– Grid Computing –

Comparison of Grid Accounting Concepts for D-Grid

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1. Introduction

- D-Grid project, started on 1 September, 2005.
- URL: http://www.d-grid.de
- The project is supported by the German Federal Ministry for Education and Research (BMBF).
- For the results presented in this paper the work of the section "Accounting" (part of "Monitoring", "Accounting", and "Billing") within the D-Grid Integration project (DGI) has been used, based on the experiences of the institutions participating in this section.

As the meaning of the terms accounting and billing is not sharply delimited with respect to Grid Computing the following conventions may be helpful:

- *Accounting* means gathering, management, and reporting of information belonging to usage of resources. The most important aims are optimisation and journaling of resource usage.
- *Billing* means calculation of certain quantities of resource usage on various economic foci. With appropriate basic implementations billing can extend accounting for this purpose. This way billing can be used for payoff either. Terms like pricing and charging belong to billing but in current prototypical implementations reside between billing and accounting.

Obective: The major aim of "Accounting" in D-Grid is the design of a substantial D-Grid-wide system for resource surveillance, user and resource management, and usage compensation.

2. Accounting/Billing

- **The sections Monitoring, Accounting, and Billing in the ongoing project develop the first overall concepts for implementing an universe monitoring/accounting/billing system for Grid Computing in heterogeneous environments, community spanned, and complex federal state background.**
- This document refers to a concise presentation of the advantages and disadvantages of the existing accounting systems and tools, that have been described for D-Grid in detail [GR2006a] and is based on an evaluation (D-Grid document [RG2006b], [Rüc2006a] [Rüc2006b]).
- For the evaluation of pro and contra a large number of descriptions of the accounting/billing systems and tools internationally available have been taken into 'account', many of them discussed and cited in [GR2006a].
- The results given in these documents have been the fundament for the D-Grid billing framework [FMM2006] and the conception of the accounting architecture for D-Grid [RG2006c].
- Foundations for evaluation are
  - the requirements derived from the requirements catalogue [GR2006b] worked out in section "Accounting" (Monitoring, Accounting, and Billing, D-Grid Integration project) and
  - the analysis of the results of the comprehensive survey done in the years 2005/2006 [Rüc2006c] [RMR+2005] regarding to the requirements of the Community Grids and Grid Resource Providers [RG2006a] in the D-Grid.
- Further work is currently done for specifying the conception of the accounting system for D-Grid [GR2006c].

3. Approaches evaluated

(The following approaches have been sorted alphabetically by name.)

- Accounting Processor for Event Logs (APEL).
- Distributed Grid Accounting System (DGAS).
- Grid Accounting Services Architecture (GASA).
- Grid Based Application Service Provision (GRASP).
- Grid Service Accounting Extensions (GSAX).
- Nimrod/G.
- SweGrid Accounting System (SGAS).

4. Overview

Criterion/Category	*System/Tool*						
	APEL	*DGAS*	*GASA*	*GRASP*	*GSAX*	*Nimrod/G*	*SGAS*
Interoperability/portability	(✓)	(✓)	(✓)	n. g.	(✓)	✓	✓
Scalability	✓	(✓)	–	n. g.	✓	✓	✓
Integrability	(✓)	(✓)	(✓)	n. g.	(✓)	✓	✓
Beyond a community	✓	✓	✓	n. g.	✓	n. g.	✓
Flexibility/extendability	✓	n. g.	✓	n. g.	✓	(✓)	✓
Supporting standards	–	–	(✓)	(✓)	(✓)	n. g.	✓
Customise	✓	–	–	n. g.	n. g.	n. g.	–
Transparency	n. g.	n. g.	n. g.	n. g.	n. g.	n. g.	(✓)
Accounting heterogeneous res.	(✓)	✓	✓	(✓)	n. g.	n. g.	–
Accounting virtual resources	n. g.	n. g.	n. g.	n. g.	n. g.	n. g.	n. g.
Support for high dynamics	✓	(✓)	(✓)	n. g.	n. g.	✓	✓
Security	n. g.	✓	✓	n. g.	✓	n. g.	✓
Uniform, generic interfaces	–	–	–	n. g.	(✓)	✓	(✓)
Support for various metrics	✓	✓	✓	n. g.	✓	n. g.	–
Precision	✓	✓	✓	✓	✓	n. g.	✓
Support var. acc. policies	✓	✓	n. g.	n. g.	✓	n. g.	(✓)
Fault tolerance	n. g.	n. g.	(✓)	n. g.	n. g.	n. g.	✓
Administration/maintainability	n. g.	(✓)	n. g.	n. g.	n. g.	n. g.	✓
Verification	n. g.	✓	✓	n. g.	n. g.	✓	✓

Tab. 1: Overview regarding compliance with the criteria categories for accounting systems and tools. Legend: ✓ "Yes", (✓) "Conditional", – "No", n. g. "Not given" / "Not specified".

5. Compliance with criteria (“Yes”-number)

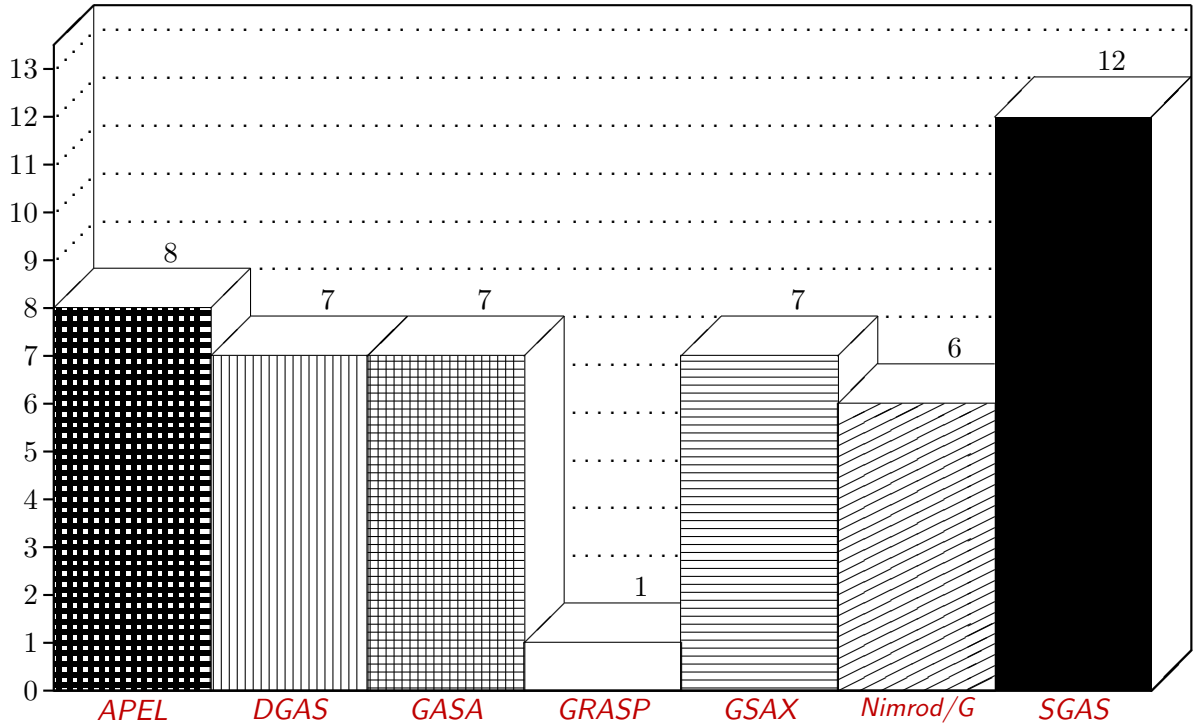

Fig. 1: Compliance with criteria (“Yes”-number) for accounting systems/tools.

6. Summary and concluding remarks

- From the accounting systems and tools known, seven freely available and most prominent implementations have been analysed in detail with respect for usage within D-Grid.
- The overall criteria reveal very different concepts, properties and status of implementation for the approaches. The current status of the concept/implementation is very important for the evaluation.
- As there are no defined delimitation between monitoring, accounting, and billing several categories of criteria have been formed to represent important requirements within D-Grid.
- So as if some approaches seem to be par regarding numbers there are some criteria more important than others. Therefore a concluding selection has been done, based on the analysis of background requirements.
- Due to the analysis of the requirements of the Grid Communities and Resource Providers, regarding the complex federal state background, and chances for future development some approaches are favourable.

  SGAS: Prototype base for an accounting system to be implemented.

  APEL: Tool that implements various features for logging file based purposes.

  GASA: Representation of theoretical base for many conceptual features that should be implemented for the accounting system.

  Interfaces to other accounting systems used, like DGAS, will have to be defined and implemented.
- The concept for an universe monitoring/accounting/billing system for D-Grid is currently developed and will be published on the D-Grid server within the current project runtime.

Thank you for your attention!

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7. Appendix

7.1. Accounting Processor for Event Logs (APEL)

Advantages of the approach:

- ⊕ Support for various metrics (CPU time, wallclock time, RAM etc.).
- ⊕ Possibilities for resource evaluation (normalisation of heterogeneous resources).
- ⊕ Support for various batch systems via plug-ins.
- ⊕ Conformity with GMA architecture of OGSA.
- ⊕ Supported middleware: LCG-2/gLite.
- ⊕ Source code available.

Disadvantages of the approach:

- ⊖ Centralised database concept (within Grid Operations Centre, GOC).
- ⊖ Exclusive accounting of batch system jobs (currently PBS, BQS).
- ⊖ Exclusive support for homogeneous nodes (homogeneous worker nodes).
- ⊖ PBS logs, gatekeeper logs and system news needed (often no longer available).
- ⊖ Dependent on monitoring- and information system R-GMA.

Additional information:

Integration planned for DGAS and APEL, APEL and Condor.
References, see [Gor2005] [BWK2005] [BCC+2005] [EGE2005].

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7.2. Distributed Grid Accounting System (DGAS)

Advantages of the approach:

- Decentralised bank structure (each Virtual Organisation (VO) has an own Home Location Register (HLR), implying high degree of scalability).
- Support for various bases of economic concepts.
- Based on Grid Security Infrastructure (GSI).
- Security based on PKI X.509 certificates; communication via Secure Sockets Layer (SSL); communication via XML-based data format.
- Simple Logging with central Workload Management System Server.
- Use of temporary user accounts (template accounts).
- Support for various accounting policies.
- Supported middleware: LCG-2/gLite.
- Source code available.

Disadvantages of the approach:

- ⊖ No conformity with OGSA and OGSI.
- ⊖ Exclusive support for virtual monetary units (Grid Credits).
- ⊖ Use of central administrated resource broker.
- ⊖ Use of only one Pricing Authority can result in scalability problems.
- ⊖ No special provision against failure and for regeneration of data specified.
- ⊖ Small number of features for administration of user accounts.
- ⊖ Implementation tightly coupled with DataGrid Workload Management System, difficult application without influence on local cluster software environment.
- ⊖ Exclusive charging/clearing of resources (no real accounting of resource usage).
- ⊖ No integrated method for resource evaluation.
- ⊖ Particulary large overhead because each resource has an own Home Location Register (HLR) that has to be administrated from a central instance.
- ⊖ Low interoperability for various middlewares like e. g. UNICORE etc.

Additional information:

Particulary central approach (central oriented resource broker). Support for various metrics (e. g. CPU time, opt. wallclock time, Mem, Vmem). Paying schema: post payment. Part of the LCG-2 middleware (Globus Toolkit). Integration planned for APEL and DGAS.
References, see [FMW2004] [ABG+2006] [PGW2003] [ABC+2003] [ABG+2006] [e-I2005].

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7.3. Grid Accounting Services Architecture (GASA)

Advantages of the approach:

- ⊕ Secure, and fully described payment- und billing system.
- ⊕ Simple attendance and modification because of modular architecture (implicit high degree of extensibility).
- ⊕ Support of Quality of Service (QoS), e. g. resources, costs, deadline etc.
- ⊕ User accounts administrated on central server (not at the resource providers).
- ⊕ Use of Resource Usage Records (RUR).
- ⊕ Different metrics supported (CPU time, main memory, secondary memory, software libraries etc.).
- ⊕ All payment activities via secure connexions, use of certificates (PKI X.509), access lists.
- ⊕ Support for monetary and virtual monetary units.
- ⊕ Support for different payment schemes.
- ⊕ Use of decentralised trade servers, which arrange prices of the resources.
- ⊕ Supported middleware: Globus Toolkit v.2 or later versions.
- ⊕ Source code available.

Disadvantages of the approach:

- Small degree of scalability due to registration on side of resource users and providers on central server.
- Not based on open standardised Grid protocols (low interoperability).
- No conformity with OGSA and Web-Services.
- Use of local accounts on side of Grid Service Provider (GSP).
- No distributed structure (central approach).
- Implicits modification of existing Workload Management Systems.

Additional information:

Grid Service Provider fixes the price of the resource, price regulated as economic system (demand and supply). Strong focus on economic structure. Payment schemes: "pay before use", "pay as you go", "pay after use".
References, see [BB2003] [FMW2004] [SGE+2004].

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7.4. Grid Based Application Service Provision (GRASP)

Advantages of the approach:

- ⊕ Conformity with OGSA in Version 1.0.
- ⊕ Usage based and service-level based accounting possible.
- ⊕ Support of OGSA based middlewares (middleware not precisely specified).

Disadvantages of the approach:

- ⊖ Accounting- and billing components still in state of development.
- ⊖ Productive usage questionable.
- ⊖ Currently no source code available.

References, see [Szc2005] [DRY+2003] [D-G2004] [GRA2005] [GGH+2005].

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7.5. Grid Service Accounting Extensions (GSAX)

Advantages of the approach:

- ⊕ Modular architecture.
- ⊕ Extensible OGSA accounting- and logging framework.
- ⊕ Extension to OGSA standard.
- ⊕ Accounting on different application levels possible.
- ⊕ Accounting informations available in various levels of granularity.
- ⊕ QoS requirements and Service Level Agreements (SLA) in different layers.
- ⊕ Specification of resource specific metrics (e. g. CPU time, network and RAM etc.) as well as application specific metrics.
- ⊕ Not directly coupled with Grid and OGSA, easy adaptability in order to be scalable with a multitude of accountable Web-Services.
- ⊕ Extension to OGSA (middleware not precisely specified).

Disadvantages of the approach:

- ⊖ Relatively theoretical approach. Productive usage questionable.
- ⊖ Source code not available.

References, see [BHH+2002].

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7.6. Nimrod/G

Advantages of the approach:

- ⊕ Consideration of user specific QoS requirements (e. g. time/budget restrictions).
- ⊕ Selection of appropriate Grid resources via meta-scheduler.
- ⊕ Support for various economic concepts.
- ⊕ Possibility for determination of resource classification number for future scheduling strategies.
- ⊕ Coupling with existing accounting systems possible.
- ⊕ Allows use of Grid middleware services like Legion, Condor, NetSolve.
- ⊕ Supported middleware: Globus Toolkit.
- ⊕ Source code avaliable.

Disadvantages of the approach:

- ⊖ No independent accounting system (focus on procuration of Grid resources).
- ⊖ No administration of user accounts, no own banking component, no specification of accounting units, no specification of monetary units etc.

Additional information:

Integration of Nimrod/G as scheduling system/resource broker in various accounting/billing systems possible e. g. GASA etc.
References, see [Bar2004] [ABG2002] [ABG2001].

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7.7. SweGrid Accounting System (SGAS)

Advantages of the approach:

- ⊕ Currently in productive use (e. g. within SweGrid, NorduGrid).
- ⊕ Uniform, extensible architecture.
- ⊕ Based on open, standardised Grid protocols and existing middleware solutions (e. g. Web-Services, Grid Services, Globus Toolkit etc.).
- ⊕ Integral part of Globus Toolkit in Version 4.0.1.
- ⊕ Bank component based on the Open Grid Services Infrastructure (OGSI).
- ⊕ Bank service: numerous security aspects (delegated User Credentials etc.).
- ⊕ Authentication via Public Key Infrastructure (PKI) and SSL based Handshakes using the Simple Object Access Protocol (SOAP).
- ⊕ Conformity with WS security, WS secure conversation, XML encoding, XML signature and GSS-API.
- ⊕ Authorisation via policy management and policy enforcement.
- ⊕ Exchange of / access on accounting informations between trusted entities.
- ⊕ Use of a transaction history (possibility for verification of transactions).
- ⊕ Possibility for decentralised administration of user accounts (high scalability).
- ⊕ High degree of scalability due to the use of template accounts (temporary).
- ⊕ Each Virtual Organisation (VO) has an own associated bank component.
- ⊕ Diverse provisions for regeneration and redundant data storage (informations on condition of user accounts and transaction logs stored in XML DB).
- ⊕ Accounting databases based on standardised Resource Usage Records (RUR).

- ⊕ Small influence on existing local accounting and scheduling systems.
- ⊕ Integration of scheduling and workload management architectures possible.
- ⊕ Support for numerous features for administration of user accounts.
- ⊕ Possible support for middleware solutions (JARM acting as integration point).
- ⊕ Supported middleware: Globus Toolkit, NorduGrid.
- ⊕ Source code available.

Disadvantages of the approach:

- ⊖ Accounting only based on project accounts.
- ⊖ High degree of homogeneity regarding the supported Grid resources (heterogeneous peripheries eventually planned for medium-term).
- ⊖ Currently only wallclock time (so called Node Hours) usable as accounting unit (support of further metrics possible).
- ⊖ Exclusive use of virtual monetary units (Grid Credits).
- ⊖ Missing possibility for evaluation of Grid resources.

Additional information:

Decentral concept (implies high degree of scalability). Payment scheme: post payment.
References, see [FMW2004] [EGMS2004] [Gar2003] [San2003] [EGM+2003].

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