GridEcon –
The Economic-Enhanced Next-Generation Internet

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Abstract. The major shortcoming of Grid middleware systems is the lack of economic-enhanced Grid services. These new services are necessary in order to let Grid users benefit from the properties of the Grid. Those properties comprise the availability of on-demand computational power, simplicity of access to resources, low cost of ownership, and a pay-for-use pricing model in addition to the already leveraged properties such as cost reduction and aggregated processing power for high-performance computing applications. This paper gives an overview of the EU-funded project GridEcon on Grid economics and business models. It describes its vision of the next generation Grid/Internet, in which individuals, universities, small and medium sized enterprises (SMEs), and large companies have access to the Grid in exactly the same way. Any resource, including servers, storage, software, or data, is accessible as a service. In addition to this, the architecture of an economic-enhanced infrastructure is illustrated and the goal of the project is described.

Keywords: Grid Computing, Grid Economics, Service-Oriented Computing, Economic Modeling, Business Model, Markets, Architecture, and Next-Generation Internet.

1 Introduction

Grid computing has not been commercially taken up to the extent expected during the past few years, although many different (commercial and public domain) Grid middlewares (e.g. glite, Gria, Unicore, Globus, GridBus) have been designed and developed [1][2][3][4][5]. The reason is hidden in the limited leverage of the properties of Grid technology. Currently, enterprises use Grid technology only to consolidate their IT resources, resulting in cost reduction. Only in a few cases, Grid technology is being used for improving the workflow within an enterprise. For example, the combined processing power of geographically distributed servers can be used to reduce the processing time of calculations, or to calculate equations more accurately. It results in reduced time-to-market of products. Grid technology also helps aggregating high-performance computing resources such that applications, generating more precise results, can be executed on those aggregated resources. The execution of these applications on a single high-performance computer would not work.

However, enterprises miss out on using other properties of Grid technology. These properties comprise the availability of on-demand computational power, simplicity of access to resources, low cost of ownership, and a pay-for-use pricing model. On-demand computational power helps enterprises to deal with unexpected demand economically efficient. Instead of declining a consumer's request simply based on the unavailability of resources (i.e. processing power, storage, bandwidth, software, and data), they could buy those resources on the Grid (if it maximizes the enterprises objective) now. The simplicity of access to resources helps users to access any resource without much effort. Low cost of ownership enables small and medium sized enterprises (SMEs) to get access to resources that they could not afford to purchase as a whole. They only have to pay for the usage of the resources. This model would allow them to compete with large companies, which have the financial resources to buy high-performance computers for their applications.

Considering this situation, two questions arise: First, what is the reason for this low take up of Grid technology; Second, are there no further sustainable business models then those three mentioned above? These questions highlight the need for better understanding the economics behind Grid technology as well as their business models. The GridEcon project addresses these questions [7]. The GridEcon project investigates the economics of participation in a Grid environment as well as how economic principles can be integrated into existing Grid middleware to make it economic-aware. Current Grid middleware lacks these capabilities, as has been analyzed in [8]. A taxonomy of business models has been proposed in [6].

2 Vision of the Future Grid

In a future Grid, which we envision to be the next-generation Internet (i.e Web 3.0), an open market (together with its trading system) is an essential part, where a huge variety of electronic services are traded. Participants (both, consumers and providers) in this market could be anyone from the general public, academia, business, and government, making it a rich economic and social environment. Based on these markets, sustainable Grid business models could be created, offering new ways to generate income. The income could come from customization of information or the creation of new workflows. These new business models would allow participants in the Grid economy to buy services and sell enhanced services at the same time [11].

However, this vision has not been implemented yet. The reason can be found in the fact that there is one technology out of four that is still missing. All of them are necessary to make the vision become reality. The three existing technologies are: service-oriented computing, virtualization of resources, and network computing. Service-oriented computing (e.g. Web services) allows useful capabilities to be encapsulated as easy-to-use, composable services. Hardware virtualization technology allows transparent use of distributed resources. Network computing allows uniform access to the Internet, which is enabled through the convergence of networks and the proliferation of broadband access. The only missing technology is economic-enhanced services, which will give participants in the market tools to evaluate the economic risk and opportunity to engage in a transaction.

This technology will have a significant impact on existing Grid businesses such as location-aware mobile services, consumer advice services, utility computing, brokers, virtual facilities, insurance contracts, software-as-a-service, and information-as-a-service. It will make them accessible to a larger base of customers.

3 Architecture

Looking at the currently available Grid middleware solutions, it becomes obvious that all of the existing Grid middleware solutions do not provide economic-enhanced Grid services. To rectify this situation, the functionality of Grid technology must be enhanced so that an economic-aware operation of Grid services becomes possible. This new functionality would reduce uncertainty and give incentives to end-users not only to consume but also to sell services on the Grid. It could also help stakeholders to resolve their conflicts in preferences. It would, thus, create a new economy, in which all stakeholders can actively participate. An abstract view of this next-generation architecture is shown in the following figure.

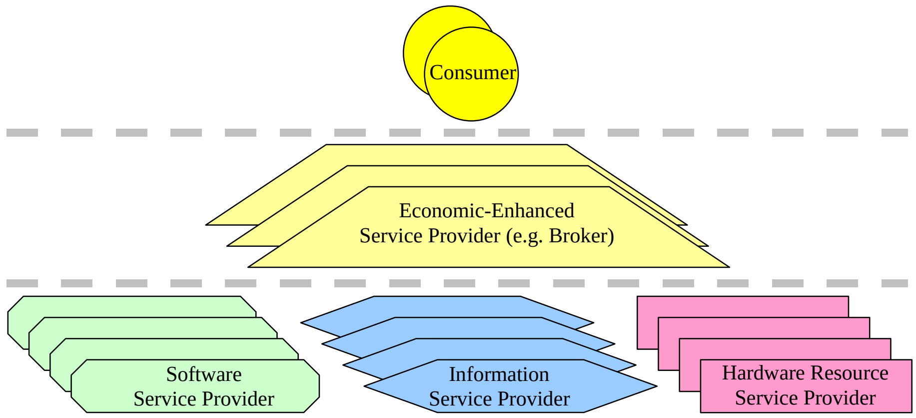

Fig. 1. Architecture of the economic-enhanced next-generation Grid

The Economic-Enhanced Service Provider of Figure 1 will provide tools for trading resources (i.e. software, information, and hardware resources) [10]. It will help Grid stakeholders (i.e. researchers, organizations, companies, and the general public) to deal with the currently existing shortcomings of Grid computing such as risk of relying on outside-company resources, lack of trust, risk in commitment to resource purchases, and uncertainty in capacity planning. These tools, which still need to be developed, range from risk broker services, capacity planning services, to services markets. The risk broker would offer a type of insurance contract to protect against financial loss from unavailable Grid resources or failed Grid resources. An accurate capacity planning tool, which is vital for service provider and end-users, would give support for making decisions about when to purchase new servers, when to put spare resources on the Grid market, and when to buy resources from the Grid. The software services market would allow trading of units of software access. The price of the software access unit would include the price for the software usage and the charge for the hardware resources on which the software would be executed [9]. A hardware resource market will allow selling different server units under a specific pricing scheme. The following figure shows a few examples of hardware resource markets and their relationship to software markets.

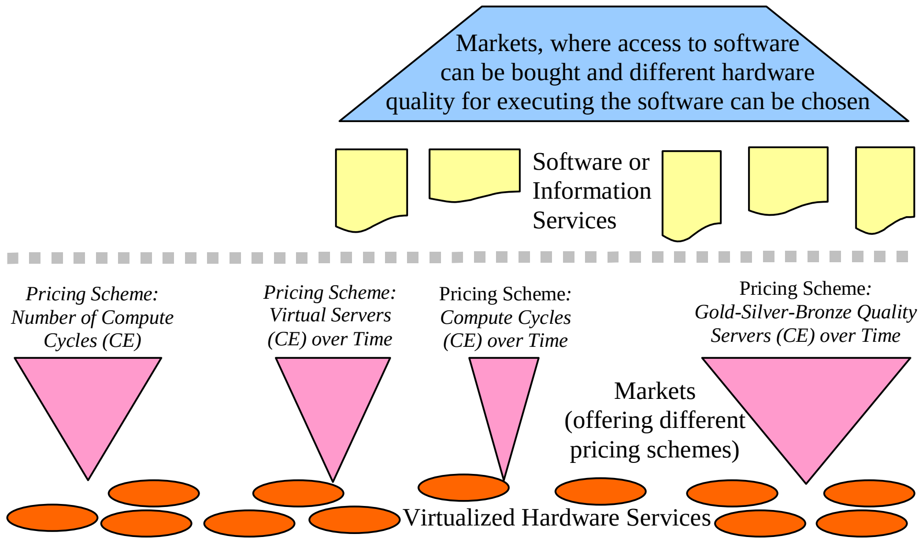

Fig. 2. Architecture of software, information, and hardware resource markets

These kinds of markets, as shown in Figure 2, are the basic services that are needed to make the Grid economic-enhanced. On top of those market services, services as the one mentioned above can be constructed.

There are two major threats. The first threat to Grid computing is the failure of developing and deploying those economic-enhanced Grid services. Since those services also require an open, economic-enhanced architecture for Grid services, which allows any stakeholder to plug in its own services, the second threat to Grid computing is that the Grid community fails to define such an open Grid services architecture.

A market that is based on this architecture will enable collaboration across individual organizational boundaries and reduce the participation risk of Grid stakeholders by allowing economically fair sharing of costs and generated value.

4 Goals of GridEcon

The goals of GridEcon are to twofold. On the one hand, the project has to identify missing technology and software. This comprises the design of the required economic enhancements to Grid technology (as described in the previous section), the implementation of a subset of these service enhancements, as well as the simulation of the workings of the enhancements. On the other hand, the GridEcon project will perform economic and business modeling. It will develop models showing how hardware, software, and information services can be bought and sold on the Grid. It will also investigate potential ecosystems and explore current and future business models.

In particular, the goals of GridEcon are to address the following issues: specify user requiments for accessing economic-enhanced services; SLA composition with respect to pricing; consumer, provider, and service reputation management; service API specification; future and spot markets, insurance contracts, and reservation schemes.

5 Conclusions

This paper discussed the opportunities that come with Grid computing. In particular, it presented the vision of the GridEcon project and the architecture of the future Grid, i.e. the next-generation Internet. The architecture comprises three layers of stakeholders: the basic resource providers (hardware, software, and information); the economic-enhanced service providers; and the consumers. We also showed how markets are the basic building block for other economic-enhanced services in the layer of the economic-enhanced service provider. Finally, we illustrated the different working areas of the GridEcon project and the challenges in this area of research.

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