Solving Winner Determination Problem in Double Combinatorial Auction by ICA in Cloud Computing

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ABSTRACT
There are many different ways to allocate resources in cloud computing. The economic methods are some of common ways to resource allocation. The auction-based method has some advantages compared with Fixed-Price method. The double combinatorial auction is one of the proper ways of resource allocation in cloud computing. Resource allocation in double combinatorial auction includes two phases. These two phases are winner determination and resource allocation. The proposed algorithm has implemented ICA to determine winner in double combinatorial auction-based resource allocation. The experimental results showed that in proposed algorithm the number of winner users is higher in proposed algorithm, but the number of winner providers is higher in genetic algorithm.

General Terms
Cloud computing, resource allocation, winner determination

Keywords
Cloud computing, resource allocation, double auction, winner determination, ICA

1. INTRODUCTION
In fact, Cloud computing has features that are attractive to companies and organizations: No advance payment, reduce operating costs, high Scalability, accessibility, reduce the risk of business and maintenance costs [1]. Resource allocation is one of the integral issues of cloud computing and data centers management [2]. These days cloud providers use fixed-price mechanisms to allocate resources to their users. But these mechanisms don't provide efficient allocation and don't maximize the revenue of providers. Economic model of cloud-based resource allocations are more suitable to adjust supply and demand of resources. A better alternative for resource allocation is to use auction-based Mechanisms. The most appropriate mechanism in cloud computing for resource allocation and pricing is combinatorial auction [3]. Prices should only depend on the demand and supply condition, in order to fair exchange between providers (sellers) and users. Therefore, using double combinatorial auction to resource allocation in cloud computing is a proper model. Double combinatorial auction includes two steps. At first, winner determination from auction offers by solving an optimization model that its aim is to maximize social welfare (by distinguishing between buyers pay and total income of sellers); Second, the allocation and pricing of resources among a winners set, But this trend of auction has some problems. The winner determination is a NP-hard problem when the number of volunteers and resources is in a particular scale and the winner cannot be found in a polynomial time [4]. Therefore, the heuristic algorithms solve problem from a scientific perspective very well. The article includes: cloud computing, resource allocation, double combinatorial auction, related works and proposed method.

2. CLOUD COMPUTING
The main idea of cloud computing is not new. John McCarty in 1960, predicted that computing, provide some tools to help public. It is obvious that, the lack of defined standard in cloud computing have led to confusing. For this reason, the standardization of cloud computing definitions has been worked recently. A large number of researchers have tried to define cloud computing in functional aspects, but they didn't success and there is not a comprehensive definition for it. Among different definition , the definition of NIST is as follow : ((cloud computing is a model that has been designed to easy access to the configurable computing resources such as networks , servers and Services, ... that is created with lowest management Endeavour and by providers' participation)) .[5]

3. RESOURCE ALLOCATION
Resource allocation is one of the continuous and integral issues of cloud computing and data Centre managements. Consider the following hypothetical scenario: a cloud service provider allocate servers to tenant virtual machines according to the requirement of CPU, memory and disk. At a later date, the provider improves model and allocates the network bandwidth resources to tenant virtual machines. At this stage, the strategy of resources allocation depends on some limitations such as servers' capacity and network band width of centre. In fact, resource allocation includes dividing and allocating of resources which have some special limitations such as server performance assurance, network efficiency and flout tolerance. Many of these resource allocation problems are NP-Hard problems. A large number of management tools of new data Centre enjoy from proper heuristically methods to solve independent problems. The recent network virtualization researches have used greedy heuristically methods to allocate virtual machines to data centers, for example. The resource allocation problem can be divided in two categories: Firstly, accepting new requests and brining virtual machines for them and putting them on hosts. Second: resource allocation process that optimize previous allocations. The first problem can be considered as a pack bin problem with different bin size. Common algorithms for pack bin problems include: worst fit, best fit, first fit, Next fit [6].

3.1 Double Combinatorial Auction
Double combinatorial auction is not of the most common combinatorial auction approaches that can model as an optimization problem to maximize social welfare (buyers'-total pay and sellers' total income). It is possible that several buyers and several sellers volunteer for goods bid bundles. Participants in auction, send a request about buying or selling

a goods bid bundles. Any bundle is a buying request that all of its goods will be bought or a selling offer that all of its goods will be sold. In this auction the request is seal bid. It means that the participants in the market don't know each other and only the auctioneer access to information [7].

4. RELATED WORKS

Fuji Ware et al in [4] used double combinatorial action to resource allocation and provided current/future booking in the spot markets and front markets. They have used a combinatorial liner programming to determine winner of auction that led to the auction winner to be determined on a large scale and in a longer time. Schnizler et al in [8] used combinatorial auction in grid computing to allocate resources. In this paper, they offered combinatorial auction-based resource allocation protocol in which, a user can offer a price for any mix of needed resource to perform his/her duties. This protocol involves an approximation algorithm to solve the combinatorial auction. The proposed approach includes four steps: request information from local market auction, generating proposals, determining resource allocation and assigning tasks to winner resources. They have used an approximation algorithm to solve combinatorial auction problem that find a near to optimization allocation and includes two steps. In first step, an approximation is determined by combinatorial auction liner programming and in the last step named hill climbing step, the quality algorithm improve the solution by performing the sequence of greedy allocation procedures obtained in the first step. The results showed that, their proposed model has an economical effect on performance of system. Ghorbanzadeh et al in [9] have used genetic combinatorial algorithm to determine auction winner in gird. They have used two type of genetic combinatorial algorithm in order to improve the efficiency of genetic algorithm. The experimental results showed that the combinatorial algorithm of genetic, hill climbing and Simulated-annealing let to better results than genetic algorithm.

5. PROPOSED ALGORITHM

Proposed algorithm to solve winner determination problem in double combinatorial auction in cloud computing is ICA. ICA identifies the auction winners. In fact, the output of this algorithm identifies that which one of the users and providers' bid bundles won the auction.

5.1 Bid Bundles

$B = \{B_{1,\dots,} B_j, \dots, B_n\}$ is a collection of bid bundles that includes n bundles (n is the total numbers of users and providers). The Bj bid can include four tipple (E_j , R_j , S_j , P_j) , where : $E_j = (E_{1j} \dots E_{ij} \dots E_{nj})$: if $E_{ij}>0$ then it is the unit of requested ECU.If $E_{ij} <0$, then, it is the unit of supplied ECU.

$R_j = (R_{1j},\dots,R_{ij},\dots\dots,R_{nj})$ where: If $R_{ij}>0$ then, it is the unit of requested memory. If $R_{ij}<0$, it is the unit of supplied memory.

$S_j = (S_{1j},\dots,S_{ij},\dots\dots,S_{nj})$ where: If $S_j >0$ then, it is the unit of requested storage. If $S_j <0$, it is the unit of supplied storage.

$P_{ij} \in R$ is the amount that the bidder eager to pay it. It is considered as a buying bid if $p_{ij}>0$ or it is considered as a selling bid if $p_{ij}<0$.

It should be noted that bundle will be won and all of its resources be allocated or never won. Moreover, every bid bundle of provider can cover several requests of users. It means that several requests can be provided by a single provider, but the resources of a provider only can allocated to a single user.

5.2 ICA

ICA is one of the approaches of evolutionary computing that try to find optimal answers of different optimization problems ,this approach provides an algorithm for solving mathematical problems of optimization by mathematical modeling of social-political evolution process [10]. At this algorithm the numbers of dimension of a country is equal to the number of bid bundle of users and providers.

$Country = [P_1, P_2 \dots P_{Nvar}]$

That $Pi \in \{0, 1\}$ and 1 indicates that the bid bundle has been won and 0 indicates that the bid bundle have not been won. In fact, any country is an array includes 0 and 1.

The purpose of this study was to allocate economical resources so that in this allocation the profits of users and also providers are considered. In fact, in double combinatorial auction, the provider that offer with lowest price will be won and also the user with the highest proposed price will be won, therefore a country is better that the sum of Its winner bid bundle be more than others.

Therefore the cost function of this algorithm calculated as follow:

$$\sum_{j=1}^{n} Pj\ Xj,\ X_j \in \{0,1\}$$

$$\sum aj\ xj \leq 0\ ,\ \forall\ a_j \in \{Ej, Rj, Sj\}$$

$$X_j \in \{0,1\}, \forall\ j \in \{0,1,\dots,n\}$$

The first equation means that a combination of winners that their offered price are higher than other considered as an answer. Of course the combination should fulfill users' request. This control has done by equation (2) and it means that the answer with negative winner bundles is proper i.e. the prospered resources be more than requested resources. P_j is the offered price of bid bundle number j and Xi is the amount of j-th member of array of country and indicates that whether this country won. In proposed algorithm, the following Assimilation was considered to determine the condition of new habitation in attraction policy: α=0.5, ß=2.

Every empire that could not add to its strength, will fail in imperialist rivalries. This failing occur gradually. It means that the weak empire lost his colony and stronger empire will seize these colonies, gradually [10].

For this purpose, firstly the total cost function of each empire and each imperial power is calculated by the Subtracting the cost of the weakest empire with a total cost function of each empire. After that, capture probability of each empire is calculated according to its power and by dividing the power of each empire to the sum of all imperial powers. Now, the empire whit the highest capture probability, randomly select a country from the weakest empire.

6. SIMULATION

The JAVA programming language was used to simulate proposed algorithm. As it has said before, the ICA was used to determine the winner of algorithm. The parameters of this algorithm are as follow:

The number of users' bid bundles: 600, The number of providers' bid bundles: 400, The number of problem dimension: The number of users' bid bindles+ the number of providers' bid bundles, The number of countries: 100, the number of empires: 10, The number of decades: 100,

Revolution Rates: 0.1, β =2, α=0.5

In fact, the providers bid the characteristics of their virtual machines in their bid bundles that we have used Amazon EC2 Standard for this purpose. The virtual machine m3 include different size of medium, large, x large and 2x larges that have used x large and 2x larges are used. Users and providers bid the amount and prices of three resources in their bid bundles.

Moreover it supposed that each bid bundle includes request or offer resources for a time unit (hour) that desired virtual machines had this amounts. The data of these machines have been shown in below table [1]:

Table 1. The characteristics of virtual machines [11]

Vm type	ECU Instance	Memory (GB)	Storage (GB)	Windows Usage
m3.xlarge	13	15	2 x 40 SSD	$0.532 per Hour
m3.2xlarge	26	30	2 x 80 SSD	$1.064 per Hour

ECU is a technical term for processor. Many of providers have various ways to allocate and sharing processor, therefore it is difficult to comprise processor performance in deferent clouds. Therefore different providers have use different technical terms to define the processors of servers, such as ECU, VPC, CORES and …… that ECU have been used in this kind of virtual machines.

7. EVALUATION

The Proposed algorithm is compared with genetic algorithm from convergence, the number of user and the number of providers' point of view. The results of comparison represented in following diagram:

The following diagram shows the convergence of genetic algorithms and winner determination in solving winner determination problem:

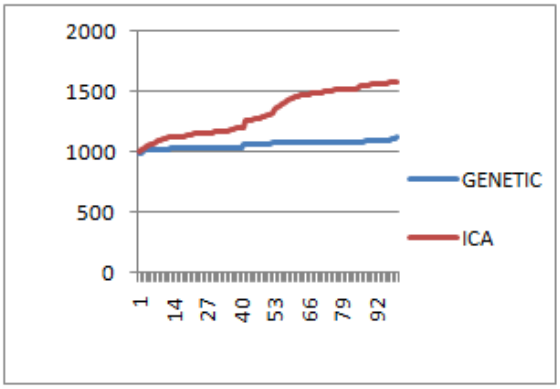

Figure 1: The convergence diagram of algorithms

The number of users' bid bundles is 600. As it can be seen in figure 2, proposed algorithm has more winner users than genetic algorithm and worked 22.5% better than genetic algorithm.

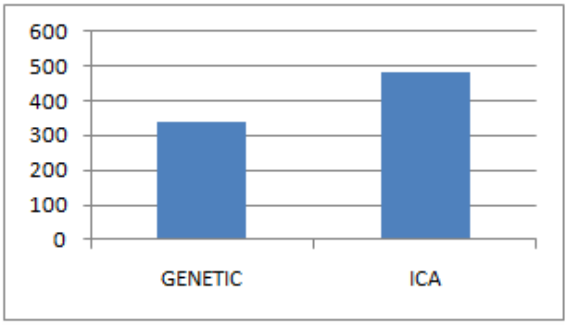

Figure 2: number of winner users of algorithms

Figure 3 shows the number of winner providers in ICA and genetic algorithm. The number of providers' bid bundles is considered at 400.

The results showed that the number of winner providers of genetic algorithm was higher than ICA and worked 4.5% better than ICA.

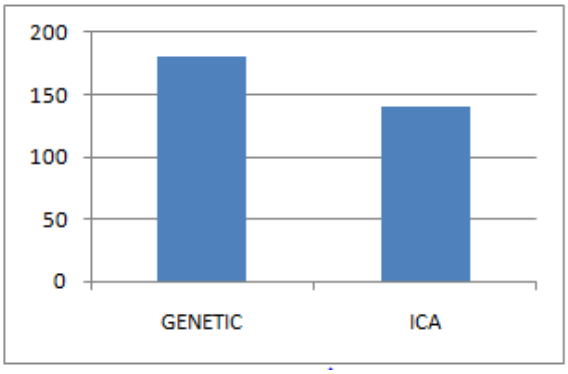

Figure 3: The number of winner providers of algorithms

8. CONCLUSION

This article has investigated the use of proposed algorithm to winner determination in double combinatorial auction-based resource allocation in cloud computing. This algorithm has used double combinatorial auction to resource allocation. Resource allocation with auction-based method has some advantages compared with fixed-price method that current providers enjoy from these advantages in cloud computing. This algorithm lead to resource allocation is performed according to the demand-supply condition. In each bid bundle, the total price of bid suggested. The winner determination stage is done by ICA, after receiving the bid bundles. At this stage the winner user and provider were identified with taking account the aim of problem that is user and provider profit.

The experimental results showed that the number of winner users is higher in our proposed algorithm, compared with genetic algorithm. But number of winner provider in genetic algorithm is more than our proposed algorithm that its reason can indicate by evaluating the convergence diagram of algorithms. The high amount of target function indicates the increase of winner users, because bided price of users is a positive number and bided price of provider is a negative number and our target function is given by the sum of bided prices of auction winner.

9. ACKNOWLEDGMENTS

This paper has been extracted from M.Sc thesis of Rezvan Alipoor sabzevari as a student at Department of Computer, Khouzestan Science and Research Branch, Islamic Azad

University, Ahvaz, Iran

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