Presentation of a new Method based on the Bargaining Model for Allocation of Resources in Grid

Mehdi Nasiri Noroozani and Mansoor Aminilari
1. Computer and Information Technology Dept College of Engineering
Science and Research Branch Azad Islamic University Fars, Iran
* Corresponding author E-mail addresses: aminilari@gmail.com (Dr. Aminilari)

Abstract

Grid is a network of computers and supercomputers which have made possible the ability to process data at very higher speeds using interconnected processors and has facilitated the possibility of doing voluminous computational operations. In solving trade issues by Grid, as both owners of the sources and also the users intend to maximize their profitability, the computational environment of Grid must support economic issues related to computations. To reach a calculating economics, various approaches and models have been proposed each of which has its specific applications. Bargaining is an approach which is well compatible with the dynamism and variety of sources in Grid and that's why many studies have been conducted in this regard. In the bargaining approach, the Grid resource manager provides customers with the list of resources and costs of access to resources which have been determined by the resource providers; by searching in this list, customers find the required resources and the negotiation begins. Subsequently, based on their own standards both sides bargain with each other until they reach a consensus or the negotiations ends with no results. In this paper, we will present an economic model based on bargaining so as to allocate resources. The stimulation results obtained from this method are indicative of an increase in the speed of negotiations and an increase in the profit of vendors compared to previously presented methods.

Keywords: Grid computations- bargaining model- resource allocation- Grid resource negotiation- GRA-B model.

1. Introduction

Grid is a broad network with a high computational power which has the possibility of connection and sharing of heterogeneous resources. This architecture is comprised of a set of computers distributed at the level of several internets or intranets which are in communication with each other by a non-propriety communication protocol through a Grid management system. In Grid, different types of different computers with various abilities and capabilities and different operating systems could be found. Grid technologies can support decentralized sources and systems and provide the possibility of communication of systems. As coordinated access to different and distributed sources is valuable, a lot of studies and investments have been conducted so far in the area of computational Grids. In this approach, mechanisms are required which bring about the possibility of such accesses and also are able to provide the possibility of using stable and scalable models and policies which improve the Grid source sharing. Based on the success of firms in the real world as a stable model for the exchange and regulation of sources, goods and services, this idea could help propose a computational economic framework. Such a framework provides a mechanism which shows which applications must be the priority in access to which sources. Most primary and highly applicable Grids are created by individuals or organizations which voluntarily provided Grid with their resources. The computational source providers to the present research Grids usually have the mentioned motivations. The chance of access to these Grids for surmounting trade issues is very low. Moreover, offering sources to a research platform doesn't guarantee access to all sources present in that platform, except in cases where there is some kind of cooperation with resource providers access to their resources will not be possible. In this situation, a model which encourages resource owners or motivates them to provide their resources for use with others must be regulated and the most stable model is obtaining of economic profit and this approach refers to computational economy [1, 2]. Also, as both resource owners intend to obtain more money and also users want to solve their problems with the least costs, the computational Grid environment must support economic problems related to computations. To reach the computational economy, various methods like trade-off, tender, auction, bargaining, etc. are proposed.
As Grid could be defined as a coordinated source for sharing and solving dynamic issues and multi-institutional cooperation and as each one of these organizations, owners and customers have different policy priority and objectives, and then again Grid applications don't generally have a comprehensive control over sources and by considering these conditions require the implementation of their tasks, the most appropriate model for allocation of sources is negotiation.

Negotiation is a form of the decision made with two or more than two other active agents; agent is a person which can't make independent decisions (or reaching their one-sided objectives) and that's why they must make decisions to reach a compromise [3]. Negotiation of sources enables Grid participants for facing unstable environmental demands.

Bargaining is an approach which is well compatible with dynamism and variety of sources in Grid and due to the same reason, many studies have been conducted in this area. Bargaining includes the three phases of finding sources, decision-making regarding consensus, and allocation of resources. The most important step in bargaining is reaching a consensus based on the standards of the negotiating sides [1]. In this paper, an economic model based on bargaining is presented with the guarantee of the benefits of both negotiating sides.

1.1. Grid

A Grid network is a network computational system with on a very big scale that can have a scale as big as the Internet. This computational system could be seen as a virtual computer which includes a network set of heterogeneous mechanisms which is created by the sharing of their local sources.

In Grid, kinds and types of different computers with various abilities and capabilities and different operating systems could be found. These computers are non-proprietary and merely if the user doesn't use the computational power of the computer completely, it is placed in the service of Grid [4].

Grid technologies can support decentralized sources and systems and provide the possibility of communication of systems. When Grid technology was primarily invented, its mere goal was to share the system sources and have a powerful system and it was generally provided with research institutes; but today, more things are expected of Grid and it is of higher importance, specifically in electronic trade and decentralized and distributed trade systems. Grid technology could also be an appropriate solution to increase access, reliability and security of decentralized systems [5].

What is for certain in Grid technology is the variability nature of computational sources in Grid since the sources under the control of a management are not centralized and are merely in communication with one another through defined protocols, and that's why one could not rely on the security, assurance, and accessibility of sources and thus necessary measures must be taken. It is observed that the environment of this type of distributed system in terms of the covered sources is a highly diverse, dynamic and as a result complex environment. Large geographic distances of distributed sources, different architectures and operating systems of different machines, differences in the methods of access to each of the accessible sources and ultimately the presence of different policies in the management of sources are all complex issues which Grid has encountered. The effective management of sources is considered to be a vital issue in Grid. In an appropriate management system, the provision of sources, allocation of sources and timing must be done in the best way possible so that users and applications can receive service in the best way and on the other hand the optimal and maximum operation is done. In fact it could be said that the efficiency of each distributed system is to a large extent indebted to the proficiency and effectiveness of resource management methods and also timing policies and mechanisms used in implementation of these duties in this environment. For instance, the practice of proper load sharing in the distributed systems leads to an effective use of sources both to the advantage of source owners and also that of the customers [6].

1.2. Bargaining Model

Bargaining model is one of the economic models in Grid. In this model, the source brokers bargain with GSPs for lower prices of access and a longer period of use. Both brokers and also GSPs have the functions of their objectives and negotiate with each other so that their objectives are met. Brokers may start the negotiation with a very low price and GSPs with a higher price. The negotiation continues as long as they reach a price acceptable for both sides or once of the sides is no longer
eager to continue the negotiation (figure 1). This negotiation is guided by the needs of the user (for instance in the user's viewpoint the deadline is very flexible). Brokers can take risks and negotiate for cheaper prices as long as possible and leave expensive locations. This may lead to a lower usage of resources; thus, GSPs may be inclined to lower the price rather than waste the source cycles. Brokers and GSPs deploy this model when the market supply and demand and the price of services are not clearly defined yet. Users can negotiate for a low price, by the promise of various aids or use of GSP services in the future.

Fig (1): bargaining of brokers for a lower access price [7].

2. Data Collection

All experiments in this article have been conducted based on the BADG data collection [8]. BADG is a standard data collection which is used in experiments related to Grid. This data collection includes 5 service providers of Grid services which are called vendors in this paper and also includes batch jobs of 400, 300, 200, 100 and 500 each which are called customers each. Thus, each experiment is repeated for all customer groups. The most important idea of the suggested model is using of the concept of rival which in each customer group 10%, 20%, 30% and 50% are considered as rivals; for instance in the 500-member group of customers, the experiments are done for 50, 100, 150 and 250 individuals. In addition, to study the economic aspects of the model the prices are in dollar. The buyer considers the maximum of a price and the vendor the minimum of a price and the distance of the negotiated price from these prices shows the profit of the traders. For instance, if the c1 customer has considered for the R source the maximum price of 100 dollars and the vendor for the same source the minimum price of 70 dollars, and after the process of bargaining the source is sold for the price of 90 dollars, the profit of the customer will be 10 dollars and the profit of the vendor 20 dollars.

A topology of the network based on the BADG network (Belle Analysis Data Grid) in stimulation is created [8]. Table 1 has summarized the information related to the source [9]. Five sources exist in 4 different areas of network topology. The parameters related to the sources are presented in [10]. The processing capabilities of CPUs sources are measured by means of the MIPS degree (Million Instructions Per Second). The task carried out in this study includes 108 of 3 * 108 instructions. Different experiments based on a specific model of incoming jobs and a different number of tasks entered in the system are conducted under similar conditions. Request pattern of the incoming sources which are used in each experiment are based on Poisson distribution. Most of the times Poisson distribution is a proper model for cases where a number of similar and independent source demands are entered into the system. In addition to this, in every stage of evaluation 100, 200, 100, 100 and 500 tasks is respectively entered the system.
Table 1: the features of the stimulated sources in BADG laboratory [8]

<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>
<tr>
<td>R4</td>
<td>IBM eServer with dual Intel Xeon 2.6 Ghz, 2 GB RAM</td>
<td>4</td>
<td>1050</td>
</tr>
</tbody>
</table>

3. The Proposed Method

The method of entrance to work and implementation of work is a many to many negotiation where each customer simultaneously negotiates with many customers and every vendor simultaneously with many customers. For every customer we have an agent named GRC (Grid Resource Consumer) and for every vendor also we gave an agent named GRO2 (Grid Resource Owner). These agents negotiate with each other in pairs and during the negotiation each vendor declares the proposed price of other customers’ o the rest of the customers or in other words, each customer broadcasts their proposed price so that other customers become aware of this proposed price. The reason for doing this practice is to find the rivals of each customer; additionally, each vendor preserves the previous shopping records of the customer so as to give the priority to its faithful customers.

1.5- The Process of Negotiation from the View of the Customer

From the view of the customer, each buyer can enter negotiation or bargaining simultaneously for a specific source with many vendors and each bargaining which is resulted sooner, the rest of the negotiations are canceled. In the many to many negotiations, each customer must rival with other customers so as to reach agreement with the utmost profitability.

The rival customer C1 refers to a customer whose behavior in bargaining and proposed price is similar to customer C1.

To determine the similarity of rivals, we use the proposed price of two customers. Utility function formula is as below:

\[
U_t = |P_{t}^{C_i} - P_{t}^{C_j}|
\]

In which the parameters are thus:

\(P_{t}^{C_i}\): the proposed price of the Ith customer in the tth stage of bargaining

\(P_{t}^{C_j}\): the proposed price of the jth customer in the tth stage of bargaining

Of course to determine the similarity instead of analyzing the price equity, A threshold could be considered and if their difference is lower than the threshold level it could be considered similar (to the rival). The customer uses the following relation to determine the coefficient of variation of the proposed prices in each round of negotiation:

\[
CF_t^{C_i} = \left[\left(1 - \frac{t}{D}\right)^{\frac{1}{RcNc}}\right]^{\frac{\alpha}{d}}
\]

Based on the relation (2), the CFt of the factor price changes in each round of negotiation has the following parameters:

\(Rc\): the number of rivals

\(Nc\): the total number of negotiators

\(D\): the deadline for reaching the negation result
Using the relations (3) and (4), the new proposed price is determined:

\[ P_{t+1}^e = (CF_t^e \times \Delta_L) + P_t^e \]  

(3)

\[ P_{t+1}^s \]

is the suggested price of the next round of negotiation that the buyer offers to the seller.

\[ \Delta_L = |P_{t}^{ci} - P_{t}^{sj}| \]  

(4)

\[ \Delta_L \]

is the difference between suggested prices from Negotiators.

Using the relations (3) and (4), the new proposed price is determined and it has the following parameters:

- \( P_{ct} \): the proposed price of the \( i \)th buyer
- \( P_{st} \): the proposed price of the \( j \)th vendor

5.2 - the process of negotiations from the viewpoint of the vendor

From the view of the vendor all other vendors are considered rivals and each vendor tries to keep their previous customers satisfied in a way that they visit them again for their next shopping; for this purpose, they keep a record of the shopping record of their previous customers and based on this record try to reach the result of negotiations sooner and consequently permanent customers will have more precedence over others.

In the relation (5), CFts is the coefficient of price change by the seller that has been shown as below:

\[ CF_t^{sj} = R_c \left( 1 - \frac{\alpha}{d} \right)^\frac{\alpha}{N_s} \]  

(5)

- \( N_s \): the number of vendors
- \( R_c \): the number of rivals (\( R_c = 1 \))
- \( d \): the deadline to reach the result of the negotiation
- \( \alpha \): type of negotiation (\( \alpha = 1 \ linear, \alpha>1 \) harsh, \( 0<\alpha<1 \) mild)
- \( t \): time (negotiation round)

Using equation (4) and (6) new suggested price will be specified:

\[ P_{t+1}^s = (CF_t^s \times \Delta_L) + P_t^s \]  

(6)

\[ P_{t+1}^s \]

is the suggested price of the next round of negotiation that the seller offers to the buyer.

All customers must deploy their requests on services based on a function to state the priorities of the customer. In addition, each customer adapts services to the priority of its employer. On the other hand, each vendor can search for the best and most appropriate proposed price and so offer services.

In this model, the customer first expresses its required services to the dealer resources. Therefore, the type of the requested source is determined like the required data rate. Also, before starting the transaction process the customers record the size of the job data, the job processing ability and the transaction deadline which are respectively in megabyte, million instructions and millisecond in GIS.

5.3 - the proposed algorithm from the viewpoint of the buyer and the viewpoint of the vendor:
The algorithms of the vendor and the buyer are based on the following paragraphs. These algorithms show the agreement or disagreement steps; also, in the case of reaching agreement the sources are allocate to the buyer and the vendor resources are deducted.

The Proposed Algorithm (from the View of the Buyer):
- First step: sending the request of the required resources to the management of Grid resources
- Second step: searching for the required resources
- Third step: in the case of finding the required resources, starting the negotiation with the resource owner
- Fourth step: presenting the base proposed price to the resource vendor
- Fifth step: receiving the proposed price of the resource owner
- Sixth step: comparing the proposed price of the owner with one's proposed price
- Seventh step: if the agreement happens, reference to the twelfth step
- Eighth step: calculation of the new price based on the preferences of the customer (relation (2))
- Ninth step: declaring the proposed price to the resource owner if the new price doesn't exceed the roof considered; otherwise reference to the thirteenth step
- Tenth step: updating the negotiation time
- Eleventh step: examining the end of the deadline, in the case of finishing the deadline reference to the thirteenth step; otherwise, reference to the fifth step
- Twelfth step: receiving the resources of its usage
- Thirteenth step: End of negotiations.

The Proposed Model Algorithm (from the View of the Vendor)
- First step: recording the resources in the list of Grid resources by the resource provider
- Second step: receiving the customer demand and the base customer proposed price
- Third step: declaring the proposed price to the customer
- Fourth step: receiving the customer proposed price
- Fifth step: comparison of the price received by the customer with one's proposed price
- Sixth step: if the agreement has taken place, reference to the thirteenth step
- Seventh step: the calculation of the new price based on the preferences of the resource provider (relation (5))
- Eighth step: declaring the proposed price to the customer if the price is not lower than the base considered price; otherwise, reference to the fourteenth step
- Ninth step: declaring the customer proposed price to other customers of the same resources
- Tenth step: updating the negotiation time
- Eleventh step: examining the end of the deadline, in the case of finishing the deadline reference to the fourteenth step; otherwise, reference to the forth step
- Twelfth step: allocation of resources to the customer
- Thirteenth step: updating the list of resources
- Fourteenth step: end of negotiation

3- Results of Stimulation
In this section, the results of stimulation and analysis of the presented model will be illustrated. To implement the proposed model the GridSim stimulation tools are used [11], and this stimulator is used for the Grid environment. The presented model will be compared with the two presented methods. One of these methods which is offered by Adabi, states a strategic negotiation model based on multiple agents to allocate the sources and regulate the supply and the present demand in computational environments of the proposed network, and the other model which is presented by Baghban is a simultaneous to-sided transaction of the number to number type which could be implemented by means of the harsh, mild formulation and the management strategies. In comparisons of this paper, we illustrate the presented method by Adabi with A and the presented method by Baghban by B.

To compare the efficiency of the proposed model with the former models, the three parameters of average response time, average customer profit and average vendor profit and for doing the comparisons the 5 customer groups of 400, 300, 200, 100 and 500 individuals each with the deadline=10 and the number of 10% rivals and the α =1 (linear model) are considered.

In comparison of the stimulation of this model with the former models it is observes that the response time in relation to the previous algorithms have decreases whose reason is the presence of rivals in the proposed model (despite the presence of rival for customers, the speed of reaching an agreement increases so that sources are not assigned to rivals.)
Table 2: comparison of the average response time

<table>
<thead>
<tr>
<th>Customer</th>
<th>ART (A)</th>
<th>ART (B)</th>
<th>ART (M)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>2229</td>
<td>2100</td>
<td>1721</td>
</tr>
<tr>
<td>200</td>
<td>5301</td>
<td>5802</td>
<td>3290</td>
</tr>
<tr>
<td>300</td>
<td>8306</td>
<td>8048</td>
<td>6880</td>
</tr>
<tr>
<td>400</td>
<td>12098</td>
<td>10300</td>
<td>8892</td>
</tr>
<tr>
<td>500</td>
<td>19894</td>
<td>19031</td>
<td>17297</td>
</tr>
</tbody>
</table>

Table 3: comparison of the obtained profit for customers

<table>
<thead>
<tr>
<th>Customer</th>
<th>Profit (A)</th>
<th>Profit (B)</th>
<th>Profit (M)</th>
<th>deadline=100</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>27</td>
<td>20</td>
<td>38</td>
<td>alpha=1</td>
</tr>
<tr>
<td>200</td>
<td>23.7</td>
<td>26.6</td>
<td>25</td>
<td>RB=0.10</td>
</tr>
<tr>
<td>300</td>
<td>21.4</td>
<td>43</td>
<td>18.5</td>
<td></td>
</tr>
<tr>
<td>400</td>
<td>22.1</td>
<td>45</td>
<td>14.2</td>
<td></td>
</tr>
<tr>
<td>500</td>
<td>20.9</td>
<td>53</td>
<td>9.6</td>
<td></td>
</tr>
</tbody>
</table>

Diagram (1): comparison of the average response time

Regarding the profit obtained for customers, in the proposed model the profit obtained from the customers is lower than the other two models and by the number of customers being added it decreases and the reason is the increase of the number of rivals and as a result more speed to reach agreement and this haste leads to a fall in the customer profit.
Diagram (2): comparison of the obtained profit for the customers

Based on the stimulation results concerning the vendors' profit in the proposed model, the average vendor profit is more than the other two models and it increases with the added number of customers since the rivals of the customers increase and the hurry to reach agreement by the customers is increased and as a result the vendor profit increases.

Table 4: average vendor profit

<table>
<thead>
<tr>
<th>Customer</th>
<th>Profit(A)</th>
<th>Profit(B)</th>
<th>Profit(M)</th>
<th>deadline=100</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>32.8</td>
<td>33.3</td>
<td>22.8</td>
<td>alpha=1</td>
</tr>
<tr>
<td>200</td>
<td>33.4</td>
<td>25.6</td>
<td>26.8</td>
<td>RB=0.10</td>
</tr>
<tr>
<td>300</td>
<td>38.3</td>
<td>19.8</td>
<td>36.7</td>
<td></td>
</tr>
<tr>
<td>400</td>
<td>41.5</td>
<td>9.7</td>
<td>43.5</td>
<td></td>
</tr>
<tr>
<td>500</td>
<td>43.2</td>
<td>10.9</td>
<td>52.3</td>
<td></td>
</tr>
</tbody>
</table>

Diagram (3): comparison of the obtained profit for vendors

In table 5 the summary of the proposed method with two other algorithms are illustrated.
Table 5: a summary of the comparison of the proposed algorithm with A and B algorithms

<table>
<thead>
<tr>
<th></th>
<th>Provider Profit $</th>
<th>Customer Profit $</th>
<th>Average Response Time</th>
<th>Number Of Agreement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proposed Alg.</td>
<td>64</td>
<td>9.6</td>
<td>17297</td>
<td>99.6</td>
</tr>
<tr>
<td>Adabi Alg.</td>
<td>44.5</td>
<td>20.9</td>
<td>19894</td>
<td>98.3</td>
</tr>
<tr>
<td>Baghban Alg.</td>
<td>11.2</td>
<td>53</td>
<td>19031</td>
<td>98.7</td>
</tr>
</tbody>
</table>

4. Conclusion

The comparison of the proposed model with some former models indicates that the main approach of this model is the increase of speed in negotiations and as a result the decrease of the time of consensus which makes the model more suitable for the implementation of straight-off tasks compared with other models. Also, the approach of this model is to increase the profit of vendors using the concept of similar customers as the rival and also the record of the customers.

One of the important characteristics of the proposed model is the simplicity of the model which simplifies the comprehension and prediction of incidents; thus, this model is applicable in places where the speed of consensus and the profit of vendors are important.

As the future task, the energy consumption factor in the bargaining process of the proposed model could be used, so that the vendor selects customers who decrease its energy consumption. The energy consumption refers to an energy which is available in the hardware like (CPU, disk, etc.) or use QoS parameters in the bargaining process of the proposed model (like entering the standard deviation of the response time in the proposed model).

References