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Enhancing a National Academic Computing Infrastructure with e-Contracting Capabilities

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Abstract: Closing ranks between industrial and academic distributed systems R&D has been and is on the agenda of many projects and initiatives. But although state-of-the-art service-oriented architectures and infrastructures are developed and deployed by both industry and academia, the services required and the service quality expected and provided differ significantly. Opening its mostly academically used Grid infrastructure to industry is an important objective of the D-Grid initiative. The SLA4D-Grid project is contributing to that goal by engineering a Service Level Agreement management layer on top of the existing infrastructure, providing e-Contracting capabilities to a large variety of industrial and academic customers. This layer will allow service providers and consumers to reliably and dependably build their business models upon it. This paper describes the aims of the SLA4D-Grid project, summarizes its developments, and shows how business use cases can benefit from an academic infrastructure enhanced with e-Contracting capabilities.

1. Introduction

Numerous national, European and global efforts in the area of Distributed Computing, Grids and Clouds bring together academic and industrial research to produce the building blocks for e-Business infrastructures. Despite those efforts, geographically distributed production deployments which are able to serve user scenarios ranging from small commercial ad hoc service requests to long-running scientific codes with demand for special-purpose hardware and software are not yet reality: the vision of a ubiquitous multi-purpose computing infrastructure is still to be realized.

The purpose of D-Grid[i], the German national Grid initiative, is to provide a nation-wide Grid infrastructure serving as many application areas as possible. Currently, the resource providers are mainly academic, whereas the user base is heterogeneous comprising scientific communities like high-energy physics, but also financial service and content providers. A number of service-oriented, community-specific solutions for e-Business within D-Grid already exist, but the means to execute ad hoc service requests, support dynamic markets or enable business models like those supported by large Cloud providers are missing.

To overcome those limitations and evolve D-Grid towards a sustainable e-Business infrastructure, the German Ministry for Education and Research (BMBF) supports an effort to specify, implement and deploy an SLA-based service stack for e-Contracting [1] within D-Grid[ii]. This service stack will provide generic means for existing and new business cases to allow providers and customers to conduct business based on clearly specified service offers and requirements. The e-Contracting framework will be integrated into the existing infrastructure to support the existing academic scenarios, but its major benefit is the support for companies, and especially SMEs, to offer their products via the D-Grid infrastructure in a reliable and commercially viable manner. To this end, it has been decided to build upon the existing D-Grid operational concepts[iii] which define a number of policies for membership in Virtual Organisations, for resource usage and for resource provisioning. Those policies provide a framework contract for providers and customers in D-Grid and can serve as the legal foundation of electronically negotiated contracts. Extending the operational concepts by defining the policies which regulate the use of SLAs within D-Grid allows the introduction of electronic contracts on an operational level while following well-established policies.

In this contribution we describe in detail the objectives of the e-Contracting solution and outline the methodologies applied to achieve those objectives. We then introduce a business case featuring a geographical data processing infrastructure, and describe both the technologies used and developments planned to realize the e-Business infrastructure and to integrate the business use case. We conclude our contribution outlining the results and business benefits we expect to achieve.

2. Objectives

The primary goal of the SLA-based service stack for D-Grid is the provision of models, processes and services to support electronic business cases on an existing nation-wide Grid infrastructure that is currently dominated by academic resource providers. To achieve this goal, we pursue a number of secondary objectives.

From a business perspective, the SLA-enhanced D-Grid has the objective to ensure that customers obtain guarantees regarding the quality of service and providers have a reliable basis for realizing their business cases. Such an infrastructure provides a breeding ground for new business models and a cost-effective yet reliable way for SMEs to offer services and added functionality, like, e.g., enhanced planning.

From a technical perspective, the objective is to specify and implement a generic D-Grid SLA model that can be extended to support domain-specific requirements. Since D-Grid has a large variety of communities and plans to further extend its community base, one single fixed SLA model is not sufficient. To actually execute e-Contracting based on this model, the current infrastructure has to be customized and extended. The objective here is to extend the existing services with SLA support, add new services for, e.g., SLA monitoring or SLA-based planning, and offer uniform user and programming interfaces. Furthermore, existing, proprietary solutions that support single communities and the respective requirements need to be taken into account, like for example those provided by the financial Grid community FinGrid [2].

Last but not least, it is our objective to exploit existing European results and integrate those suitable into the service stack. The authors have experience from projects such as BREIN [3], NextGRID [4] and SLA@SOI [5], some of which also released open source service implementations that are of potential interest to our development.

3. Methodology

Methodologically, we gather business-related requirements from various industrial and academic application domains and derive the generic D-Grid SLA model from those requirements. To achieve this, existing D-Grid communities as well as companies like SAP, Sun and NEC contribute their experience at dedicated workshops. These workshops allow the SLA "modelers" and the business stakeholders to synchronize and iterate the D-Grid SLA model. The generic model is then extended with domain-specific requirements from two business cases, one from a leading global Infrastructure-as-a-Service (IaaS) provider and one from an SME (cf. Section 4).

The two aforementioned business cases will be fully implemented and deployed on the D-Grid production infrastructure to validate the SLA model and services, which, if necessary, will be iteratively refined. This will provide the necessary knowledge to deliver best practice examples for other user communities and future business cases.

The architecture of the SLA management layer will be designed in a way that makes it independent of particular Grid middleware. This is an important requirement as the D-Grid infrastructure consists of no less than three different middleware realizations, as further elaborated in Section 5. The SLA infrastructure therefore needs to abstract from the middleware interfaces and focus on shared functionality instead (i.e. focus on "what" rather than "how"). The SLA layer will be implemented following a service-oriented approach. Functionality will be realized as independent and loosely coupled services. The integration with particular D-Grid middleware is realized via specific lightweight adaptors.

4. The Business Cases

As business cases we have selected a storage-on-demand scenario from a global industrial player and a geographical data infrastructure scenario supported by an SME [6]. Through them, two different yet complementing evaluations of the SLA service stack guarantee that the foundations for a maximum of upcoming uses cases are laid. In this paper we have selected, due to space limitations, the geographical data infrastructure business case. An overview is given in this section, while technologies used, results and benefits from porting the case to the D-Grid SLA service layer are described in the subsequent sections.

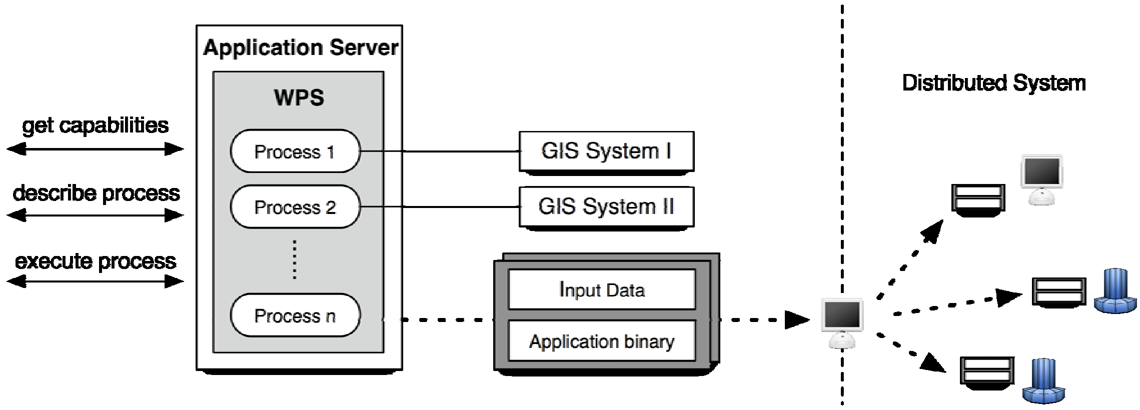

Figure 1: An architectural overview of the Web Processing Service [6]

As shown in Figure 1, a Web Processing Service (WPS), implemented according to the Open Geospatial Consortium's[iv] WPS specification, offers a number of processes to end users while itself using other legacy Geo Information Systems (GISs) or third-party libraries. For executing a process, the respective input data together with the application binary is transferred via a gateway to the distributed system where the process is executed in parallel on a number of nodes. Once finished, the WPS fetches all results, concatenates them, and sends them to the end user.

Within the SLA4D-Grid project, the existing geographical data infrastructure will be extended with SLA capabilities and integrated with the D-Grid SLA service stack. Through this integration it is possible for users and providers of geospatial data and processing services to negotiate and agree on quality of service parameters. This is especially necessary to offer customers reliable services and guaranteed processing times.

5. Technology Description

The basic service stack D-Grid is operating on is based on three different middleware products which are equally supported: gLite[v], Globus[vi] and UNICORE http://www.unicore.eu[vii]. Those are complemented by a number of core services required for most usage scenarios, including data management, monitoring and VO management. The middleware is deployed on a large number of resources that are spread across Germany. Links to trans-national systems are provided through various partners.

To enable this basic service stack with Service Level Agreements, we rely on standards, existing results from European research projects like BEinGRID, BREIN and NextGRID, national German projects like FinGrid and InGRID, and open source service implementations for SLA registries, SLA negotiation and SLA-based resource planning. Those technologies are complemented by D-Grid specific extensions and service customizations to enable a maximum of business usage scenarios. The SLA stack is designed following service-oriented principles, realized through Web Services and implemented in Java.

The foundation of the SLA layer is a generic D-Grid Service Level Agreement based on the WS-Agreement standard [7]. This generic SLA is specified taking the requirements from multiple heterogeneous user groups into account. Based on this generic SLA domain-specific ones are developed, like, for example, for the aforementioned business use case.

6. Developments

The SLA4D-Grid project is designing and implementing an SLA management layer. The functions of the developments cover the complete SLA lifecycle, including SLA design, contract establishment, SLA provisioning, and SLA monitoring [8]. As mentioned before, the SLA management layer is an add-on to the existing D-Grid infrastructure. It therefore has to interoperate seamlessly with the given infrastructure. A general overview of the architectural location of the new layer is shown in Figure 2.

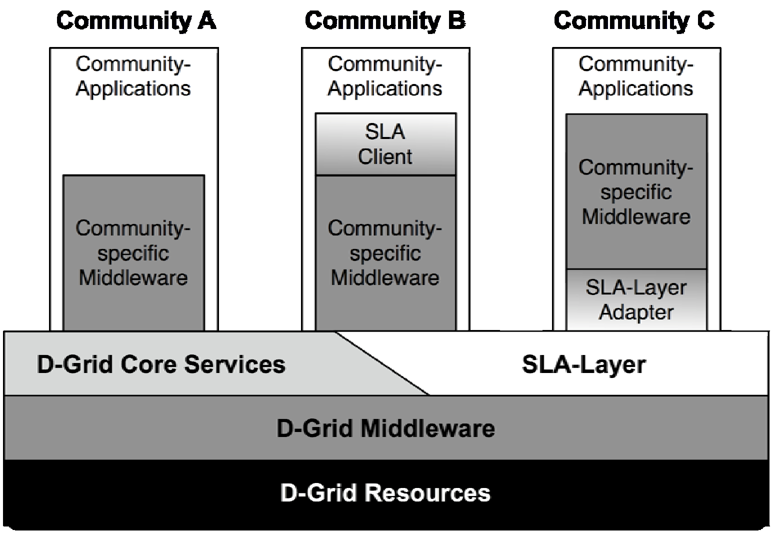

Figure 2: D-Grid plus SLA layer architecture overview

As shown through the example of Community A, the complete functionality of the existing infrastructure is still available to client applications. Existing applications and those not needing enhanced SLA features can therefore continue to operate unchanged. The introduction of the SLA management layer is therefore transparent to those applications. Applications and users that want to make use of the new SLA features can use them in two ways. First, there will be a separate SLA client that allows the establishment of SLAs independent of the application that will later on make use of the negotiated SLAs. Second, applications can use a dedicated application programming interface (API) that provides access to the functions of the SLA management layer. Regarding the geographical data processing infrastructure, for example, the API will be exploited to achieve reliable and assessable Quality of Service (QoS) guarantees like maximum response time or potential indemnities for undelivered services.

The developments consist of two different kinds of artefacts. On the one hand, there are models and definitions for the actual Service Level Agreements. On the other hand there are components constituting the SLA layer. The SLA models and definitions are informed by the two business use cases that the SLA4D-Grid project is realizing. In addition, workshops with other potential SLA users will be held in order to avoid solutions that are restricted to the two use cases. Instead, the developed solutions must be easily amenable to other domains and use cases. The exchange with other user domains is expected to help in this respect.

The main output of the development of SLA models and definitions are term definitions and sample SLAs. Term definitions allow the unambiguous specification of particular quality of service aspects in SLAs. There will be generic terms that are to be used in various application domains, including terms about payments, penalties, etc. On the other hand, terms specific to the addressed application domains will be specified. Although these can be re-used in other environments as well, their applicability is more restricted than that of the generic terms.

Sample SLAs will be developed in the form of SLA templates. SLA templates are SLAs with a few fields kept open. SLA templates are used as the basis for negotiation and can be seen as proposals for actual SLAs. The open fields will be filled in during negotiation resulting in an actual SLA. SLA templates can also serve as best-practice examples for its intended as well as other domains.

The functions offered by the SLA management layer are as described in the following. They are realized as either services accessible via Web Services interfaces or as components that are linked to applications locally.

The *SLA negotiation components* (*Negotiation Service, SLA Template Factory and SLA Template Storage*) facilitate the negotiation and establishment of Service Level Agreements for both the service customer and the service provider. They are guided by the requirements of their users and shield the applications from the peculiarities of the actual negotiation process used.

SLA4D-Grid will provide *SLA Discovery* functions to discover services based on QoS requirements and SLA templates. We expect these to be realized via registry services and components that facilitate interacting with registries, including simplified registration of services and SLA templates as well as facilitated query processing.

SLA Provisioning components automatically translate terms in SLAs to appropriate system and monitoring configurations and resource reservations. The translations will be implemented prototypically for the two selected use cases. Whether the quality provided actually matches the consumer's requirements is monitored by *SLA-specific Monitoring* services.

Except for trivial cases, workflows make use of multiple services, potentially provided by multiple providers. A workflow with overall QoS requirements therefore needs to have QoS guarantees for the individual steps of the workflow. Some of the steps might be executed most efficiently if allocated to the same service provider. An *Orchestration*

Service will therefore be implemented which allows for the establishment of multiple SLAs and which can deal with co-allocation of tasks.

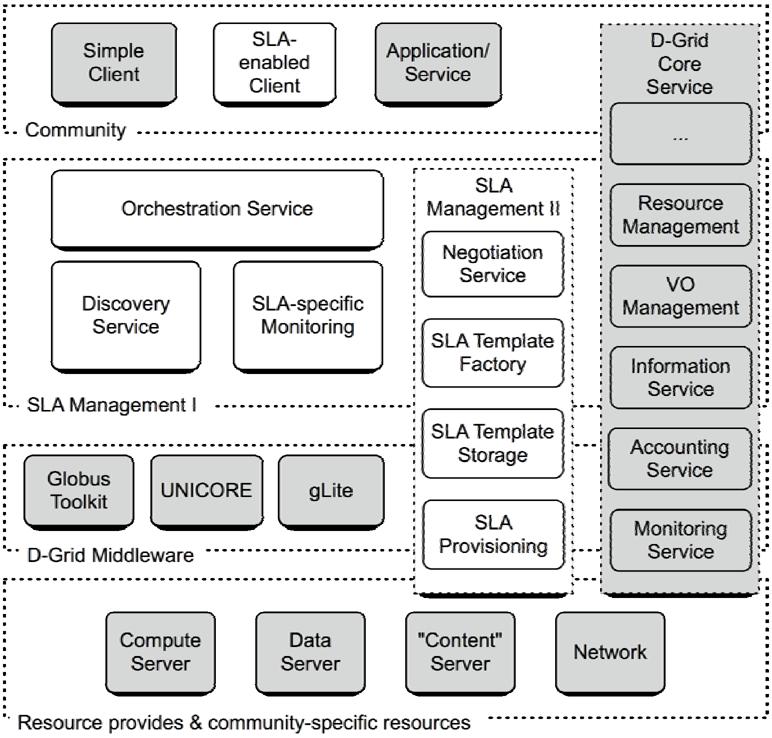

Figure 3: SLA Management integrated into the D-Grid Infrastructure

7. Results

The SLA4D-Grid project will provide six main results:

1. An SLA service layer integrated into the existing D-Grid infrastructure as depicted in Figure 3. To achieve this, the developments described in Section 6 will be integrated with community services, D-Grid core services, the middleware, and management services residing on the resource level.
2. A D-Grid generic Service Level Agreement formalization and two instantiations of this SLA based on the two business cases (as described in Section 3). Those results will be fed back to the Open Grid Forum hosting the WS-Agreement specification group GRAAP[viii].
3. Two business use cases using the SLA service layer as early adopters. Parts of the software resulting from the geo-data business case will be contributed to the open source software repository 52° North[ix] and findings from the project will be contributed to the Open Geospatial Consortium’s standardisation efforts.
4. Best practices guiding application and client developers through the process of integrating e-Contracting capabilities into their services and realizing the required steps of the SLA lifecycle for their products.
5. Contributions to the community at-large regarding SLA models and protocols. Especially the ongoing research on SLA negotiation protocols [9] will benefit from the broad requirements set and the large variety of communities.
6. Contributions to the community at-large regarding the transformation of a mainly academic Grid infrastructure into an e-Business platform. The experiences and solutions are expected to be applicable to other national Grid infrastructures both technically and administratively. Technically, as a broad range of Grid middleware

stacks is supported; administratively, as many national Grid infrastructures are expected to look for a sustainable business model.

8. Business Benefits

The introduction of Service Level Agreements for service interactions creates benefits for both service consumers and service providers. Besides the well-known advantages of on-demand outsourcing, including reduced OPEX and CAPEX for service users and increased revenue for providers, there are SLA-specific benefits. SLAs give service consumers guarantees on service quality, including technical parameters needed to get their work done, as well as non-technical ones like the price and observance of regulatory issues. These guarantees give consumers a solid basis to build their business on. The establishment of penalties in case of quality violations gives consumers a form of insurance against the ensuing loss of revenue.

Service providers can use SLAs to better predict service usage and thereby optimize resource allocation and utilization. Prices of service access can be changed according to (future) service demand which can on one hand increase revenue (due to increased prices for high-demand services and during high-demand periods) and on the other even out load over time (due to shifting non-urgent service requests to cheaper low-load times) [10].

Taken together SLAs foster the creation of a decentralized marketplace for services. Such a marketplace not only enables companies to outsource parts of their value creation chain to external services, but also allows them to dynamically replace service providers in order to adjust for varying service demand, to increase reliability, and to decrease costs. In such a marketplace, service prices fluctuate with service demand likely leading to an efficient market with competitive prices for consumers and optimal resource usage with increased revenue for service providers.

Besides providing the benefits of market mechanisms to participants, the introduction of e-Contracting can also be of direct benefit the society as a whole. In the case of the described geo-data use case, benefits can be discovered throughout the whole range of geo-data exchange, analysis and simulation. Resources can be easily and reliably assigned to disaster recovery applications. SLAs granting highest access priority to the offered resources can be established a priori or on demand, granting benefits for the whole German society in situations where, for example, the containment of a flood is of highest priority.

9. Conclusions

The e-Contracting environment for the German D-Grid infrastructure will provide essential capabilities for the transition from an infrastructure with a majority of academic stakeholders towards an e-Business platform for the exchange of electronic services. The introduction of Service Level Agreements, supporting services and best practices will enhance reliability of services, ease the automation of process execution and last but not least strengthen the German IT landscape. We expect that the experiences and solutions of the SLA4D-Grid project will be beneficial to other national Grid infrastructures as well as they undergo the same transformation into a business-oriented utility. Although the ubiquitous multi-purpose infrastructure mentioned in the beginning will still be a vision, the e-Contracting solution will provide an essential building block for realizing that vision.

References

[1] Angelov, S. and Grefen, P., The business case for B2B e-contracting, In: Proceedings of the 6th international Conference on Electronic Commerce (ICEC '04), M. Janssen, H. G. Sol, and R. W. Wagenaar (eds.), vol. 60. ACM, New York, NY, 2004, pages 31-40. DOI: 10.1145/1052220.1052225.

[2] Vykoukal, J., Wolf, M. and Beck, R., Services Grids in Industry - On-Demand Provisioning and Allocation of Grid-based Business Services, In: Business & Information Systems Engineering, 1(2), 2009, pages 177-184.
[3] Hasselmeyer, P., Wieder, P., Koller, B. and Schubert, L., Added Value for Business through eContract Negotiation, In: Collaboration and the Knowledge Economy: Issues, Applications, Case Studies (Proceedings of the eChallenges Conference 2008), Cunningham, P. and Cunningham, M. (eds.), IOS Press, Amsterdam, NL, 2008. ISBN 978-1-58603-924-0.
[4] Mersch, H., Wieder, P., Koller, B., Murphy, G., Perrot, R., Donachy, P. and Anjomshoaa, A., Improving Business Opportunities of Financial Service Providers through Service Level Agreements Grid Middleware and Services, In: Challenges and Solutions, Talia, D., Yahyapour, R. and Ziegler, W. (eds.), Springer US, 2008, pages 397-407.
[5] Theilmann, W., Yahyapour, R. and Butler, J., Multi-level SLA Management for Service-Oriented Infrastructures, In: Towards a Service-Based Internet, Lecture Notes in Computer Science, Vol. 5377, Springer Berlin / Heidelberg, 2008, pages 324-335. DOI: 10.1007/978-3-540-89897-9_28.
[6] Baranski, B., Grid Computing Enabled Web Processing Service, In: Proceedings of the GI-Days 2008, 2008. Available online (last accessed 07/2009): http://www.gi-tage.de/archive/2008/downloads/acceptedPapers/Papers/Baranski.pdf.
[7] Andrieux, A., Czajkowski, K., Dan, A., Keahey, K., Ludwig, H., Nakata, T., Pruyne, J., Rofrano, J., Tuecke, S. and Xu, M., Web Services Agreement Specification, Grid Forum Document, GFD.107, Open Grid Forum, May 2007.
[8] The TeleManagement Forum, SLA Management Handbook, Volume 2, Concepts and Principles, Release 2.5, The TeleManagement Forum, Morristown, New Jersey, United States, 2005.
[9] Demirkan, H., Goul, M. and Soper, D. S., Service Level Agreement Negotiation: A Theory-based Exploratory Study as a Starting Point for Identifying Negotiation Support System Requirements, In: Hawaii International Conference on System Sciences (Proceedings of the 38th Annual Hawaii International Conference on System Sciences (HICSS'05)), Vol. 1, 2005, pages 37b.
[10] Hasselmeyer, P., Koller, B., Kotsiopoulos, I., Kuo, D. and Parkin, M., Negotiating SLAs with Dynamic Pricing Policies, In: Service Oriented Computing: a Look at the Inside (SOC@Inside'07), Vienna, Austria, September 2007, pages 28-32.

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[i] http://www.d-grid.de/index.php?id=1&L=1
[ii] http://www.sla4d-grid.de/
[iii] http://www.d-grid.de/uploads/media/D-Grid-Betriebskonzept.pdf (in German)
[iv] http://www.opengeospatial.org/
[v] http://glite.web.cern.ch/glite/
[vi] http://globus.org/
[vii] http://www.unicore.eu/
[viii] http://forge.gridforum.org/sf/projects/graap-wg
[ix] http://52north.org/