Improving a Satellite Mission System by means of a Semantic Grid Architecture

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Abstract. The use of a semantic grid architecture can make easier the deployment of complex applications, in which several organizations are involved and diverse resources are shared. This paper presents the application of the architecture defined in the Ontogrid project (S-OGSA) into a scenario for the analysis of the quality of the products of satellite missions.

1. Introduction

In the last years, complex applications have arisen in multiple domains. Many of these applications have been solved by means of traditional techniques. Although these solutions are feasible, they are also error prone and difficult to implement.

In these scenarios, where a huge number of resources are shared and even several organizations are involved, the use of grid computing can help to deploy flexible solutions [5]. If there are complex interactions between all the components and participants of the applications, it is possible to take advantage of the use of a common vocabulary and conventions, which provide semantics and interoperability. The *"Quality Analysis of Satellite Missions (QUARC)"* use case of the Ontogrid project[1] is one example of this kind of scenarios, since the current operational system for the selected Satellite (EnviSat) has been developed through the use of traditional techniques. This use case is intended to improve the possibilities in the analysis of the

[1] www.ontogrid.net

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quality of the products for satellite missions, whose main goal is obtaining measures of the Earth observation. On the other hand, Ontogrid has as main goal the explicit sharing and deployment of *knowledge* to be used for the development of innovative Grid infrastructures and for Grid applications, that is, the *Semantic Grid*.

We consider that the use of a semantic grid architecture [2] for solving this use case can provide a large number of benefits.

This paper describes this use case and its adaptation to the semantic grid architecture developed in the Ontogrid project, S-OGSA [3].

2. QUARC Use Case Definition

Earth Observation can be defined as the science of getting data from our planet by placing in orbit a HW/SW element with several observation instruments and processing the scientific data obtained in order to get meaningful information (i.e. images).

In a nutshell and putting aside other aspects, basic working of an Earth Observation Satellite System consists on a simple process that is repeated over time. The instruments on board the satellite act like cameras that can be programmed (very complex cameras nevertheless), taking "pictures" (images) of specific parts of the Earth at predefined times. Parameters for taking this pictures (like any camera would need to operate) and also parameters for the satellite general configuration, constitute the information included in the Planning issued by the Mission Planning System (MPS), sent to the FOS (Flight Operation Segment), which also sends an equivalent information to a Ground Station (GSt) located, for the Envisat satellite, in Kiruna (Sweden) and from there to the satellite.

FOS converts the information in the Planning into the shape of MCMD´s. This means a translation from one format to another that is meaningful to the satellite. The Ground Station translates the MCMD information into a RadioFrequency link to communicate with the satellite antenna in the Service Module of the satellite. MCMD´s in a radiofrequency link are generically called TeleCommands, TC.

Computer on board the satellite will store the list of MCMD´s, each of them with a time tag that marks the execution time of that MCMD. Taking one "picture" would mean, for instance, the execution of a MCMD that copies those parameters for taking the picture, from the memory of the satellite computer to the instrument computer memory, and then the execution of the MCMD that triggers the camera shot.

Each MCMD is a command (constituted by different pieces of information) that asks an instrument or any other part of the satellite to perform an action (load a table or trigger an operation).

Some MCMD´s are also included by the FOS (in the whole bunch of MCMD´s sent to the Ground Station) in order to get information from the Satellite internal status and configuration at a particular moment. When this information is sent by the satellite to the Ground Station is called Telemetry (TM).

"Pictures" from each of the instruments are stored onboard (in the satellite computer memory) as a kind of raw data and when the satellite over-flies the Ground station that information is sent to the Ground Station antenna (Data downlink). In that

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Ground Station a preliminary conversion from raw data to a so called "Level 0" product is performed (basically adding a identification label to each of the pictures). These "Level 0" products are sent to the PDS (Payload Data Segment) that produce the Level 1b and Level 2 products that are made available to the final user community (scientist, environmental organizations, etc).

QUARC is a system that checks off-line the quality of the product instrument files. This process needs as input the product files, the MCMD and the mission planning, which other facilities provided to the system. QUARC returns reports and plots, which allows the operator to produce a new planning. Therefore, the QUARC system is designed to help to take decisions when an instrument or the whole system begins to malfunction and detect that something incorrect has occurred in one part of the data generation and circulation system. A more detailed explanation of the whole system is described in [4]. Figure 1 picture shows graphically the overall scenario:

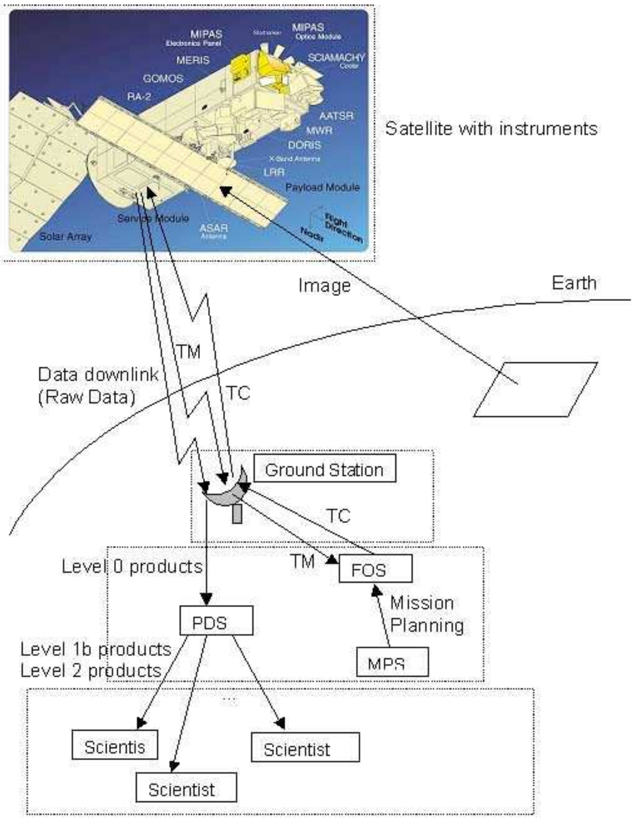

Figure 1 A general overview of the use case.

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3. A Grid Infrastructure for the QUARC process

The QUARC system involves a complex process in which distributed data belonging to different organizations must be queried, processed and transferred. These operations must be made by using suitable access control mechanisms.

Currently, the location of the resources and the processing of data are made in a *wired* way, according to filenames and content of these files in an “ad-hoc” format.
The use of a grid framework will provide a flexible way of locating required resources and the virtualization of these resources by means of (Semantic) Grid Services.

Besides, there is a need for managing lifetime of certain data resources linked to the used databases in the system, since there are database changes along the lifetime of the system.

A notification scheme can help in the Satellite Mission system due to the interactions between the processes of different organizations.

Regarding security, the involvement of several organizations implies the establishment of different access policies and the definition of virtual organizations. The role of each specific actor within an organization also defines its privileges as a member of the virtual organization.

4. Semantics in the QUARC process

Many resources used in this use case can benefit from metadata.

Annotation is needed to link file resources and their actual content meaning. Provenance information and temporal information (time stamp) of the processes should also be annotated (it can be done even automatically). The formal relationship between parameters of the satellite instruments should also be done (in this case in a manual fashion). These relationships should be established by means of axioms; therefore heavy weight ontologies are required and the WebODE Knowledge Representation ontology [1] will be used for that.

Figure 2 describes an example of the use of the components of the semantic grid architecture the files annotation for the first scenario:

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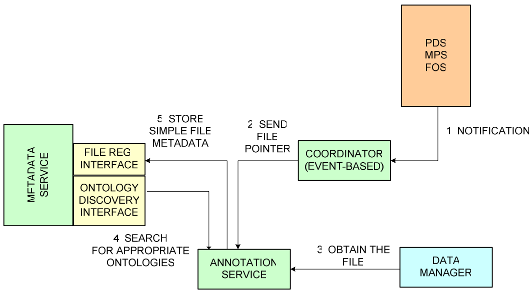

Figure 2 Components of the Semantic Grid Architecture involved in the files annotation scenario.

5. S-OGSA in the QUARC process

S-OGSA is the reference semantic grid architecture developed in Ontogrid. The most important elements of S-OGSA applied in the QUARC process are:

- Annotation Services, more precisely ODESGS and Grid-KP, in order to obtain the information through metadata associated to resources in the system.
- Workflow engine, in order to add new functionalities in the system without software updates.

Acknowledgements

This work has been partially financed by the Ontogrid Project (FP6-511513) and by a grant provided by the Comunidad Autónoma de Madrid (Autonomous Community of Madrid).

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