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Danny OH
*Singapore Management University*, dannyoh@smu.edu.sg

Shih-Fen CHENG
*Singapore Management University*, sfcheng@smu.edu.sg

Dan MA
*Singapore Management University*, madan@smu.edu.sg

Ravi BAPNA
*Indian School of Business*



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# DESIGNING AN EXPERIMENTAL GAMING PLATFORM FOR TRADING GRID RESOURCES

DANNY OH, CHENG SHIH-FEN and MA DAN

*School of Information Systems*
*Singapore Management University*

RAVI BAPNA

*Centre for Information Technology and the Networked Economy*
*Indian School of Business*

This paper describes our current work in designing an experimental gaming platform for simulating the trading of grid resources. The open platform allows researchers in grid economics to experiment with different market structures and pricing models. We would be using a design science approach in the implementation. Key design considerations and an overview of the functional design of the platform are presented and discussed.

## 1. Introduction

Utility computing is a recent and exciting development in IT outsourcing whereby IT resources are provided as needed and the customer pays only for actual use. Companies who wish to provide shared computing facilities to customers often face the challenge on how to price their services. For example, Sun, IBM and HP have all adopted the fixed price model for various practical reasons. However, the fixed price model may not lead to an economically-efficient resource allocation, especially when market demand is high and volatile. The question then arises as to what economic market mechanisms are suitable for facilitating price discovery and economic valuation based resource allocation for shared computing services. Currently, little market data is available to test the efficacy of current approaches. Yet, such data are critical to build and test theories of consumer behavior and choice in the utility computing context. In addition, the experimental data provide a data source in situations where relevant field data cannot be obtained. This motivates us to develop an experimental platform for understanding the dynamics of trading of computing resources.

## 2. Motivation

To do research in grid economics, it is essential for researchers to have a platform which allows them to design and test various market models and pricing strategies. To the best of our knowledge, there is no such publicly available simulation system yet. In this work, we use the design science approach [5] to conceptualize a novel IT artifact that permits real human players and automated agents to trade in computing resources to accomplish jobs for which they have monetary values, as well as to sell unused computing capacity on their networked machines.

## 3. Design Science Approach

As per Hevner *et al.* (2004), the first step in pursuing the design science approach is to design an IT artifact. In that spirit, the availability of an open-sourced market simulation system will allow researchers to conduct experiments on various pricing mechanisms such as different types of auction and negotiation models, posted price model, and different tariff structures of pricing models. These pricing and allocation mechanisms will be evaluated in the context of an experimental trading environment that is designed using the principles of induced value theory [12].

## 4. Research Contributions

The key research question of this work is to evaluate various market models and pricing strategies for the trading of grid resources so as to make recommendations for suitable ones. Additionally, we are also interested to find out how uniform and discriminatory pricing schemes compare viz efficiency and fairness given rationally bounded agents? Finally, we are keen to determine if it is feasible to introduce spot and future prices for CPU and storage commodities.

## 5. Market Game Simulation Platform

Instead of developing a full fledged market simulation system from scratch, we will take advantage of existing systems which have already been developed for the running of market games. Examples of such systems include AB3D [6], AuctionBot [8], e-Game [7], eMediator [11] and Meet2Trade [2]. To the best of our knowledge, the only openly available system is AB3D. Therefore, in this project, we will use AB3D as the software foundation for our development.

For all these scenarios, there are two major components: 1) agents that represent individual decision makers, and 2) market mechanisms that allow exchange of resources. Due to the decentralized nature of the problem, most agent-specific information, including preferences over tasks, capabilities in performing tasks and resource holdings, are endowed to each agent. Moreover, probability distributions are usually used in describing much of this information to account for uncertainties involved in the problem. This probabilistic representation of the problem makes it very difficult to analytically evaluate the performances of combinations of strategies.

To estimate the performances of combinations of strategies, we can define a market game as a collection of agents and market mechanisms, and execute Monte Carlo simulations, in which each agent's related information is generated according to the governing distribution. The AB3D platform is developed to support massive simulation efforts. In the following paragraphs, we provide more details on the various components of the platform. The interactions of the above components are illustrated in Figure 1.

- **Scripting auction engine**. AB3D supports a wide range of market mechanisms, specified in a high-level rule-based auction scripting language. The scripting language exposes parameters characterizing the space of bidding, information revelation, and allocation policies [9]. With proper programming constructs, flow control can also be easily achieved.
- **Market game engine**. To generate a market game probabilistically, we need to provide both common information and agent-specific information, as described as follows:
    - *Common information*: this refers to important information agents should know even before the game is actually executed. Most common information is related to the structure of the game, including (but not limited to): i) length of the game, ii) number of agents in the game, and their respective roles, if any (e.g., buyer, seller), and iii) number and type of auctions used in the game.
    - *Agent-specific information*: in a typical decentralized resource allocation problem, each agent is endowed with information that is only accessible to itself. This information may include task properties (e.g., the value for fulfilling the task, the deadline of the task, and the resource requirement of the task), and initial resource endowment. To support probabilistic game generation, a set of programming constructs, called game description language (GDL) is developed to support basic variable declarations, looping, and random variable generations. A detailed description on GDL is available in Ref. 10.

- **Agent interface**. The game system implements a communication interface through which bids, queries, and any other game interactions are transmitted.
- **Scorer**. The scorer evaluates the performance of each agent at the end of each game. Scoring typically entails the assembly of transactions to determine final holdings, and for each agent, an allocation of resources to activities maximizing its own objective function. For each agent and the strategy it represents, this score indicates how well it performs in this particular strategy combination for some realization of the agent preferences.
- **Market control room**. An important element of the design science approach is to build in an iterative methodology that searches for gaps between the design objectives and the observed metrics. To achieve this, a market control room will be created which is under the control of the researcher. It takes as input the performance metrics, such as efficiency measures and profits, from the monitoring of the market and sets a variety of system level parameters that are in constant need of fine tuning and exploration.
- **WS-Agreement Generator**. The outcome of the games (i.e. resources to be allocated per agent) will be composed as WS-Agreements. WS-Agreement is a XML based language and protocol designed for advertising the capabilities of resource providers and creating service agreements, and for monitoring agreement compliance at runtime. It is the proposed standard for the Grid Resource Allocation Agreement Protocol [4].

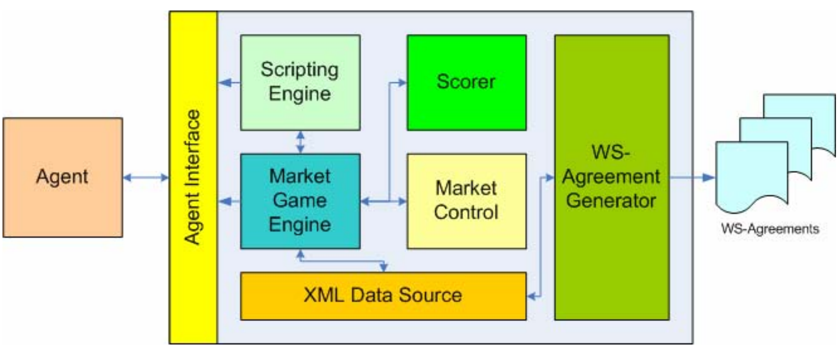


Figure 1: General market gaming platform, depicted at functional level.

With this general market gaming platform, we can execute large number of simulations in order to accurately estimate the payoff for each agent strategy in a strategy combination. Note that since it is possible that multiple copies of the same strategy may appear in a strategy combination, when estimating the payoff associated with some strategy, we compute the average payoff for all agents using this strategy, and let the average payoff be the estimated payoff of this strategy.

## 6. Market and Pricing Models

We plan to use the market gaming platform to experiment with different market models. Existing literature focuses more on market-based models [1,3]. Therefore, in the initial phase, we plan to support the commodity market model and auction model first. Other models such as bargaining model and tendering model will be supported in subsequent phases.

We also plan to experiment with different pricing models. We will take the fixed pricing model as benchmark, and study and compare it with other pricing models. We are interested in examining how vendor profit, consumer surplus, as well as social welfare will change under different pricing models. As a result, we are able to identify the optimal resource allocation strategy.

In the initial phase, we will focus on different variations of the auction-based pricing. In particular, we are very interested to model the market as a multi-attribute combinatorial exchange since it allows multiple buyers and sellers to simultaneously submit bids on heterogeneous services. Support for other models such as multi-part tariffs will be available in subsequent phases.

Since different businesses have different requirements, goals, policies and strategies, we expect a grid market to support a variety of market models. It is important to understand how each of these models affects allocation fairness, system efficiency and performance.

## 7. Conclusion

In this paper, we describe our current work in developing an experimental gaming platform for trading of grid resources. We also describe key design considerations such as the different ways of commoditizing grid resources, market structures and pricing models which have significant impacts in the design of the platform. Moving forward, we would be concentrating on developing the gaming platform and designing games for real players and automated agents involving the trading of grid resources. We hope to use the platform to gather data that will help us answer our research questions and to further understand the entire Grid economy concept.

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