A New Resource Allocation Model for Grid Networks based on Bargaining in a Competitive Market

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Abstract
Resource allocation is an important subject in Grid computing environment. Many types of non-similar resources exist in the grid computing environment which can also be considered from economics’ point of view. Moreover, suppliers and customers are independent subjects with two very different environments in the grid computing environment. Therefore negotiations are considered very important. Bargaining is one of the most functional methods of negotiation in economic grid. In this paper a new resource allocation algorithm based on bargaining in a competitive market is proposed. The presented paper tries to increase the number and speed of successful negotiation by considering the meaning of competition in the market and deadline in the bargaining model. The proposed model is suitable for real-time software implementation to illustrate the concept of buying from seller’s competitive market. The Simulation results on prototype data show the effectiveness of the proposed method.

Keywords: Bargaining, Competitive Market, Grid, Market-Based Dealers, Negotiation Strategy, Resource Allocation.

1 Introduction

Resource consumers pay the cost of resources to their owners in grid computing. Grid computing is a market where the resource suppliers are the sellers and resource consumers are the buyers. To sell the resources a seller has a set of rules in his mind. Similarly, the buyers have a set of rules and standards in mind. If the seller does not satisfy the rules and conditions required by the buyer and thinks of his own conditions, the buyer will seek another seller. So resource discovery systems must attend to economic criterion during the process of discovery.

In an environment where the cost is not predetermined, the process of resource discovery is based on the price requested by the customer. In fact in such an environment resource discovery is carried out according

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to economic criterion. Anyhow, the process of discovery based on economic criterion needs certain price setting mechanisms for the resources in environments where the price is not defined [1].

There are many pricing models offered in the grid computing [2]. One of the most functional models is the reciprocal negotiation model in which the participants in a contract can only take one role in a specific course [3]. This means that one side makes a proposal and the other side either accepts or rejects it. Every negotiation model consists of specific strategies to express the aims of each section of negotiation. In the first model the two sides are firm and strong meaning that the reserved price changes very slowly. In the second model the reserved price in every round of negotiation changes moderately, in the last type the rate of price change is more rapidly. In multiparty negotiation [3], the customers meet with various providers and the process of negotiation continues until an agreement is reached with a specific seller [3]. The negotiation strategies can happen orderly or simultaneously. Double-sided simultaneous negotiation is proved to be more efficient compared to other methods.

Other models used are: bargaining, suggestion and contract (bidding), discount (auction) and the model based on exchange clearing [3, 4]. The bargain model has a few advantages compared to other models: for example it can be used in environments where supply and demand systems and resource prices are not clear cut. This model is a fair method for setting the price of the resources and it does not need a central controller which can act as system bottleneck either. The bargaining protocol is straight forward and it nicely reduces computing and communicating costs [5]. There are two bargaining models: cooperative bargaining in which the two sides are aware of each other’s strategies and the non-cooperative model in which the two sides are not aware of other side’s strategies. The first model is not operational in the grid [6].

In the bargaining model the seller and the buyer negotiate the resource price in order to increase their own profit. The customer starts with a very low price and the seller with a high one and the negotiation continues by the two sides until an agreement is reached.

In this paper a new resource allocation algorithm based on bargaining in a competitive market is proposed. The presented paper tries to increase the number and speed of successful negotiation by considering the meaning of competition in the market and deadline in the bargaining model. The proposed method is implemented and the simulation results on prototype data show the effectiveness of the proposed method.

2 Related Works

The issue of transaction in resource management is a complicated issue because although it is aiming to improve profits, it must also consider the time of negotiation and the opponents. One of the important and successful models of decision making process in negotiations is marked-based negotiation [7]. Market-based models can be categorized as follows: bartering based model, price-based model and bargaining model [1]. In the bartering based model presented in [1] and [8], all companies must possess sources and perform business by exchanging them (for example the exchange of CPU time with storage space). In the priced-based model, the sources have a price which is set according to supply, demand and value in the economic system. In bargaining model [9], the suppliers and consumers of resources bargain for the price, period of access and use of these resources. The brokers of both sellers and buyers have their own interest at heart and negotiate to achieve that goal. [9], [11] negotiations continue until they reach a price which is accepted by both sides or one side is no longer willing to continue the negotiation. This negotiation is led by the user’s needs (for example from the user’s point of view, the deadline can be very flexible or not). The sellers’ broker can risk it and negotiate for lowest price possible and leave expensive places. This can result in using less of the resources and so suppliers may be inclined to lower the price instead of wasting the resource cycles [9], [10]. In the process of negotiation many criteria can be considered, such as deadline, determining the minimum possible profit or maximum possible loss [9], [11]. Using any one of
these criteria in the buyers’ and sellers’ broker’s aim function depends on the grid environment and type of application and the required service from the distributed computing economic system. For example in the soft immediate service where there is a deadline, the parameter for fast negotiation must be present. In negotiations based on market, various parameters and aims have been stated in different research. Those related to the purpose of this paper are mentioned below:

- **Dynamic market:** similar to conventional resources (e.g. electricity and gasoline), calculation resources in a distributed computing economic system is of a dynamic nature too. The value of the grid resources are deducted from a need and scarcity structure [12]. A customer’s need for resources stays constant in the grid but is subject to change over time. For example: during a project, users may have loading with different responsibilities in different parts of the project. Naturally, when calculation resources are rare, there will be difference in the result of evaluating the required resources by the customers. So, resources and services will permanently be added or deleted from the distributed computing economic system [13][14]. That is why it is vital that market dynamism is eliminated from the concept. 1) Resource values change with customer needs and customers can place/cancel orders, this may be related to the machines’ speed too. 2) Resource capacity increases the suppliers’ ability to build services / available resources and disconnecting from a distributed computing economic system. Using marketing mechanisms helps regulate demand and supply of resources[15].When required resources have limited budget and are rare, using assigned motives for resource suppliers for collaboration and usage of distributed computing economic system, must be carried out carefully. Therefore, using a marketing mechanism may decrease the possibility of users wasting limited calculation resources [16]. Also, a resource managing system needs continuous adaptive changes in 1) calculation resources’ availability (like: suppliers leave the distributed computing economic system or more customers join the system) and 2) users’ needs (like: most works need customers) [15].

- **Corporate resources:** resource management system must be a support to Joint allocation of computing resources (or data) [17]. In the distributed computing economic system’s calculations, the subject of allocating joint resources is an applied multiple resource allocation pertaining to different administrative domains. To coordinate the use of leased multiple resources to different administrative domains; the reserved resources are valid that only have very necessary time and period of a resource capacity [18]. In contrast to e-commerce negotiations; where there is one set of buy/sell negotiation for a product or service, maybe in a single phase negotiation, there is a user of distributed computing economic system which needs to engage in a multi-phase negotiation process with resource owners for reservation, achievement, coordinating time and availability of potentially renegotiated resources. Although normal contract protocols like the ones mentioned in [16] are enough for most general e-commerce negotiations, business (trade) with negotiating the allocation of shared resources, needs more complex negotiating protocols. An example protocol is the learning and negotiation protocol, SNAP service.

- **Mild bilateral trade and profits:** The laws in PANDA [19] state policies that consider the customer’s satisfaction and with regard to the seller’s brand reputation, arranges the two sides’ profit ratio. For example: PANDA can state a policy like: “if the client’s proposal was near to the agent’s, and if the customer is new, accept the proposal” using a rule, when market-based strategy considers optimized utilities. This protocol uses a set of fuzzy laws for guiding agents in making decisions in transactions. These agents employ fuzzy laws to determine profitability. The facts used in these laws are based on statistics from demand for present resource and rate of recent success/failure of customer, amount of presented resources and statistics of contracts based on foreign policies such as: priorities given to new customers[20], [21]. In the distributed computing economic system environment, more success is designed in negotiation for achieving calculation resources in order to avoid any possible kind of delay which blocks waiting for a resource allocation. In short, usually in a contract, many aspects are
considered, the most important of which are the rate of contract success, method of pricing the grid resources, social factors (e.g. in-business communications) and customer satisfaction/communication [22],[23].

There are several methods suggested for resource management in distributed systems [24, 25, 27, 28, 29, 30]. It has stated various methods in relation to grid resources allocation with economical approach. In [26], the use of negotiation agents about e-commerce to negotiate the resources in grid computing has been studied. Here, the areas worked on are as follows: 1. e-negotiation agent; 2. Gcommerce; and 3. initialization in terms of creating agents for G-negotiation.

Basically, negotiation is necessary in grid computing, because resource owners cannot hand over the computing resources to the buyer without any knowledge [31]. In addition, since the members of a grid work independently, it is necessary that different mechanisms are conducted. The negotiating parties in the grid have the chance to increase investment and decrease expenses through bargaining. The two sides must also pay attention to resource allocation and the delay caused by bargaining in the negotiation process because any kind of delay in resource allocation can result in great burden on the system. So the act of bargaining needs a protocol [32]. Such protocols, rules and strategies are designed with regard to parameters like deadline.

In the four phase model (e.g., see [33] and [34-39]), the strategic negotiation model based on a few suggested factors, is the center of four phase scenario for resource allocation network. The resource allocation scenario in the economic awareness network environment includes the following four main phases:

1. Registering the grid resource owners (GRO) and grid resource consumers (GRC).
2. Making market - and behavior - driven negotiation agents and preparing necessary information (which is the existing information needed to start the negotiation).
3. Start of negotiation based on the suggested strategic negotiation model.
4. Closing the negotiation and conducting the task (if the negotiation is successful).

The suggested scenario is based on synchronous and asynchronous message exchange systems. In synchronous message exchange system, the sending and receiving agents await each sent message. In other words, the sender does not continue work until a receiving agent is received. On the other hand, in the asynchronous message exchange system, the sending agents sends a message to the receiving agent regardless of waiting to see whether it is ready or not.

In the negotiation model [10] the proposed transaction model is a two way simultaneous contract of the number – for - number type in which every customer must request the services based on function, in order to prioritize the needs of the customer. Also every customer adjusts the services according to his manager’s priority. On the other hand, every seller can search the best and most appropriate proposed price and offer services accordingly. In this model the customer first declares his required services to the source’s broker. So the type of resource is determined as is the amount of required data.

Negotiation strategies in this model consist of utility function, negotiators’ priorities and the time of negotiation. Grid resource allocation model presented in this paper in based on market and customer and seller profit is based on utility function. In this model there is also a deadline for the bargaining process. The bargaining model we present is compared to the two models in the [10] and [33] articles because the presented model and the models used for comparison have some similarities in aims and characteristics.

### 3 The Proposed Model

Bargaining model presented in this article is one of multiparty type, meaning there are a few buyers and a few sellers. In this model every customer declares his needs together with preferences and the sellers
search for the best and most appropriate proposed price for the requested service. At first, the customer’s agent declares the needed service to the resource broker. Customers’ agents specify the amount of data, the ability to process the required work and deadline before bargaining starts in the negotiation process. These three quantities are presented by the units: Megabyte, million instructions and milliseconds in grid information service (GIS) accordingly.

![Sequence Diagram](image)

As it can be seen in Fig.1, the process of requesting the services from the customer and receiving it from the seller is obvious. By considering negotiator deadline the bargaining process between the Customer and the Seller is used to select the most appropriate service.

### 3.1. The process of negotiation from the customer’s point of view

From a customer’s point of view a buyer can enter negotiation and bargaining for a specific resource with a few sellers simultaneously and whoever reaches an agreement sooner the other negotiations are canceled. In multiparty negotiations a customer must compete against other customers to succeed with maximum profit.

Opponent of customer $C_1$ means a customer who has a similar bargaining behavior and proposed price to customer $C_1$. To determine similarity utility function is used.

The utility function formula is as follows:

$$ U_t^{C_i} = \frac{(R P_t^{C_i} - P_t^{C_i})}{(R P_t^{C_i} - R P_t^{C_i})} $$  (3.1)
According to equation (3.1), the utility function $U_t$ contains the parameters $RP$ (roof price for customer), $IP$ (initial price proposed by the buyer) and $Pt$ (proposed price at t round of bargaining).

To determine the opponent, every customer gets the other customers’ proposed prices from the seller and decides the amount of $U_t$ accordingly.

Those customers having the same $U_t$ as the buyer are regarded as opponents and their number is shown by $R_c$. Although to determine similarity, instead of analyzing the equality of $U_t$ values, one can imagine a threshold value and the $U_t$ values which are lower can be considered similar (opponent). The customer uses the equation below in order to determine the coefficient of variation of the proposed prices in both negotiations:

$$\text{CF}_{t+1}^C = R_c - N_c \left[ (1 - \frac{t}{d})^{\frac{\alpha}{N_c}} \right]$$  (3.2)

According to equation (3.2), the price change factor in each round of negotiation $\text{CF}_t$ consists of the parameters $R_c$ (number of opponents), $N_c$ (total number of negotiators), $d$ (deadline to reach an agreement), $t$ (negotiation round), $\alpha$ (type of negotiation, the value $\alpha=1$ is linear, $\alpha>1$ is hard, $0<\alpha<1$ is mild).

Using equations (3.3) and (3.4) a new proposed price is specified which has the parameters $P_{t+1}^C$ (proposed price by customer i) and $P_{t+1}^J$ (proposed price by customer j).

$$P_{t+1}^C = (\text{CF}_t \times \Delta t) + P_t^C$$ (3.3)

$$\Delta t = |P_{t+1}^C - P_{t+1}^J|$$ (3.4)

### 3.2. The process of negotiation from a seller’s point of view

From a seller’s point of view all other sellers are considered rivals and every seller tries to satisfy their previous customers so that they return for future purchases. To this end the seller records all the customers’ previous purchases and with regard to that record tries to reach an agreement sooner, so regular customers will have higher priority.

In equation (3.5), $\text{CF}_t$ shows the number of rivals and has the parameters $N_R$ (number of customers) and $N_A$ (the number of times an agreement has been reached with a customer (record)).

$$\text{CF}_t = \left( 1 - \frac{t}{d} \right)^{\frac{\alpha}{N_R \times N_A}}$$ (3.5)

### 4 The Experimental Results

In this part the result of the simulation and the analysis of the proposed model are presented. To execute the new model, the simulation tool GridSim is used [33]. The presented model will be compared to the two models presented in [10] and [33]. A network topology based on BADG network is created in the simulation [40]. There are five sources in four different areas of network topology. The parameters related to the sources are stated in [10]. Processing abilities of CPU resources is measured using MIPS degrees. The work done in this article consists of $10^8$ to $3 \times 10^8$ instructions. Various experiments have been carried out based on specific model of input work and different number of works that have entered the system under similar circumstances. The model for requesting input resources used in every experiment is on the basis of Poisson distribution. Usually Poisson distribution is a suitable model for cases where a number of similar and independent requests for resources have entered the system. In addition, in every step of evaluation, 100, 200, 300, 400 and 500 works enter the system sequentially. The proposed model is evaluated regarding the average response time (ART), number of negotiation rounds (NNR) and the rate of seller and buyer profit. The rate of seller and buyer profit is assessed based on the difference between the
reserved price and the agreed price. The results are compared with the two sided simultaneous negotiation models in the [10] and [33] sections.

Table 1: Australian bell analysis data testbed simulated using gridsim[40].

<table>
<thead>
<tr>
<th>Name</th>
<th>Resource Type &amp; Characteristics</th>
<th>Num CPU</th>
<th>Processor Ability</th>
</tr>
</thead>
<tbody>
<tr>
<td>R0</td>
<td>PC with Intel Pentium 2.0 Ghz, 512 MB RAM</td>
<td>1</td>
<td>684</td>
</tr>
<tr>
<td>R1</td>
<td>Ibm eServer with dual Intel Xeon 2.6 Ghz, 2 GB RAM</td>
<td>4</td>
<td>1050</td>
</tr>
<tr>
<td>R2</td>
<td>Ibm eServer with dual Intel Xeon 2.6 Ghz, 2 GB RAM</td>
<td>4</td>
<td>1050</td>
</tr>
<tr>
<td>R3</td>
<td>Ibm eServer with dual Intel Xeon 2.6 Ghz, 2 GB RAM</td>
<td>4</td>
<td>1050</td>
</tr>
</tbody>
</table>

The model is evaluated based on four criteria:
1. Average response time: the periodical number of negotiation continues and comes to the conclusion that may results in agreement or disagreement.
2. Buyers moderate profit: per buyer's profit is the difference between the agreed price and the booked price. As the buyers are too many, the average profit of all buyers is calculated to evaluate the model.
3. Average profit per seller: the difference of the agreed price and the real reserved price for the sale.
4. Number of agreements: number of successful negotiations.

Factors in each test are evaluated as (test variables) factors of the number of the competitors, competition deadline and prior agreements.

All experimental dataset BADG [40] the standard dataset used to test grid. This dataset contains five servers that this paper salesman called Grid services as well as batch jobs, 100, 200, 300, 400 and 500 of that are called clients in here. Thus, each experiment is repeated for all customer groups. The main idea of the proposed model is the use of the concept of competing clients, 10%, 20%, 30% and 50% considered as a competitor. Tests, for example, in 500 clients are carried on for 50, 100, 150, and 250 people. In addition, to investigate the economic aspects of the model, prices are based on U.S. dollars. The buyer considers the maximum price for himself and the seller considers a minimum price, the difference of the agreed price and these prices show the dealers' profit.

4.1. Scenario one
The experiments based on evaluation of proposed model with its criterion which include:
1) the number of agreements (successful negotiations),
2) buyer’s average profit,
3) seller’s average profit,
4) average response time (the number of rounds in which an agreement is reached).

The results are shown in figures two to seven.
Figure 2: effect of number of opponents on the average response time

Figure 3: effect of number of opponents on number of agreements reached

Figure 4: effect of number of opponents on customer profit
4.2. Scenario two
The experiment is based on the comparison between the proposed model and the previous algorithms. The results are shown in figures eight to nineteen.
Figure 8: comparison of average response time with A. and B.’s algorithms

Figure 9: comparison of average response time with A. and B.’s algorithms

Figure 10: comparison of average response time with A. and B.’s algorithms
Figure 11: comparison of buyers’ profit

Figure 12: average profit of seller R_0

Figure 13: average profit of seller R_1
Figure 14: average profit of seller R_2

Figure 15: average profit of seller R_3

Figure 16: average profit of seller R_4
5 Conclusion

In this paper a new resource allocation algorithm based on bargaining in a competitive market is proposed. This will increase the number and the speed of successful negotiation by considering the
meaning of competition in the market and deadline in the bargaining model which makes it suitable for real-time software implementation. These points are based on the proposed model taking into account the period of negotiation, the client's competitors and customers of the dealer trying to speed up the negotiation, the seller can increase profits by increasing the number of successful negotiations. Evaluation and comparison of the proposed model revealed that the main approach in this model is increasing the speed of negotiation and as a result reducing the time in which an agreement is reached, which makes the model more appropriate for prompt works compared to other models. Also this model’s approach is to increase seller’s profit by presenting similar customers as opponents and also the record of the customers.

One of the important characteristics of the proposed model is its simplicity which makes comprehension and prediction of events easier. So this model is usable where the speed of negotiation and seller’s profit are important.

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