Sharing a conceptual model of grid resources and services

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Grid technologies aim at enabling a coordinated resource-sharing and problem-solving capabilities over local and wide area networks and span locations, organizations, machine architectures and software boundaries. The heterogeneity of involved resources and the need for interoperability among different grid middlewares require the sharing of a common information model. Abstractions of different flavors of resources and services and conceptual schemas of domain specific entities require a collaboration effort in order to enable a coherent information services cooperation.
With this paper, we present the result of our experience in grid resources and services modelling carried out within the Grid Laboratory Uniform Environment (GLUE) effort, a joint US and EU High Energy Physics projects collaboration towards grid interoperability. The first implementation-neutral agreement on services such as batch computing and storage manager, resources such as the hierarchy cluster, sub-cluster, host and the storage library are presented. Design guidelines and operational results are depicted together with open issues and future evolutions.

1. INTRODUCTION

Grid technologies aim at enabling a coordinated resource-sharing and problem-solving capabilities over local and wide area networks and span locations, organizations, machine architectures and software boundaries. The heterogeneity of involved resources and the need for interoperability among different grid middleware solutions require the sharing of a common information model in order to enable both intra- and inter-grid resources awareness.

The research area of computing in High Energy and Nuclear Physics (HENP) is populated by several Grid related projects that mostly rely on basic services provided by the Globus Toolkit [9] and the Condor Project [23]. Due to the large adoption of the provided functionalities, interoperability issues are mostly related to what is built on top of these components. For the purpose of enabling HENP Grid middlewares interoperability, the Grid Laboratory Uniform Environment (GLUE) collaboration [1], a joint US and EU High Energy Physics projects effort, has been set up.

One of the main achievements of this collaboration has been carried out in the context of the GLUE Schema activity. The main purpose was to define a common resource information model to be used as a base for Grid Information Service (GIS) for both resource discovery and monitoring activities. Starting from the Globus MDS schema [12] and the EU DataGrid (EDG) schema, the first implementation-neutral agreement on services (such as batch computing and storage managers) and systems (such as the hierarchy cluster, sub-cluster, host and the storage library) has been defined [13]. The EU DataTAG (EDT) project [4] has contributed in the collection of requirements from several projects (mainly EDG) and has developed both the implementation-neutral description by means of Unified Modeling Language (UML) [3] class diagram and schema implementation for the LDAP data model [17].

In this paper, we recall the outcomes of the collaboration to which we have participated, and we also suggest refinements and improvements based on our experience related to both analysis, implementation and deployment within EDG [5], EDT [4] and LCG [6] testbeds.

We present the involved entities categorized into two main categories:

- System: a set of connected items or devices which operate together as a functional whole.
- Service: actions that form a coherent whole from the point of view of service providers and service requesters.

From the viewpoint of discovery and monitoring, the distinction between systems and services is fundamental, since even though they are strongly related (systems provide services), they have different lifecycle and different status related attributes. The main focus was on the service level in order to enable an efficient service selection. Recently, within the DataTAG project, extensions for the host system have been done in order to improve monitoring capabilities.

This paper is organized as follow: in section 2 we describe entities within the system category, while in section 3 services are discussed. In both cases, defined concepts are recalled and feedback from our deployment experience is described. In section 4, the implementation results are presented, while in section 5 related works are mentioned and compared to the GLUE

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Schema. Finally, in section 6 conclusions and plans for future work are depicted.

2. Modelling systems

As mentioned in the introduction, a system is here defined as a set of connected items or devices which operate together as a functional whole. Within the GLUE Schema, two main systems categories have been defined: cluster systems providing computing services, and storage systems providing storage spaces.

2.1. Cluster Systems

A cluster is essentially a container that groups together computing nodes (hosts), such as a computing farm. Since in the context of computing in HENP, a cluster is composed by many nodes, in order to avoid poor performance in the resource discovery process, the concept of subcluster was introduced. A subcluster represents 'homogeneous' collection of computing nodes, where the homogeneity is defined by a collection whose some node attributes (which can be freely selected among the ones defined for the single node entity) all have the same value. For example, a subcluster could represent a set of nodes with the same architecture, operating system, CPU model, etc. It must be stressed that the elements of a subcluster are homegeneous only with respect to the considered chosen attributes. Subclusters therefore provide a convenient way of representing collection of nodes, useful in the resource discovery process. The host (computing node) element represents detailed information (related to both hardware and software) of a specific node.

In summary, a cluster is a set of nodes, and nodes can be partitioned in disjointed sets called subclusters, for which a summary description is available.

From our point of view, the cluster definition should be refined enforcing the property of being a system. This implies that some functionality is provided. In the cluster case, the provided functionality is the ability of executing jobs. Therefore, all nodes managed by the same batch system, form a unique cluster.

2.2. Storage Systems

In a Grid environment, storage systems can vary in complexity from a single disk server to hierarchical massive storage systems. Within the first phase of the GLUE Schema activity, the main goal was mainly oriented towards the service component modelling (see section 3.2), more than the system component. The modelled storage system is called Storage Library and represents the machine providing for the storage manager service. This entity presents the file system component offered to the service, an architecture component and a performance component.

Our opinion is that this concept should be refined. As is for the cluster system, a storage system should allow the representation of all entity participating in the service.

3. Modelling services

A service can be defined as an activity that performs some task. Within core grid services, the computing service and the storage manager service have been defined. Each modelled service has a unique identifier, a human-readable name, a set of policies, a set of access rights and a state.

Referring to the access rights, one of the main design guideline was to move from the current practice of user-grained access right to the virtual organization-grained one. This approach is beneficial for the activity of authorization management in a distributed environment such as the Grid. The idea is that virtual organizations set up agreements with service providers. When a service is requested by a user, both his membership and his capabilities are verified using organization-based authorization services. Considering this approach, local resources can therefore avoid to maintain and publish the list of authorized user identities. The two main proposals in this area are the Virtual Organization Membership Service (VOMS) [19] developed in the context of the EDG-EDT collaboration, and the Community Authorization Service (CAS) [22] developed by the Globus Project.

3.1. Computing Service

As computing service, we identify a service able to provide computing power to an application with a certain quality. Within the GLUE Schema, the modelled service is called Computing Element (CE) and it is a one-to-one mapping to an entry point into a batch queueing system. Essentially a Computing Element represents a queue of a local resource management system, such as PBS or LSF. Since it is a service, it presents policy, state and access rights attributes.

The CE concept was already present in the EDG Schema. With the GLUE Schema the separation between system and service related info was introduced.

In order to be able to perform a proper service selection, during the matchmaking process some data related to the system providing the service is needed (e.g. hosting operating system, available software packages). Moreover, the desired data should be provided as an aggregate description of the system part that can participate in the service functionality (e.g. in a cluster, only a subset of nodes can be assigned to a computing service). Such flexibility is not well modelled at present.

3.2. Storage Manager Service

With Storage service we identify a service which task is the management of storage extents. With Storage Space, we identify a storage extent managed under a uniform set of policies and having the same access rights. Stored files can be accessed by means of Data Access Protocols (e.g. GridFTP, rfio).

Currently, the Storage Service has been modelled as a generalization of:

- trivial file system
- Storage Resource Manager (SRM) [15]
- EDG Storage Element (SE) [20]

Current practice shows that there is lack of some information. For instance, a Storage Space is lacking of ownership info and of a unique ID, possibly in the form of a URI.

4. Implementations

Currently, the implementation-neutral description of the GLUE Schema has been mapped into three different data models:

- LDAP data model [17]
- Relational data model [21]
- XML data model [18]

The LDAP implementation has been done within the DataTAG project and covers the full schema. The testing phase has been carried out within the DataTAG testbed based on the EU DataGrid middleware (release 1.4.x with Globus MDS 2.x). Strong support has been given for the rewriting of both information providers and EDG Broker interaction with the MDS. The schema implementation is going to be deployed as the base schema in the next release of EDG, LCG and VDT grid middlewares. This has been also contributed by INFN [10] to the Globus Project under the signed Globus Contributor's License.

The Relational implementation has been developed by DataGrid WP3 in the R-GMA [11].

The XML implementation has been developed by the Globus Project in Globus Toolkit 3.0 (at present, only cluster system and computing element).

5. Related work

The first resource information model introduced within the HENP Grid community was the one coming with the Globus MDS. This was mainly oriented at modelling computer systems and lacked in capabilities of modelling grid services. Conversely, the former DataGrid schema was mainly oriented at creating abstractions for grid services. While this presented new concepts useful for discovery and matchmaking purposes, it did not clearly separates systems from services.

Another work to mention is the NorduGrid information model [16]. The distinguish feature is the User entity, modelled in order to provide per-user information, such as available storage space and processors. This is a different approach than the one taken within the GLUE Schema, where general authorization rules are on a per-organization base.

It is important to mention also the outcomes of the ongoing activities of the CIM Grid Schema Working Group of the Global Grid Forum (GGF CGS-WG) [24]. The considered approach is not only targeted at discovery and monitoring purposes, but also at the more complex task of resource management. The chosen strategy is to extend the industry standard Common Information Model (CIM) [8]. While this approach provides detailed resource description and relationship, it needs special framework in order to offer the management interface. For the purpose of distributed discovery, it needs to be interfaced with the Grid Information Service. Due to the wider spectrum of goals envisioned by CIM, the information model is more complex.

6. Conclusions and future work

In this paper we presented the results and the outcomes of the GLUE Schema activity. Besides presenting the modelled entities, both at the system and at the service level, the current shortcomings and some ideas to address them have also been described.

In the next future the focus will be on the the refinement of both subcluster and storage library entities. We also envision the evolution of the current proposal in order to model a general ancestor service. Moreover, attention will be given to monitoring requirements.

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References

[1] "The Grid Laboratory Uniform Environement (GLUE)", http://www.hicb.org/glue/glue.htm.

[2] "Distributed Management Task Force", http://www.dmtf.org/.

[3] "Uniform Modeling Language", http://www.omg.org/uml.

[4] "The DataTAG Project", http://www.datatag.org.

[5] "The DataGrid Project", http://www.datagrid.org.

[6] "The LHC Computing Grid Project", http://www.cern.ch/lcg.

[7] "The NorduGrid Projejct", http://www.nordugrid.org.

[8] "Common Information Model", http://www.dmtf.org/standards/standard_cim.php.

[9] "The Globus Toolkit", http://www.globus.org/toolkit/.

[10] "Istituto Nazionale di Fisica Nucleare", http://www.infn.it.

[11] S. Fisher *et Al.*," R-GMA: First results after deployment", Proceedings of the International Conference for Computing in High Energy and Nuclear Physics (CHEP 2003).

[12] "The MDS 2.x schema", http://www.globus.org/mds/Schema.html.

[13] "GLUE Schema documents", http://www.cnaf.infn.it/∼sergio/ datatag/glue/index.htm.

[14] K. Czajkowski, S. Fitzgerald, I. Foster, C. Kesselman. "Grid Information Services for Distributed Resource Sharing", Proceedings of the Tenth IEEE International Symposium on High-Performance Distributed Computing (HPDC-10), IEEE Press, August 2001.

[15] A. Shoshani, "Storage Resource Managers: Why They Are Important to Data Grid Architecture", White paper, 2001.

[16] B.Kónya, "The NorduGrid information system", 16/09/2002.

[17] S. Andreozzi, "GLUE Schema implementation for the LDAP model", Draft, 29/05/2003.

[18] The Globus Project, "GLUE Schema implementation for the XML data model", Draft, 29/05/2003.

[19] R. Alfieri, R. Cecchini, V, Ciaschini, L. dell'Agnello, A. Frohner, A. Gianoli, K. Lőrentey and F. Spataro, "An Authorization System for Virtual Organization", 1st European Across Grids Conference, 13-14 Feb 2003.

[20] J.C. Gordon *et Al.*, "Architecture and Design for Mass Storage Management", DataGrid-05-D5.2-0141-3-4, 2002.

[21] EU DataGrid WP3, "GLUE Schema implementation for the relational data model", http://hepunx.rl.ac.uk/edg/wp3/ documentation/doc/schemas/.

[22] L. Pearlman, V. Welch, I. Foster, C. Kesselman and S. Tuecke, "A Community Authorization Service for Group Collaboration", IEEE Workshop on Policies for Distributed Systems and Networks, 2002.

[23] "The Condor Project", http://www.cs.wisc.edu/condor/.

[24] E. Stokes, L. Flon, "Job Submission Information Model", GGF Proposed Standard, 11 Jun 2003.