Taxonomy of Grid Business Models

Jörn Altmann[1,2], Mihaela Ion[1], and Ashraf Adel Bany Mohammed[2]

[1] Intl. University, Bruchsal, Germany
[2] Seoul National University, Seoul, South-Korea
jorn.altmann@acm.org, mihaela.ion@i-u.de, ashraf@tepp.snu.ac.kr

Abstract. Grid Computing, initially intended to provide access to computational resources for high-performance computing applications, broadened its focus by addressing computational needs of enterprises. It became concerned with coordinating the on-demand, usage-based allocation of resources in dynamic, multi-institutional virtual organizations, and eventually creating new business models based on this technology. This trend in Grid computing holds a lot of potential in many industries with respect to saving costs, improving efficiency, creating new services and products, increasing product quality, as well as improving collaboration between companies. This will change the way business is done and it will change our classical view of the value chains, its stakeholders, and their roles. However, in order to encourage more companies to adopt Grid computing, value chains have to be explained and business models have to be understood. This paper makes a first move in this direction. It analyses existing business models. Based on the result of the analysis, it formally defines a taxonomy of existing and future roles that a stakeholder can take on within the value chains of the Grid and gives examples of those roles. Finally, this paper applies the taxonomy to two reference business models: utility computing and software-as-a-service.

Keywords: Grid Computing, Grid Economics, Business Models, Functional Roles, Taxonomy, Utility Computing, and Software-as-a-Service (SaaS).

1 Introduction

Grid Computing started out of the necessity to solve computational-intensive scientific problems that needed more resources than available at a single high-performance computing center (HPCC). Using Grid technology, storage capacity and processing power at several HPCC could be combined on-demand. As a next evolutionary step, the research in Grid computing broadened and became concerned with coordinating the allocation of resource in virtual organizations. This technology is based on virtualization of resources (i.e. processing power, storage capacity, bandwidth, and data). It makes distributed resources available to the user as a single unified system. In general, organizations using Grid technology can optimize the use of their departmental resources by sharing them across departments, run computational-intensive applications on their Enterprise Grid, and even enable collaboration with other organizations [8].

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Although the Grid could potentially offer a more efficient way of developing products and creating new business opportunities, the use of the Grid is quite limited at present. Grid Computing is mostly used as a mean for simplifying resource management. Because of that, only a small number of companies are deploying Grid-related technologies and none of the small companies (SMEs) consider using the Grid at the moment [9].

To make the Grid being adopted, companies need to understand the benefits they could gain from using the Grid. The support that they need is a clear analysis of the value chains and the cost models of the Grid. Both will help them understanding the real cost cuts (i.e. the amount of money and time that could be saved using the Grid).

In addition to this, the analysis of incentives and concrete business models is needed. A Grid business model defines a framework for creating new value chains. The analysis of Grid business models will show providers and consumers how to trade resources and software services on the Grid. This opens up opportunities for creating new businesses and revenue streams.

Within this paper, we present the results of our analysis of a set of Grid business models. In particular, we give an overview of existing business models and projects investigating Grid business models in chapter 2. Chapter 3 introduces the taxonomy. It classifies and defines the roles that stakeholders could take on within the Grid. The roles describe atomic functions that could be the basis for new value chains on the Grid. Two examples for using the taxonomy are given in chapter 4. It demonstrates the usefulness of the taxonomy and explains in more detail two abstract business models (i.e. utility computing and software-as-a-service). Finally, the conclusion is given in chapter 5.

2 Classifications of Grid Business Models

2.1 Existing Business Models

The existing Grid business models can be classified according to their origin in research or in commerce. The business models of the research category have mainly been developed by universities and research centers. These business models are based on an open Grid architecture that would allow several providers and consumers to be interconnected and to trade services. The business models of the commerce category have been developed and deployed by a single company with the purpose of selling its own products. These business models usually do not involve several providers.

Research Business Models. The following research projects on Grid business models were examined: GridASP [5], GRASP [6], GRACE [7], and BIG [1]. These projects promote open value chains for trading services on the Grid.

GridASP and GRASP rely on the concept of an application service provider (ASP) for delivering and composing services on the Grid. GridASP offers a scalable and service-oriented architecture (SOA), which offers a lot of potential for creating new products and business models. The business model involves only four roles: the consumer, the service provider (which functions as a portal for the consumer, basically aggregating applications and resources), the application provider (which

offers the use of software applications), and the resource provider (which owns hardware resources). From a technical perspective, GridASP addresses all relevant aspects: user management, data and job management, workflow handling, resource brokering, semi-automated application deployment, and security [2][3]. GridASP lacks a better integration of economic functions such as SLA management, negotiation of services, accounting, capacity planning, and pricing.

GRASP also offers a scalable and service-oriented architecture focusing on Web Services and OGSA standards, which offer a good support for service integration. The main focus of GRASP is to allow innovative business models and to integrate economic functions such as accounting, billing, and SLA management into the architecture. As opposed to GridASP, the GRASP architecture offers better support for collaboration between organizations and ASPs by allowing to create virtual organizations and a federation of ASPs.

Compared to GridASP and GRASP, GRACE is very economic-oriented and less focused on architectural issues, aiming to develop a generic framework or infrastructure for a computational Grid economy. The framework provides brokering, service discovery, and trading through an innovative API for negotiating prices and services on the Grid. GRACE relies on existing Grid middleware such as Globus [10] and Legion [11]. GRACE defines only two main roles in exchanging services on the Grid: the consumer, represented by the broker, and the seller or resource owner.

The BIG project addresses the problem of Grid business models from a more general and theoretical perspective [1][4]. It classifies the current Grid projects in four levels based on the support for economical functions and business models. It also focuses on requirements for innovative business models on the Grid and identifies transparency, QoS, brokerage, SLA, and dynamic trust management in virtual organizations to be the most important requirements. BIG supports a large set of innovative applications such as dynamic collaborations, workflows, applications on demand, dynamic resource-management, and resources on demand.

Commercial Business Models. The following commercial models were analyzed: Sun Grid Compute Utility [12], Amazon EC2 [13], the Virtual Private Grid (VPG) [15], and WebEx Connect Application Grid [14]. Both, Sun Utility Grid and Amazon EC2, provide on-demand computing resources while VPG and WebEx provides on-demand applications.

Sun Utility Grid allows the user to create jobs and submit an application, but does not give the user means to control or monitor the execution. The logs and results, together with error reports are provided once the execution is completed. Amazon, on the other hand, allows the user to create virtual machines, which makes the job execution fully transparent. The user has access to virtual machines with 1.7Ghz Xeon CPU, 1.75GB of RAM, 160GB of local disk, and 250Mb/s of network bandwidth. Users can initiate, run, and monitor applications on each virtual machine. Additionally, Amazon provides storage through Amazon S3. For both models, the user is only charged for the consumed resources. Sun Grid Compute Utility charges $1/CPU-hr. Amazon charges $0.10 per instance-hour consumed (or part of an hour

consumed), $0.20 per GB of IP data transferred into and out of Amazon, and $0.15 per GB-Month of Amazon S3 storage (as of February 2007).

The VPG has been designed by the British Telecom (BT) together with industry partners [15]. The VPG will allow BT to provide its customers with services such as music or video on-demand. The services and resources are developed and are owned by BT's partners. The VPG is based on virtualization of resources and a SOA architecture. This allows combining resources of application and resource providers. However, VPG does not support complex applications such as workflows and has no support for composition of services. Economic functions also lack. Another shortcoming of this model is that BT has full control over the network, and manages the resources and applications, acting as the only reseller. The VPG does not allow other network providers and resource brokers to coexist on the same Grid.

WebEx provides online meeting, web conferencing, video conferencing, and teleconferencing for enterprises. Their software-as-a-service (SaaS) implementation allows innovative and complex, on-demand composition of services and workflows. Moreover, WebEx enables developers to attach new applications to the Grid and sell their products to customers through the WebEx platform. The applications are delivered through their WebEx MediaTone Network, a private global network and platform. MediaTone Network includes connected data centers and servers distributed around the world. However, WebEx only focus on a specific kind of application, namely Web meeting software [14].

2.2 State-of-the-Art in Grid Business Model Classifications

The identification of stakeholders and their roles in Grid business models has been addressed by many scholars [16][17][18][19][20]. Our work harmonizes these classifications and builds our taxonomy of Grid business models (see section 3) on top of it.

Some classifications of classical Internet service providers can be found in [17] and [19]. Their classifications of roles are based on business transactions and are organized in layers. The Software-as-a-Service business was classified in [16]. Another classification of Internet businesses can be found in [18], where the authors illustrate a five-tier classification. Standard bodies, consortia, academic groups of interest, and governments are at the lowest layer, setting the rules for collaboration. This layer is followed by the layer of large technology vendors, niche vendors (who integrate), and application vendors. Within the third layer (influenced by media and information sources), there are consultants, resource service providers, and resellers, which provide customized services to the next layer consisting of business users and retail service providers. This layer provides the provisioning to the last, the fifth layer, consisting of end-users.

In more detail, Grid has been analyzed in [20]. Their model of Grid businesses focuses on the structure of Grid-aware markets. Its layers are divided into two main groups: the Grid market participants and the technology enablers. The Grid market participants consist of three tiers: the service tier (consisting of service providers, content providers, consolidators), the platform tier (consisting of Grid infrastructure

providers such as Grid operators and resource providers), and the consumer tier (consisting of partner Grids, virtual organizations (VOs), enterprise Grids, department Grids, and end-users). The technology enablers are also organized into three tiers with the same name as the tiers of the Grid market participants. However, the service tier consists of application providers, the platform tier of middleware vendors, and the consumer tier of consultants and integrators.

3 Roles and Stakeholders

This chapter presents a classification of roles that stakeholders on the Grid could take on. The definition of stakeholders and roles that we follow is: A Grid *stakeholder* is an entity that takes on one or several *roles* in a business model for selling Grid services. A *grid service* is defined as any service that can be provided on the Grid.

Figure 1 shows a classification of roles. There are five categories of roles that a stakeholder could assume on the Grid. Those categories are the roles of a Hardware Resource Service Provider, a Grid Middleware Service Provider, a Software Service Provider, Content Provider, and a Consumer.

I. **Hardware Resources Service Providers:** This is the lowest layer of the classification representing hardware providers. The hardware can belong to many different providers. In detail, this layer includes:
   - **A. Storage Resource Providers:** This role represents the stakeholders providing huge storage systems or a collection of physical or virtual storage resources (located on geographically distributed PCs). Examples are systems such as Amazon's Simple Storage System (S3) or Openomy.
   - **B. Computing Resources Providers:** They provide computing resources such as Amazon (Elastic Compute Cloud (EC2)) and Supercomputing centers.
   - **C. Network Services Providers:** This layer represents the network providers including ISPs and their multi-tier classification as explained in more details in [17].
   - **D. Devices Service Providers:** They provide the access devices such as sensors and microscopes.

II. **Grid Middleware Service Providers:** The stakeholders in this layer provide the services build upon the above-mentioned physical layer. This role is comprised of two distinct roles:
   - **A. Basic Grid Middleware Service Providers:** This role represents the collection of stakeholders providing basic Grid functionality. This layer includes the following four main roles:
     a. *Grid Resource Management Service Providers*: This role comprises the stakeholders that provide the following management functionalities:
        1. Resource discovery services.
        2. Resource allocation management services and virtualization.
        3. Resource connectivity services.
        4. Metering and monitoring services.
        5. Job scheduling services.

b. *Security Services Providers*: This role comprises the stakeholders involved in providing security functionality.
c. *Fault Tolerance Service Providers:* This role consists of error detection, error recovery, job mapping, and check pointing services.
d. *Grid Billing Management Service Providers:* This role covers the entire billing stack for any kind of service (1. Accounting services. 2. Charging services. 3. Pricing systems services. 4. *Payment* management services.)

B. Composite Resources Service Providers: This layer represents the role played by stakeholders providing a value-added composite service, which includes services of the previous layers. The stakeholders in this layer take one or more of the following roles:
a. *Service Level Agreement Services (SLAs) Providers:* They provide services for the contract (SLA) management, negotiation, monitoring, and auditing.
b. *Grid Services Brokers:* Based on the specific task that they provide, brokers can be classified as:
1. *Risk Brokers*: These brokers minimize the cost for consumers by finding not only the best deal from several offers based on user specified parameters but also based on the uncertainty of the availability of resources.
2. *Trust Brokers*: They help users of the Grid to assess the uncertainty, which results from using resources of unknown providers.
3. *Value Brokers:* They perform the task of managing jobs (even entire workflows related to Grid) on behalf of a consumer. This role can also be further sub-divided based on the kind of job (e.g. finding hardware resources and *composing resources).*
c. *Capacity Planners:* They assure in the long term that the balance between demand and supply is met. In order to maximize their utility, they calculate how many and when to buy / sell resources.
d. *Market-Place Providers:* Stakeholders in this role provide a market place for trading Grid services. These services can be hardware resources, basic grid middleware services, and composite resources.
e. *Grid Service Resellers*: They provide selling and retail services of Grid-oriented services.

III. Software Service Providers: A stakeholder in this role takes on one or more of the following sub-roles dealing with software:

A. Application Service Providers: These stakeholders provide (commercial or open-source) application services, either ready to use of-the-shelf packages or customized services. Applications (services) include all types of application such as multimedia, scientific, and business applications. Types of application service providers are:
a. *Software-as-a-Service (SaaS) Providers.* An example is the execution and maintenance of an Apache Web server.
b. *Software Repository Providers*. This provider maintains a repository of software and controls access to this software.
c. *Software Hosting Providers:* This type of stakeholder provides the software *environment* for applications to be executed.

- **B. Billing Management Service Providers:** They are equivalent to the providers of II.A.d.
- **C. Software Market-Place Providers:** Stakeholders in this role provide the market place for software services.
- **D. Software Brokers:** Stakeholders in this role provide the brokering services for software services. They are similar to II.B.b.
- **E. Software Resellers and Retailers:** They sell software services.
- **F. Applications-to-Grid Wrappers:** They provide integration of applications into the Grid.
- **G. Software Vendors:** This stakeholder develops software. They can be:
  - a. *Open Source Software Developer:* The source code of this software is available under certain licensing conditions.
  - b. *Commercial Software Companies:* This software is mainly proprietary. The use of the software is restricted.
  - c. *Software Integrators:* These stakeholders develop software to interface different software components.

IV. Content Providers: This layer represents *roles* available on the information side of our model. Stakeholders in this layer can be divided into the following groups:

- **A. Content Creators:** Any entity that creates content, regardless of the content type (e.g. photo, video, and text).
- **B. Content Aggregators:** They aggregate, classify, and organize content for either business or individual use, using applications such as *mediawiki*, tags as in *clipmarks*, or bookmarking services as *blinklist*.
- **C. Content Composers:** They re-build and modify the content. They add some value and then resell it. An example is the company *programmableweb.com*.
- **D. Content Distributors:** This type includes content update disseminators. Examples are *RSS* services as in *Tailrank* and *Topix.net* as well as traditional content distribution channels such as classical Web media channels.
- **E. Content Brokers:** Stakeholders in this role provide matching services between content providers and consumers.
- **F. Content Resellers and Retailers:** They provide retail services for content (e.g. flicker).
- **G. Content Market-Place Providers:** They provide the market place where content can be exchanged according to some economic rules (e.g. *Flicker*, *YouTupe*, and *Democracy 2.0*).

V. Consumers: This layer represents roles taken on by stakeholders who simply consume a service. Three major types of consumers can be distinguished:

- **A. Business Users:** This entity is either a virtual or physical business entity; seeking value-added services. They can be classified into:
  - a. *Core-Business Consumers*: They seek core business process applications. Examples of those stakeholders include: pharmaceutical companies (run applications for drug discovery), financial institutions (run complex applications to make accurate financial estimations).
  - b. *General-Business Consumers*: They seek general business process services (i.e. outsourcing of storage, CPU, content development). Examples of stakeholders can be any government agency and business.

B. End-Users: This entity is a single person or group, which consumes the services without the intention of modifying or reproducing the application.
C. Universities: This entity has non-monetary objectives when using resources.

In addition to this classification, we need to mention the emergence of the following three roles. These roles provide additional services for stakeholders, spanning over the above-described layers (Figure 1):

- *Grid Consultants:* This role provides consultation service (such as economic analysis, technical analysis, education, and training) for Grid adopters. Examples of stakeholders are software integrators and strategic consultants.
- *Grid Standardization Bodies*: This role provides standardization services, which could be taken on by stakeholders such as academia, governments, and consortia.
- *Regulators*: This role will guide the development of the Grid through policies.

To complement our classification of roles on the Grid, we need to mention the following four facts about stakeholders that take on those roles:

- Any provider can offer integrated services through *horizontal service integration* (i.e. integration roles of the same layer) and / or *vertical service integration* (i.e. integration of roles of different layers). The integration of Grid technology, Web services, and Web2.0 enables this. It will give each stakeholder the potential to change his role by adding / deleting more roles to his stake and build new business models. It will allow all stakeholders to adapt quickly to new market conditions.
- Service providers can become consumers of services and vice versa.
- Not all of the providers mentioned have to be present in the future market. Each of the providers can serve a different niche market.
- Even though the layered structure is the ideal case, the stakeholder relationships between the layers can follow different paths. The path that a consumer takes to use a service does not have to go through all the layers. The consumer can directly choose the most appropriate service from any layer. However, the services of different layers have to be ordered according to the layered structure.

Figure 1 summarizes the roles of the stakeholders and depicts the relationships between them. The arrows represent the direction of service delivery. They are used to indicate the service that a stakeholder delivers to another stakeholder in a different role. The following chapter analyzes two business models using this taxonomy.

4 Role Analysis of Two Reference Business Models

We discuss two abstract business models with respect to the service functionality that they require for their implementation. The first reference business model is “Economically Efficient Utility Computing”. In this case, the user owns the software that will be executed on the Grid. The second reference business model is “Software-as-a-Service”, which explains the value chain of software on demand. In this case, the user rents the software and has the option to specify the hardware resources on which the software should run.

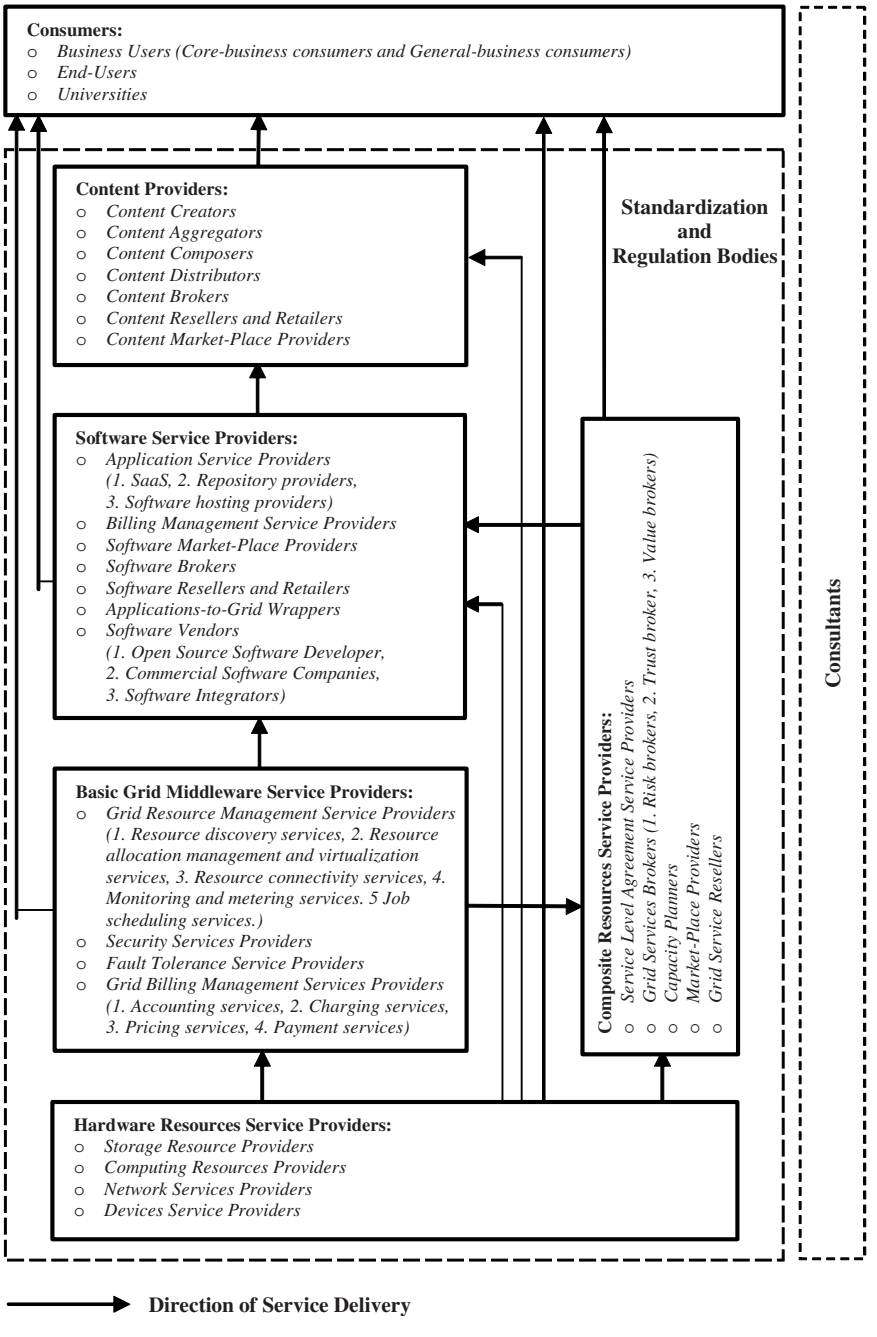

Fig.1. Roles of stakeholders and their relationships

4.1 Reference Business Models: Economically Efficient Utility Computing

There are a number of advantages of utility computing. First, different Grid systems that provide utility computing can perform load balancing amongst each other, thus ensuring that the capacity of the Grid is used to the highest extent possible. Second, utility computing implies that computational power is always present. The Grid is inherently fault-tolerant. (It is unlikely that all single Grid systems will fail on the Grid at the same time.) Furthermore, the operation of the Grid is transparent, meaning that the user is not aware of the fact that the application is running on a geographically distributed system. All these advantages do not only enable the execution of computationally intensive, scientific applications but also allow commercial customers to use the power of such a Grid to solve their problems quickly and efficiently.

However, there are many different kinds of users (e.g. SMEs, large enterprises, the general public, and academia), distinguishing themselves in the amount of budget, urgency of their application, and quality of service expectations. For example, industry users, which try to achieve a competitive advantage, require the termination of the execution of their application within a specific period of time. Because of that they are willing to pay a higher price than other users. In order to get their job executed on time, i.e. get priority over other users, the Grid could charge them a premium fee, which is specified in an agreement between the user and the Grid system. This agreement, which is called a Service Level Agreement (SLA), states what the user wants and what the provider promises to supply in a legally binding way. An SLA also describes a measurable performance standard and a penalty fee if it is not delivered.

This paradigm of utility computing supports the execution of any application (i.e. high-performance computing workflows, parallel applications, or simple sequential application, such as Web servers). Any end-user can get access to any kind of computational resource, ranging from supercomputers, which provide large computing power, to a single PC. Figure 2 shows the interaction between the consumer and the Grid. In this case, the consumer owns a software application and executes it on the Grid. The Grid offers the mechanisms for deploying and executing the application (e.g. automatic deployment, execution monitoring, and hardware resource discovery). Figure 2 also illustrates the business processes (or service interactions) for purchasing hardware resources on the Grid and for executing the application. Implementing such a business model requires at least the following basic roles, which belong to three layers:

- **Hardware Resource Service Providers:** For the utility computing business model, server, storage, and network resources are considered.
- **Grid Resource Service Providers:** This intermediate layer between the Consumer and Hardware Resource Service Providers offers only services needed to execute an application:
    - **Basic Grid Middleware Service Providers:** The basic Grid middleware must provide at least security, and accounting.
        - **Billing Stack Service Provider:** Interacts with the Resource Broker to charge the Consumer for consumed resources. It has a Pricing component for storing current and past prices and components for accounting, charging, and billing. When the execution completes, it bills the consumer.

- **Grid Resource Management Service Providers:** It provides virtualization, metering, job deployment, and resource discovery.

- **Composite Resource Service Providers:** In this example of utility computing business models, only one type of provider is needed:
  - **Resource Broker:** It selects the best-fitting resources from different Hardware Resource Service Providers upon user request and initiates the job deployment and monitors the job execution.

- **Consumers:** The consumer runs its application on the Grid, using the services of the Grid Resource Service Provider. The consumer can be of any type.

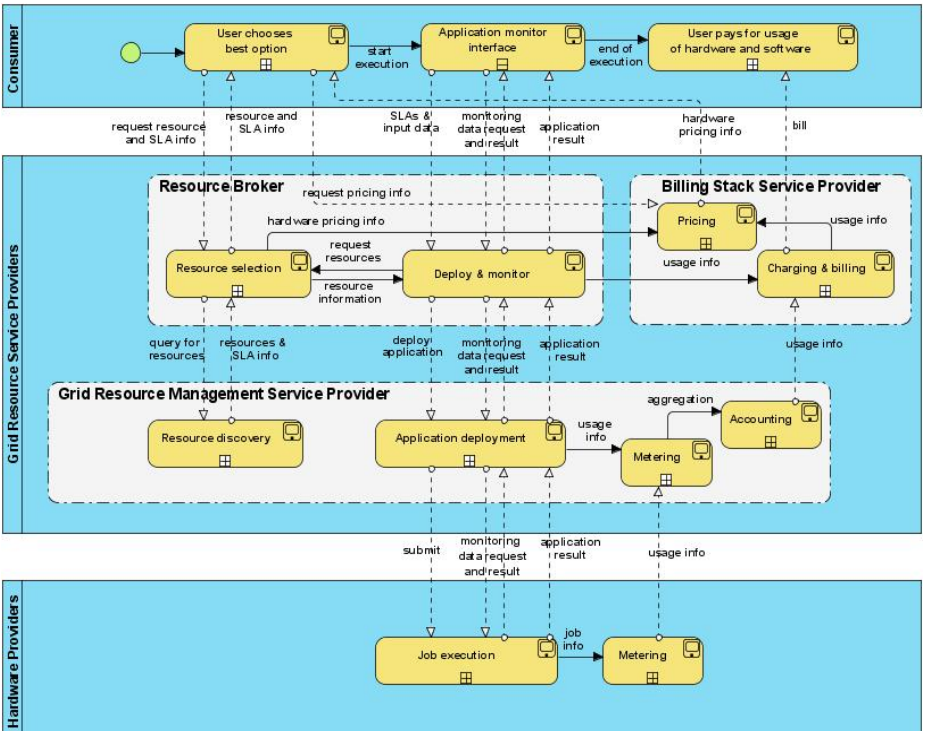

Fig. 2. Interaction of roles in the utility computing business model

A typical scenario of this business model can be found in high-performance computing. Applications in this scenario require huge amount of hardware resources. Applications range from scientific (simulations such as weather and climate modeling, weather prediction), digital media (animation, special effects, rendering), life sciences and health care (drug discovery, structure-based design, molecular dynamics, medical imaging), financial services (Monte Carlo simulations, risk analysis) to manufacturing.

4.2 Reference Business Model: Software-as-a-Service (SaaS)

For software owners, this model has a number of advantages. First, they no longer need to be concerned with license agreement violations, which are common when software is sold directly to the customer. Second, since consumers pay only for their usage, even consumers, who cannot afford buying very expensive software, can now purchase units of software usage. These additional customers will increase the amount of income for the software owner and, thus, contribute to higher profits from software development. However, the following third reason is the most important one for software vendors. Since the software vendor can use the Grid to run its software, they do not need to own the hardware resources themselves. Instead, they can reserve a set of hardware resources for a long time period on the Grid and, should more hardware resources be needed, buy additional resources on demand. This degree of flexibility cannot be achieved without the Grid (i.e. without sharing of resources). It makes the Grid an attractive alternative to buying and maintaining hardware resources.

The SaaS business model also has advantages for customers. First, customers do not have to buy additional, sometimes even highly specialized hardware resources to run purchased software anymore. This does not necessarily reduce the cost of hardware resources, but reduces the cost of ownership of software and hardware for customers. Therefore, the pay-per-use model opens the opportunity to use the most powerful software, which would otherwise be too expensive to buy. For customers, such as SMEs, SaaS levels the playing field when it comes to competing with large companies. This aspect is especially important for SMEs in fields like metallurgy, which require highly complex computations, and for SMEs, which specialize in customized products in niche markets.

This reference business model, Software-as-a-Service, involves the purchase of software and hardware resources. Figure 3 shows the business process of running a SaaS business model on the Grid. The basic services that a system has to provide to offer software-as-a-service belong to four layers:

- **Hardware Resource Service Providers:** This layer consists of servers, storage, and network capacity that are required to run the SaaS software.
- **Grid Resource Service Providers:** The services offered within this layer are identical to the services offered by the Grid Resource Service Providers of the utility computing business model.
- **Software Service Providers:** For the SaaS business model, this layer represents service providers who maintain software, which they do not necessarily own and execute on Grid resource hardware. The providers considered here are:
    - **Software Discovery Provider:** Software vendors have registered their applications in a Software Registry. Information about available software applications and their SLA can be retrieved from the registry.
    - **Software Broker:** It uses a Software Discovery Service to retrieve information about similar applications that match the consumer's preferences. It then offers a selection to the consumer.
    - **Application Service Provider:** In the SaaS business model case, it is the environment, in which the SaaS software is executed on the Grid.

- **Billing Management Service Provider:** Interacts with the Application Service Provider and with the Billing Stack Service Provider of the Grid Resource Service Provider layer to provide services for billing the consumer for the consumed hardware resources and the application usage. When the execution completes, it bills the consumer.

- **Consumers:** This entity is the consumer, who uses the software. It buys access to the software on a usage-basis, using the services provided by the Software Service Providers. It can be a SME or an individual.

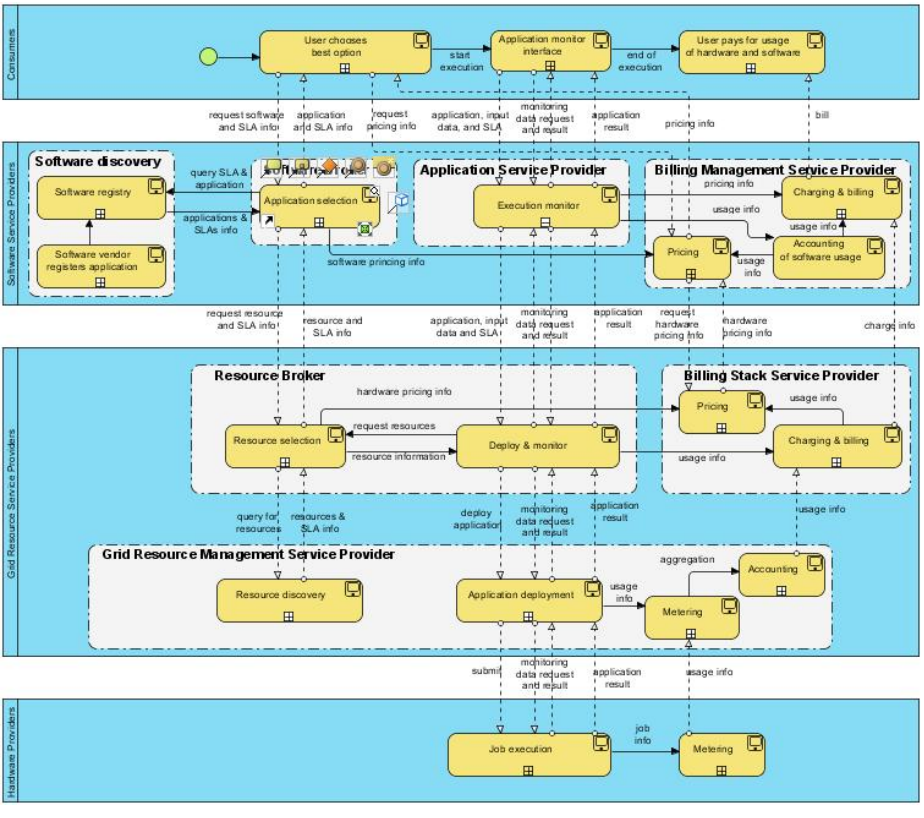

Fig. 3. Interaction of roles in the software-as-a-service business model

The SaaS business model allows SMEs to gain access to expensive commercial software that they could not afford to purchase licenses for or because they do not have the expertise to develop the application inside the company. Another interesting scenario is the one of starting a business with little investment by using the software services (or a composition of them) provided on the Grid and adding own expertise. For example, an interior decorator could use rendering and visualization software to provide advice on house decoration.

5 Conclusions and Future Work

This paper presented a survey of current Grid business models. It then identified the roles, which can be assumed by different stakeholders on the Grid, and classified those roles into five groups, defining the taxonomy of Grid business models. The groups are: Hardware Resource Service Providers, which own storage, network capacity, devices, and server capacity; Grid Resource Service Providers, which provide the Grid middleware and composite resource services; Software Service Providers, providing the software and the environment for managing and executing software on the Grid; Content Providers, which create, aggregate, and compose information; and, finally, Consumers, which are entities who consume services on the Grid. It is to note, that a stakeholder can assume multiple roles as well as roles within different groups.

In addition to this, we discussed two reference business models and applied the taxonomy to those two business models. These reference business models are "Economically Efficient Utility Computing" and "Software-as-a-Service". In the first case, the user owns the software that will be executed on the Grid. In the second reference business model, the user pays for the usage of the software and the Grid hardware resources. The business processes, which are represented through interactions between roles, give a general guideline for what is needed to implement those business models on the Grid with respect to the service functionality required.

After having made the first step with this analysis of existing business models and roles, the incentives for deploying and using the Grid need to be investigated. In particular, the impact of different pricing schemes for service-oriented computing has to be investigated. This will provide more insight into value chains of Grid businesses.

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