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Resource Provision Scheduling in Cloud using Game Theory

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***Abstract*—** In cloud computing environment, resource allocation problem identifies that the cloud provider expects profit and the users expects best resources by considering budget and time constraints. In this paper, game theory mechanism has been used and an auction-based method is proposed which determines the auction winner and holding a repetitive game with incomplete information in a non-cooperative environment. In the proposed method, users calculate suitable price bid with their objective function during several round and repetitions and send it to the auctioneer; and the auctioneer chooses the winning player based on the suggested utility function. In the proposed technique, the end point of the game is the Nash equilibrium point where players are no longer inclined to alter their bid for that resource and the concluding bid also satisfies the auctioneer's utility function. The proposed model is simulated in the Cloudsim and the results are compared with previous work.

***Keywords*—** Cloud Computing, Resource Allocation, Game Theory, Auction, Nash Equilibrium

I. INTRODUCTION

One of the most complex issues in cloud computing environment is the problem of resource allocation. Most of the previous work in resource allocation is conducted using heuristic and evolutionary approaches. [1] presented a novel market-based algorithm for grid resource allocation where the grid resource allocation could be measured as a double auction in which the resource manager works as an auctioneer and the jobs act as buyers and sellers. Based on this approach, resource allocation becomes an activity of each participant in the auction. [2] introduced an auction-based approach to allocate resources (CPU and disk storage). The elementary idea behind the technique is that the uppermost bidder gets the resource and the cost is find out by the bid price. In a double auction model, the consumer and provider submit bids and requests respectively during the time of trading. If at any time the bids and requests match, the trade is achieved. A continuous double auction (CDA) based protocol checks a perfect match between the buyer and the seller. The immediate detection of compatible bids was proposed by [3]. When no match is originating, the task query object is deposited in a queue till the time to live (TTL) expires or a match is found. A combinatorial auction-based resource allocation protocol is a technique, in which a user bids a price value for each of the likely groupings of resources essential for its task implementation [4]. It practices an estimate algorithm for resolving the combinatorial auction and a grid resource allocation problem. A compensation-based grid resource allocation is proposed in [5].

In this paper a model has been proposed which focus on helping a cloud consumer to make a rational decision in a competitive market. Game theory studies multi-person decision making problems. If no one wants to deviate from a strategy, the strategy is in a state of equilibrium.

In order to establish a proper model for cloud, several important consumer characteristics should be highlighted. First, service consumers are insensitive and coherent who wish to get better service at lesser cost. Second, in management practice, these buyers have more than one behavioural constraint, so they must make a trade-off of one constraint for another. Third, the pay-as-you-go feature in cloud means that transactions are repeated gambling processes. Each user can adjust its bid price according to prior behaviour of other competitors. Fourth, cloud customers are unknown to each other because they are distributed globally. In other words, there is no common purchasing knowledge in the whole system. Fifth, tasks arrive in datacenter without a prior arrangement. Sixth, the accurate forecast becomes more challenging in such a complex scenario, so a good allocation model integrating compromise, competition and prediction should be further generalized and well evaluated. Therefore, game theoretical auctions are used to solve the resource allocation problem in cloud and propose auction-based practicable algorithm for user bidding and auctioneer pricing. With Bayesian learning prediction, resource allocation can reach Nash equilibrium among noncooperative users even if common knowledge is lacking or dynamically updated.

The rest of the paper is organized as follows: Section II describes the problem formulation. Section III provides experimental results of the proposed model for different number of users and compares the proposed model with the dynamic auction model. Section IV provides the conclusion of the paper.

II. PROBLEM FORMULATION

The problem is evaluated at the infrastructure as a service level. In the formulated problem, it is assumed that the IaaS provider manages an infrastructure which can provide to his user's best combination of VMs and to give the best combination of VMs, provider should have information regarding the execution of tasks.

Assume that r resources are allocated to t tasks. Each user U_i has a number of similar interdependent K_i tasks which need equal amount of computing. The sum of total cost of each resource should be minimized and t relevant tasks are implemented in the least time with minimal cost. It is assumed that matrix m consisting of t rows each for one user and r columns each for one resource. Also m_i is the representative of i^{th} row of the matrix m and m_{ij} represents the amount of each task of user U_i that is assigned to R_i. The allocation vector of m_i is represented as:

$$\sum_{m_{ij} \in m_i} m_{ij} = K_i$$

Completion time matrix CT and cost matrix C is derived from m matrix. The t_{ij} amount of CT matrix indicates the execution time of the tasks of user U_i. When they are assigned to R_i resource, since all tasks of user U_i are implemented in parallel and independently, the execution time of all tasks of user U_i equals max{} so that i is indicative of the i^{th} row of the T matrix. The c_{ij} amount of the C matrix represents the cost paid by user U_i to implement its a_{ij} task on R_j resource. Therefore, the cost for implementing the U_i's task equals:

$$\sum_{j=1}^{m} c_{ij}$$

A comparison and trade-off exist between the execution time and cost for each of the tasks. In this model it is assumed that all the participants have complete information of the environment and identical view of the cost and time matrix.

Our objective is to minimize expenses and increase utility. We can calculate the utility for U_i as:

$$U_i(m_i) = \frac{1}{Total\ Cost}$$

A. Game Theory Mathematical Model

Resource Allocation Game. Game theory is a mathematical approach which attempts to resolve the exchanges between all players of game to make certain the best outcomes for themselves [6–9]. A game includes of three aspects, that is, a set of players, all the likely strategies each player will select, and the specified utilities of players related with the strategy achieved by every player. At each step, players decide one of their strategies and acquire a utility in return. Each player of a game attempts to maximize its own utility by selecting the maximum profitable strategy against other player's selections.

Definition 1. The normal form of resource allocation game G is represented as a three-tuple vector <P,S,U>.
(i)P is the players in the allocation game. There is a finite set of players P = {1,2,3…….., m}.
(ii)S is the sets of player's strategies.
(iii)U is the utility function of game players. At the outcome of one game, the utility received by a single player is payoff which determines the player's preference. For resource allocation, payoff stands for the amount of resource received e.g. $u_i(s)$,represents the payoff of player i when the output of the game is s,s∈S. Utility function $U = \{u_1(S)), u_2(S), \ldots u_m(S)\}$ specifies for each player in the player set P.

Definition 2. (Pareto optimality). An allocation is Pareto optimal if there is no other allocation in which some other individual is better off, and no individual is worse off.

The proposed problem is solved using game theory where the game g = <p, s, u>, in which p represents players, s their strategies and u their obtained utility. This game is repetitive and simultaneous game. Each player of this game aims to choose a strategy to maximize its own utility so that the goal of a resource allocation game would be considered as the following optimization problem:

Maximize $u_i(a_i)$ s.t.

$$\sum_{a_{ij} \in a_i} a_{ij} = k(i), \quad a_{ij} \geq 0$$

where a_{ij} is assignment vector and is represented by selective strategy of player. k(i) stands for all the tasks of user U_i.

B. Game Theoretical Allocation Model

Bid shared Auction

In a cloud market, there are N users asking for services, each having a sequence of tasks to complete. The maximum number of tasks is k. Cloud provider entirely virtualizes K resources, each of which can render a specific service with a fixed finite capacity c.

$c = (c1, c2, \ldots\ldots\ldots ck)$

To complete the task, the amount of computing capability is described by its size. All the users have different task itinerary and the size of an inexistent task is zero in the matrix x.

$$x = \begin{bmatrix} x_1^1 & \cdots & x_k^1 \\ \vdots & \ddots & \vdots \\ x_1^i & \cdots & x_k^i \end{bmatrix}$$

If a task x_k^i can occupy its corresponding resource ck, the computation speed will be $\mu_k^i = \frac{x_k^i}{c_k}$. However, in the proposed model, resource capacity is never for exclusive use but shared by multi users. It is reasonable and fair that resource partition is proportional to the user's outlay. We assume that a resource is always fully utilized and unaffected by how it is partitioned among users. Resource allocation in cloud is a noncooperative allocation problem where consumers are competitors and unwilling to cooperate with each other. Every user has a bidding function, which decides the bid in any round considering task size, priority, QoS requirement, budget and deadline. The repeated bidding behaviour is considered as a stochastic process indexed by a discrete time set. The outputs are random variables that have certain distributions, when these above deterministic arguments and time are fixed.

$\{B^i(k), k \in (1,2, \ldots\ldots K)\}$

where B^i is the money that the user is willing to pay for one unit of resource per second. User i bids for task k at price b_k^i which can be treated as a sample for B^i.

The execution time of task i on the resource k is defined as thus:

$$t_k^i = \frac{x_k^i}{C^k p_k^i} = \mu_k^i + \mu_k^i \frac{\theta_k^{-i}}{b_k^i}$$

where $p_k^i = b_k^i \Big/ \sum_{i=1}^{N} b_k^i$ and $\forall k, \sum_{i=1}^{N} x_k^i = 1$.

Cost taken to complete task k is

$$e_k^i = b_k^i t_k^i = \mu_k^i \theta_k^{-i} + \mu_k^i b_k^i$$

For each player to choose their best strategy, an amount must be considered as their payoff. The payoff must be carefully selected in order to indicate the outcome preference of a game. To fully depend upon only one i.e. time or cost is not reasonable in noncooperative games where both time and expenditure depend not only on the bid that user is willing to pay but also on the bid other competitors pay. The best solution in choosing payoff is the combination of expenses and computation time into aggregate quantity.

Objective Function

In a cloud market, customers are rational decision makers who seek to minimize the expenses and have constraints of cost $E=(E_1,E_2,\ldots..E_N)$ and time $T =(T_1,T_2,\ldots\ldots T_N)$. For this purpose, the weighing sum of time and cost can be obtained. Each time unit is recorded as a fixed amount of cost. In this problem, each time unit is considered the equivalent of 100 economic unit and the ratio $N_t:N_e= 1$ is assumed. Each player can consider a deadline, displayed with T^0, and a maximum budget amount, E^0, the optimal objective function of the user is:

$$Min \ \epsilon$$

s.t.

$$\sum_{k=1}^{K} e_k^i \le E^0 \ , \quad \sum_{k=1}^{K} t_k^i \le T^0$$

For user i, the capital sum $\sum e_k^i$ and time sum $\sum t_k^i$ remain the same for any two tasks, it is therefore determined that the relationship between any two bids in one task sequence, is $\frac{\theta_k^{-i}}{{b_k^i}^2} = \frac{\theta_k^{-i}}{{b_j^i}^2}$.

III. EVALUATION OF THE MODEL

To implement resource allocation algorithm in cloud computing real environment, it is very expensive and time consuming, therefore Cloudsim simulator has been used for the execution of this algorithm. Multi users can submit their tasks over time according to certain arrival rate or probability distribution and that resource nodes can freely join or leave cloud datacenter. The assignment in the proposed simulation model is much closer to a real market than before.

The proposed work has been tested for different number of users and results for average resource utility and profit are given in table 1:

Table 1. Results

Number of users	Average resource utility	Profit
36	100	86.57
52	100	97.71
60	100	50.15
64	100	91.32
69	100	71.1
98	100	55.91
100	100	78.08
153	100	43.1
437	98.62	77.32

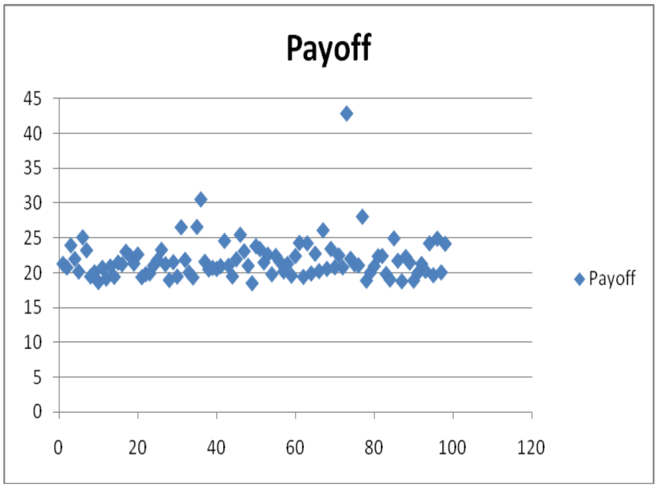

Figure 1. Payoff for 98 Users

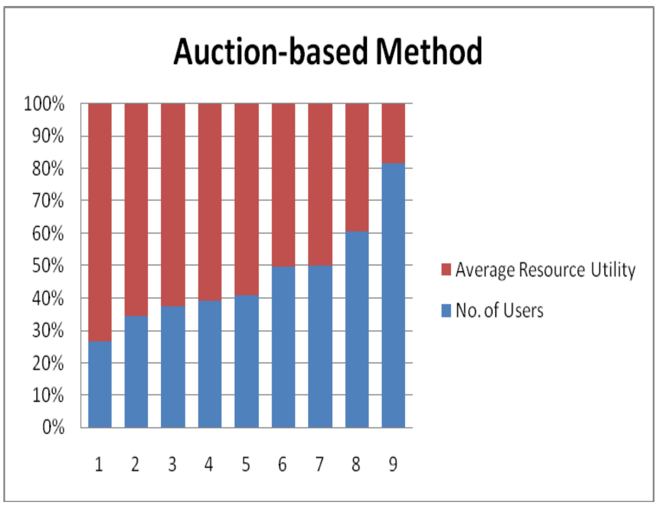

Figure 2. Average Resource Utility

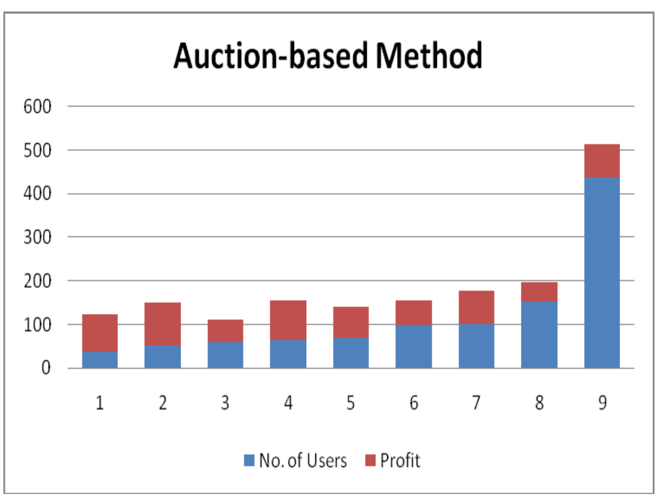

Figure 3. Profit

Table 2. Workloads from Parallel Logs

Type	Months	CPU	Jobs
NASA iPSC	3	128	18239
LANL CM5	24	1024	122060
SDSC Par95	12	400	53970
SDSC Par96	12	400	32135
LLNL T3D	4	256	22779
SDSC SP2	24	128	59715
DAS2 fs1	12	64	40315
DAS2 fs3	12	64	66429
DAS2 fs4	11	64	66737

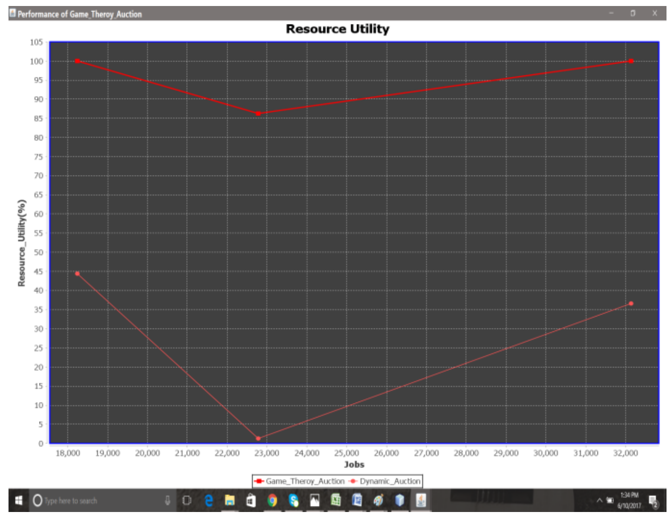

Figure 4. Comparison between Game Theory Auction and Dynamic Auction Algorithm [10] for Average Resource Utility

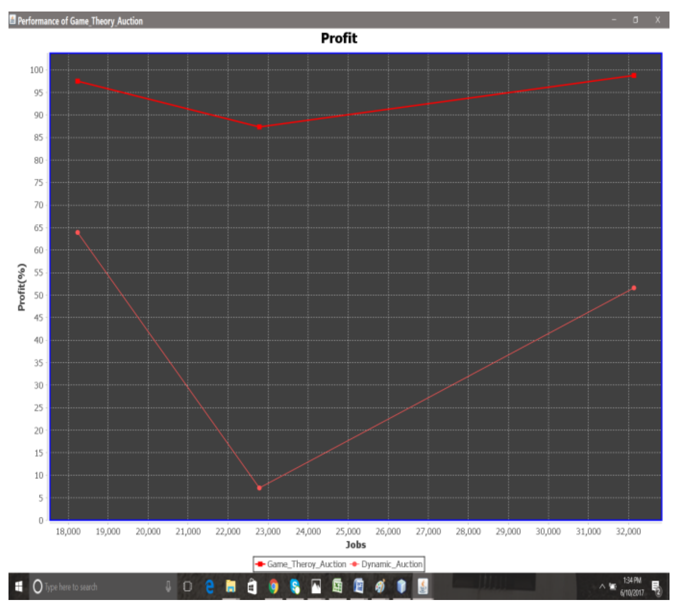

Figure 5. Comparison between Game Theory Auction and Dynamic Auction Algorithm [10] for Profit

IV. CONCLUSION

This paper proposes a noncooperative game to solve the problem of multi-user allocation in cloud scenarios. The proposed model evaluates auction, bidding function, cost prediction and equilibrium point analysis. The results demonstrated that resource allocation during a noncooperative game between users achieves Nash equilibrium point even when common knowledge of the environment is insufficient. Simulation results of the model shows that despite competition among users and presence of users with various financial capability and deadlines in the execution of their demands, the system achieves a sustainable mode after executing a few stages and the proposed bidding function prevents from reaching standoff. It is concluded that in auction-based method using game theory if the number of users increases, profitability metric in the model increases but average resource utility metric in the model remains unaffected (100%) with different workloads. Also proposed algorithm provides better results than the existing algorithm with different workloads.

REFERENCES

[1]Parsa S., Shokri A., and Nourossana S., "A novel market-based grid resource allocation algorithm", International Conference on Network Digital Technologies, Tehran, Iran,2009.

[2]R.Wolski, J.Brevik, J.S.Plank and T. Bryan, "Grid resource allocation and control using computational economics", Berman F., Fox G., and Hey A., editors, Grid Computing: Making The Global Infrastructure a Reality, John Wiley & Sons, 2003.

[3]Izakian H., Abraham Ajith and Ladani T.B., "An Auction Method for Resource Allocation in Computational Grids", Future Generation Computer Systems, 26(2): 228-235, 201.

[4]Das Anubhav and Grosu Daniel, "Combinatorial Auction-based Protocols for Resource Allocation in Grids", 19th IEEE International Symposium on Parallel and Distributed processing (IPDPS'05) – Workshop 13, Vol. 14, 2005.

[5]Wang X., Teo Y.M. and Gozali J.P., "A Compensation-based Scheduling Scheme for Grid Computing", In Proceedings of the Seventh International Conference on High Performance Computing and Grids in Asia pacific Region, 2004.

[6]N.Nisan, Algorithmic Game Theory, Cambridge University Press, 2007. View at MathSciNet.

[7] M. J. Osborne, An Introduction to Game Theory, vol. 3, Oxford University Press, New York, NY, USA, 2004.

[8]Y.Shoham,"Computer science and game theory," Communications of the ACM, vol. 51, no. 8, pp. 75–79, 2008. View at Publisher · View at Google Scholar · View at Scopus.

[9] L. Guijarro, V. Pla, J. R. Vidal, and J. Martinez-Bauset, "Entry, competition, and regulation in cognitive radio scenarios: a simple game theory model," Mathematical Problems in Engineering, vol. 2012, Article ID 620972, 13 pages, 2012. View at Publisher · View at Google Scholar · View at Zentralblatt MATH.

[10]Wei-Yu Lin, Guan-Yu Lin, Hung-Yu Wei, "Dynamic Auction Mechanism for Cloud Resource Allocation", 2010 10th IEEE/ACM International Conference on Cluster, Cloud and Grid Computing.

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