Web pages for humans to read, Triple Space servers would provide Triple Spaces to publish machine-interpretable data. Providers and consumers could publish and consume triples over a globally accessible infrastructure, i.e., the Internet. Various Triple Space servers could be located at different machines all over the globe and hence every partner in a communication process can target its preferred space, as it is the case for Web. This highlights many advantages for providers and consumers. The providers of data can publish it at any point in time (time autonomy), independent of its internal storage (location autonomy), independent of the knowledge about potential readers (reference autonomy), and independent of its internal data schema (schema autonomy).

3. Triple Space Computing for State-of-the-art technologies

As discussed above that Triple Space Computing can be useful in enhancement of semantic enabled communication and coordination. In this section we highlight its use in related technologies i.e. Semantic Web, Web Services, Semantic Web Services and eventually can show its applicability in Semantic Grid.

3.1 For Semantic Web i.e. RDF

We are analyzing the existing technologies developed for Semantic Web, particularly concerning RDF in order to bring semantics to the Tuple Space Computing. The extension of Tuple Space Computing to support RDF will form a basis for Triple Space Computing. This Triple Space Computing middleware can hide the processing of the semantic enabled data in form of RDF objects inside it, rather than providing it on web pages.

3.2 For Web Services and Semantic Web Services

The Triple Space Computing can be used as communication paradigm for Web Services. It provides asynchronous invocation support and hence improves the communication as shown in Figure 1:

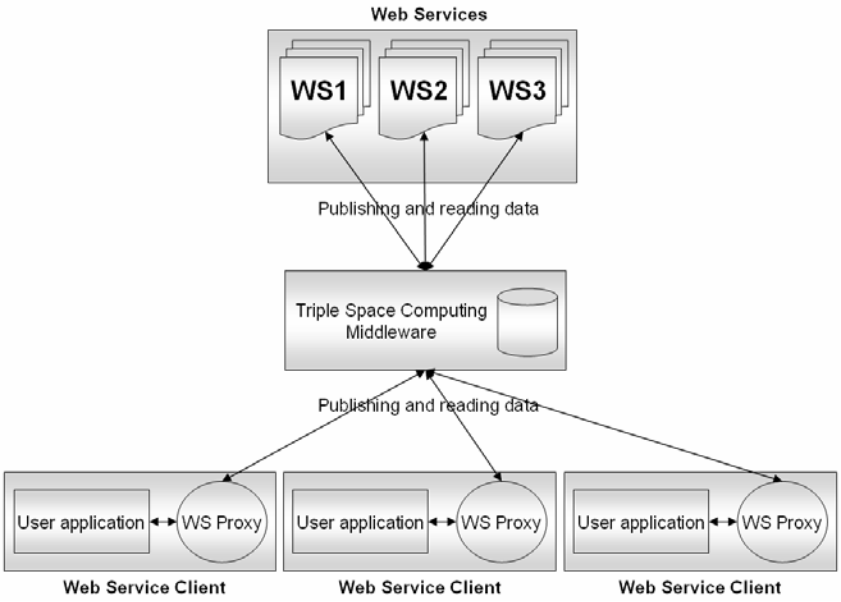

Figure 1: Asynchronous communication support for Web Services through Triple Space Computing middleware

The Triple Space Computing middleware acts as third party among the Web Service clients and Web Services. When a Web Service client sends a request to some Web Service, it should publish data in the Triple Space Computing middleware. Similarly, Web Service can receive the invocation request from client by reading data from the Triple Space middleware. Same applies to semantically described Web Services. We started to investigate that how the Triple Space Computing could be applied to our implementation for Semantic Web Services i.e., The Web Service Modeling Execution Environment. Using Triple Spaces for asynchronous communication between different WSMXs enables and brings them a step closer to their architectural goal i.e., to support greater modularization, flexibility and decoupling in communication of different WSMX nodes. Similarly, it enables WSMX to be highly distributed and easily accessible. Furthermore, being a third party element Triple Space Computing can resolve communication disputes that may arise.

3.3 For Open Grid Service Architecture (OGSA)

The OGSA [7] framework provides the conceptual model for Grids. It takes a Service-Oriented approach and defines a set of services that are vital for a Grid environment. It is a major building block for Grid environments and its role will be significant in the realization of Semantic Grid as well.

As shown in the figure below, we envision the empowering and extension of OGSA in two directions by using:

i. WSMO descriptions for OGSA services
ii. Triple Space Computing as a communication and coordination paradigm for OGSA services

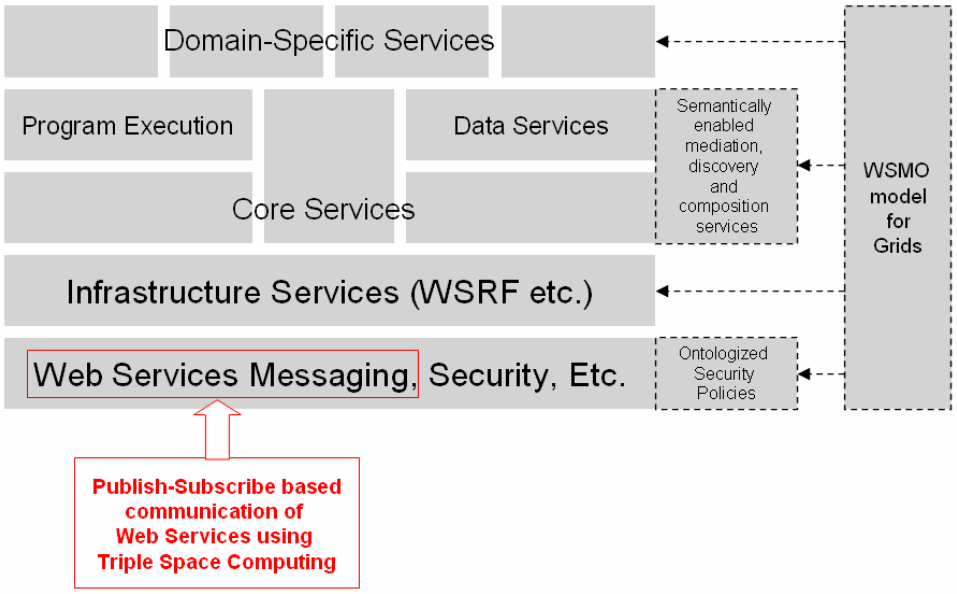

Figure 2: Web Services communication through Triple Space in OGSA

Some initial thoughts on how to employ WSMO to semantically extend OGSA were presented in our previous work [9]. The second extension and improvement of OGSA that we envision is the use of Triple Space Computing as a publication based approach for OGSA services communication and coordination. Using a Triple Space approach features like time, data schemas, location, reference autonomy would be automatically available for communication between OGSA services as well.

3.4 For Semantic Grid

Semantic Grid envisions semantics in information and services of existing Grid [10]. The Semantic Grid core services have been proposed in [8]. The Triple Space Computing communication paradigm can also be used in context of Semantic Grid as shown in Figure 3.

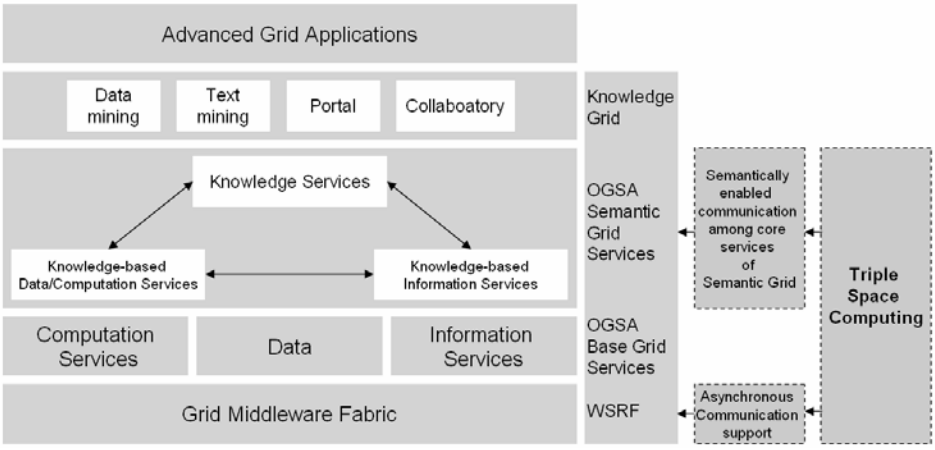

Figure 3: Triple Space Computing for Semantic Grid Architecture

As a first step it would bring asynchronous communication support for Web Services Resource Framework (WSRF) which acts as basis for Semantic Grid architecture. Secondly, it can also be used for enhancement of semantic enabled communication by exchanging RDF objects among knowledge-based data, computation and information services in the Semantic Grid architecture.

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