Jörn Altmann
Daniel J. Veit (Eds.)

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Grid Economics and Business Models

4th International Workshop, GECON 2007
Rennes, France, August 2007
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GECON - Grid Economics and Business Models

Although more and more applications can be executed on the Grid and the management of resources shifts from "buying hardware" to "computing on demand", a global commercial Grid system does still not exist. The concurrent execution of Grid applications on this commercial Grid system would allow the emergence of new marketplaces, namely, markets for processing power, storage, bandwidth, and information services. The emergence of such markets would be the first step towards achieving the goal of a global, commercially operated, and efficiently utilized Grid system. These markets, which can be used for resource selection, resource allocation, access control, and resource planning, are addressed in the research domain of Grid economics. Their realization will make the Grid evolve from a large, distributed system offering best-effort, zero-cost computing services into an environment capable of resolving differences in service preferences of Grid users. This new economic-enhanced Grid will create additional value for its participants through better means for expressing preferences, sharing resources, and generating revenue. It builds a stable and scalable economy of resources.

In such a new Grid system, there is no longer a distinction between specific Grid users. The general public, academic institutions, SMEs or larger institutions are able to use the services of such a new commercial Grid system in the same way. The concrete services could range from a simple service, charged at low rate but aiming for mass usage, to complex services encapsulating e-Science or HPC methods. However, in order to make this vision operate in practice, innovative schemes of charging for the usage of services have to exist in this novel kind of service-oriented, market-based Grid system, stimulating providers to offer and customers to demand these services.

The 4th International Workshop on Grid Economics and Business Models, GECON 2007, aimed at presenting current results and innovative research in the area of Grid economics. In particular, the target is to facilitate the discussion of new business models for the Grid and the capability of the existing Grid to allow the economic operation of the Grid. The purpose of this endeavor is to concretize directions of research and amendments to existing technologies, aiming at the successful deployment of a global commercial Grid system.

In the first contribution, Thanos et al. identify the main objectives and associated economic issues while applying Grid in business purposes. Herein, the authors state that real-life economics within business perspectives is more important than complex theoretical economic problems. The concept picks up at players, who do not exhibit the required technological expertise in order to elaborate on Grid issues. Thanos et al. aim at identifying critical economic issues that should be taken into consideration by industrial partners in order to create trust and confidence in this novel technology.

Hwang and Park investigate the adoption of enterprises to autonomous Grid computing rather then individually owned ICT infrastructures. They highlight the importance of the quality of Grid solution providers for this decision based on a conjoint analysis. Their results show that interoperability is the most indispensable element to a successful utilization of Grid infrastructures in enterprises.

In the third contribution, Altmann and colleagues formulate a taxonomical approach to Grid business models. They survey the development and origin of Grid technologies and focus on the importance of business-directed values when trying to commercialize today's Grids. Therein, they identify the reduction of costs, the improvement of efficiency, the creation of novel products and services as well as the quality and collaboration between companies as key factors for the differentiation of Grid business models. The paper concludes by applying the proposed taxonomy to a utility computing scenario and a software-as-a-service scenario in practice.

Stanoevska-Slabeva and Zsigri propose a generic value chain for the Grid industry. In their contribution, they suggest a case study on aggregating results from different Grid middleware modules into a generic Grid value chain.

In their contribution, McKee and coauthors propose a set of strategies for acting in future service-oriented markets. The costs of negotiations are put in relation to the value of the offer under negotiation. Hence, the contribution adds to the state of the art by extending the vision of service level agreements (SLAs) within service frameworks.

Sandholm and Lai propose a novel, prediction-based enforcement of performance contracts. Their approach aims at controllable quality of service (QoS) within Grid computing platforms. The proposed mechanism is based on a hybrid resource allocation system using both proportional shares and reservations.

In the seventh contribution, Huang proposes a flexible, refundable auction concept for limited capacity suppliers. The mechanism that is introduced is called Decreasing Cancellation Fee Auction (DCFA). It proposes the use of uncertainties of the resource availability for the substantiation of the consumers' decision to use resources. A partial refund of the users payment for reservations provides an incentive to participate in the market. It shows that the mechanism is incentive compatible, individually rational at still high efficiency.

The following contribution by Vanmechelen and Broeckhove aims at introducing a dynamic pricing scheme by comparing single-unit Vickrey auctions and commodity markets. They highlight that a key research issue is the choice of a market organization. The results that the authors provide are a quantitative analysis of the comparison between the two indicated allocation schemes. Based on their simulation results, they conclude that – although similar outcomes are achieved – a commodity market organization leads to more stable market behavior at the cost of higher communicative requirements.

Giordano and Di Napoli focus on provisioning a sophisticated computing methodology in order to provide Grid services in a continuous and seamless way. The main contribution is the provisioning of a flexible and easily programmable middleware to experiment with different economy-driven scheduling policies for service-oriented computing.

In the tenth contribution, Franke and coauthors address necessary modifications and extensions to existing Grid computing approaches in order to meet modern business demand. They attempt to bridge the gap between architectures for solving large scientific problems and concepts for dealing with performance, monitoring aspects, security, and isolation issues.

Assunção et al. elaborate on the simulation of service-oriented computing and provisioning policies for autonomic utility Grids. They address the issue of QoS in the context of the provider's decision about the resource allocation. In their simulations, they propose a decentralized, self-organizing resource allocation and provisioning scheme based on Friedrich A. von Heyek's Catallaxy approach.

In the next paper, Maillé and Toka present a peer-to-peer backup system where users offer some of their storage space to provide services for others. Their economic model differentiates from the regular peer-to-peer models by incentivizing users to contribute to a service. In the following, they show that their proposed symmetric scheme is outperformed by a revenue maximizing monopoly with respect to social welfare maximization.

Finally, contributions on the research projects ArguGrid, AssessGrid, CatNets, edutain@grid, GridEcon, and SORMA give an overview on current and ongoing research in Grid economics.

In preparation of this fourth workshop, 96 reviews were written for which we would like to thank our Program Committee. The Program Committee served within a very short time frame in order to enable the successful preparation of this workshop. In particular, we would like to thank for this: Hermant K. Bhargava, Rajkumar Buyya, John Chuang, Costas Courcoubetis, Dang Minh Quan, John Darlington, Torsten Eymann, Thomas Fahringer, Kartik Hosanager, Chun-Hsi Huang, Junseok Hwang, Harald Kornmayer, Ramayya Krishnan, Kevin Lai, Hing-Yan Lee, Jysoo Lee, Steven Miller, Dirk Neumann, David Parkes, Omer Rana, Peter Reichl, Simon See, Satoshi Sekiguchi, Burkhard Stiller, Yoshio Tanaka, Maria Tsakali, Bruno Tuffin, Gabriele von Voigt, Kerstin Voss, and Stefan Wesner. As a result of the review process, the overall acceptance rate of the workshop was at 40% of the submitted contributions.

Furthermore, we would like to thank Alfed Hofmann and Ursula Barth from Springer, who made this volume possible through their patience and continuously positive support. We would also like to thank the organizers of the 2007 Euro-Par Conference – namely, Luc Bougé – for the substantial support in hosting the GECON 2007 workshop in Rennes, France.

Finally, we would like to express our gratitude to Sonja Klingert for her extensive effort in preparing the manuscripts for the proceedings of this workshop.

August 2007

Daniel J. Veit
Jörn Altmann

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GECON 2007 was organized by the International University in Germany, Bruchsal, Germany, Department of Computer Networks and Distributed Systems and the University of Mannheim, Germany, Department of Business Administration and Information Systems, in collaboration with EuroPar 2007.

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Table of Contents

Grid Business Modeling

Market Mechanisms for the Grid

Economic Grid Service Provisioning

Research Projects on Grid Economics

Adopting the Grid for Business Purposes: The Main Objectives and the Associated Economic Issues

George A. Thanos, Costas Courcoubetis, and George D. Stamoulis

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Abstract. Grid technology offers numerous opportunities for the players involved. Despite the fact that the academic community has already exploited many of them, there is an evident reluctance from the business community to act likewise. Recent analysis reveals that the problem lies in overcoming certain business barriers rather than technological ones. At this stage understanding the real-life economic issues from a business perspective is deemed as more important than gaining understanding of complex theoretical economical problems, such as those related to accounting or resource sharing mechanisms especially in cases where the players do not exhibit the required technological expertise. This paper is stimulated from interaction with players from the industry and aims to fill this gap. In particular, we identify and evaluate a number of economic issues that should be taken into consideration by industrial players so that their trust and confidence in the adoption of this promising technology be increased.[1]

Keywords: Grid Technology, economics, resource sharing, virtual organisations, market, economies of scale, network externalities etc.

1 Introduction

Grid technology promises a new way of delivering services across IP-based infrastructures. These range from common ones, such as existing mass multimedia services, to more complex and demanding customised industrial applications. Over the last years Grid technology has proven its merits through enabling the execution of highly resource demanding applications for the scientific community some of which were previously only realised over expensive high-performance computing (HPC) centres.

However, in order for Grid technology to fulfil the aforementioned promise, it has first to be adopted by the diverse business community thus being provided and consequently validated, by a significantly larger number of providers and users. Recent studies [1] and European initiatives [2] have indicated a reluctance and slow take-off of Grid technology and market by the industry, something attributed mainly to economic and market barriers rather than to technological ones.

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[1] This project has been partly supported by FP6 EU-funded IST projects BEinGRID (IST5-034702) and GridEcon (IST5-033634).

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So far there has being a lot of work around theoretical economical analysis examining issues like accounting and resource sharing mechanisms for Grid architectures etc. However, our experience from interacting with industry players and discussing their concerns has shown that prior to solving complex architectural issues there is an evident need for analysing the Grid phenomenon and its economic side effects from a business perspective. Thus, in this paper we identify and analyse those criteria and economic issues that a new player should take into consideration prior to making his decision whether to adopt Grid technology for his business or not and how these will affect his Grid business afterwards. Such a decision can be made by means of a relevant model, which will take the factors identified in the present paper as inputs. Our overall aim is to increase the confidence of the industry towards Grid adoption by exposing the business issues, both positive and negative ones, that once taken into careful consideration by the value chain players will enable them to realise the numerous opportunities that Grid technology has to offer and at the same time construct feasible business plans to fully exploit them.

Our identification and analysis has been performed with support by the Integrated Project Business Experiments in Grid – BEinGRID [3], European Union's largest integrated project funded by the Information Society Technologies (IST) research, part of EU's Framework Programme 6 [4]. The communication with 18 real-life Business Experiments from various industries provided the practical framework to validate our theoretical analysis.

The paper is structured as follows: a brief introduction to Grid economics is presented in Section 2 followed by a discussion on the main economic objectives for adopting the Grid and an initial identification of associated economic issues in Section 3. Section 4 identifies and analyses a number of economic issues related to Grid adoption from the industry whereas Section 5 provides a case study and evaluation of how these issues affect real-life scenarios. Section 6 provides some concluding remarks.

2 A Brief Introduction to Grid Economics and Related Work

Firstly, it is imperative to review some basic definitions related to Grid Technology and the current work in Grid Economics. To start with, we define a Grid service as a Web Service that provides some well-defined interfaces and follows specific conventions [5]. The interfaces address issues such as address discovery, dynamic service creation, lifetime management, notification, and manageability. The conventions regulate naming and upgradeability of services. Each service described in the Open Grid Services Architecture (OGSA) [6] is a single Grid service or a composition of Grid services. A Grid middleware is typically composed of several Grid services with different functionality. Usually, at least the following functionalities are covered: resource management, Job management, Service discovery, scheduling, accounting and security.

Nowadays, a single business process and value chain of a company can be performed by several business partners. The company involved in this process is then a virtual company or organization (VO), as it is only a temporary aggregation of partners in order to perform a specific process. The corresponding concept from economics is called the coalition. VOs can be seen one of the most important drives for Grid technology adoption as it allows these organisations to efficiently share and utilise their geographically distributed computing, storage and data resources over a common infrastructure.

Among the first to raise a number of true economic issues focused on the commercialization of Grid resources (i.e. computing) were Kenyon and Cheliotis. Specifically, in their work they argue that Grid commodity is rather a stochastic one rather than as a deterministic one (such as oil, electricity, etc). Since Grid resources are non-storable, the authors claim that future contracts will be the basic building blocks in Grid environments instead of spot markets. Market uncertainty and decision support are the most important issues that need to be addressed in this context.

The authors identify a set of requirements for commercialization of Grid resources such as product construction and reservation, contract management, clearing, accounting and billing, trading support, price formation and decision support. Also, in [7], Cheliotis et al. set a number of important questions on the successful creation of a Grid market. They argue that the most important part for a successful Grid market creation is to fully understand and foster user requirements and demands. Overall, [8], [9], [7] mostly define the most important issues for Grid commercialization and they do not propose any specific solutions for them.

Gray on the other hand in [10] discusses the economic tradeoffs of doing Grid-scale distributed computing (WAN rather than LAN clusters). Specifically, Gray analyzes the economics of outsourcing. Using simple commercial examples, he calculates the corresponding value of 1$ for bandwidth over the WAN, for number of CPU instructions, for CPU time, for disk space, for database accesses and for disk bandwidth. Identifying communication cost as a bottleneck, Gray concludes on a rule of thumb regarding outsourcing, according to which computations must be nearly stateless and have more than 10 hours of CPU time per GB of network traffic before outsourcing the computation makes economic sense. Otherwise, LAN cluster provide a more economically viable alternative.

Probably the most extensive work on Grid Economics up-to-date has been performed by the GRIDS (Grid Computing and Distributed Systems) laboratory, headed by Buyya. Their most significant research work related to our work is the Economy Grid project where it is clearly identified that a major challenge for next-generation Grid computing is the creation of an "Economy Grid", meaning a competitive realistic Grid Marketplace that regulates supply and demand, and offers the right incentives to players (suppliers and consumers) for improving the utilization of resources. The next step was the Gridbus [11] project, aiming at producing a set of Grid middleware technologies to support e-science and e-business applications. In some of the designed and developed components for this technology one will find incorporated features relevant to "Grid Economics", such as a broker agent software for job scheduling, a market directory for publishing and searching for available services, and a centralized infrastructure that provides accounting and payment services. The "Economy Grid" project, the GRACE architecture and an overview of related work on price setting, market-based resource allocation and scheduling systems are presented in [12].

Other works in the Grid Economics include a centralized strategy-proof architecture for Grid Computing by Egg [13] and the Mojo Economy [14], the Weng

Price-setting mechanisms [15], the price prediction mechanisms by [16], and work driven from European funded IST projects.

As already mentioned the aforementioned work is more focused in the theoretical analysis of economic mechanisms and fails to analyse specific economic issues from a business perspective such as the economies of scale/scope, network externalities, free-riding problems, information asymmetry, and impacts to other markets etc which we will address in the subsequent sections.

3 Economic Objectives for Adopting the Grid and Initial Identification of the Associated Economic Issues

The aim of this section is to discuss the main economic objectives for adopting the Grid for Business and identify the underlying economic issues/concerns. We propose at this stage the main three alternative economic reasons for Grid to be used in commercial applications. By keeping the number of alternatives small and hence abstracting to a significant level the implementation context, we can understand the economics better. These are discussed in the subsequent sections.

3.1 Optimization of Processing Power in a Single Organization

A single organization may require processing power that cannot be provided by means of stand-alone machines. By interconnecting these machines in a Grid, high processing power can be used even by a single application. Thus, the organization achieves both a high peak processing capacity and a high average utilization of the processing power available, since this can be flexibly allocated to multiple Grid-enabled applications. These features also lead to increased cost-efficiency for the infrastructure deployed. This is particularly important for a large organization with several departments scattered around the world, each possessing its own local infrastructure. Interconnecting these in a Grid attains the aforementioned performance enhancement, high exploitation of resources, and cost-efficiency and economies of scale, due to the fact that interconnection of all machines improves utilization of each individual one. Moreover, the whole approach is scalable, due to the fact that the Grid middleware provides automatic load balancing and transparent usage of the hardware. Besides these, if the various departments possess complementary infrastructure, then the organization also attains economies of scope.

Regarding management, since the Grid belongs to single organization, a centralized approach is always an option. On the other hand, particularly if there are multiple departments in the organization, with some notion of autonomy (e.g. own infrastructure contributed to Grid and IT budget), then self-management of the Grid by means of economic/market mechanisms is possible and probably preferable. Indeed, the centralized approach requires complete information, which is not always straightforward to gather in a highly distributed single-domain system. On the other hand, a market mechanism defining prices for accessing and using the Grid resources by the various departments provides the right incentives for rational usage and results in shaping of demand according to the actual needs, which in fact may be thus discovered; prices may either be really monetary, or virtual ones with each department being allocated a Grid virtual budget. This approach also requires