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A Resource Allocation Method for Computational Grids Based on On-line Reverse Auction

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***Abstract*—Resource allocation and task scheduling are two key technologies in grid computing system. The market-based resource allocation model is considered as a good one. In this paper, an on-line reverse auction method of resource allocation for computational grids was proposed to solve the problem of resource management considering the dynamic characteristics of computing resources in the computational grid environment and the advantages of economics mechanism. In this method, the current price can be set using former bids. And bidders arriving one by one the on-line buyer must be required to make a decision immediately about each bid as it is received. Then we prove that the algorithm is incentive compatible and simulate the auction protocol in Gridsim to evaluate its communication demand.**

Keywords-grid reource allocation; online reverse auction; incentive compatibal; gridsim

I. INTRODUCTION

Grid computing [1] came along from the need to utilize globally distributed computing and storage resources in a networked environment for solving large scale problems in science, engineering and commerce [2]. Auctioning models are a source of solutions to the challenge of resource allocation in Grid because they provide a decentralized structure, are easier to implement than other economic models and respect the autonomy of resource owners [3].

In the literature, we find several work applying auction models for resource management for Grid systems. In [3] MARCOS et al. present an example of reverse Dutch auction [4] for Grid computing. However there is a bottleneck in this auction protocol. In the process of auction the more increment of t-he price the less rounds of the auction. This deals to a higher closed price. On the contrary, the less increment of the price, the more rounds of the auction, which make the communication requirement increase. Mathias et al. [5] present a resource allocation protocol according First-Price sealed auction. This auction protocol is actually off-line problem because the organizer of an auction makes decisions after receiving all the bids. Because of dynamic characteristics of computing resources in the computational grid environment, supply and demand all change dynamically. Players are not willing to wait a long time for the final purchase decision because waiting may make costs increase and efficiency lower. And it may compromise the social welfare of the system by excessively benefiting users. This decreases the enthusiasm of the resource providers to provide his resources.

In this paper, we apply on-line reverse auction [6] to computational grid for solving the problem of resource allocation. In this method, the current price can be set using former bi-ds. The bidders arriving one by one the on-line buyer must be required to make a decision immediately about each bid as it is received.

The paper is structured as follows: In the second part of paper we introduce the simple grid resource allocation model based on auction and the on-line reverse auction protocol. Then we will prove this pricing algorithm is incentive compatible. We simulate the auction protocol in a Grid simulator called the GridSim [3] and compare the communication requirements with three one side auction protocols, namely English [7], Dutch [4], First-Price Sealed auction in the third section. At last we conclude in section 4.

II. A RESOURCE ALLOCATION METHOD BASED ON ON-LINE REVERSE AUCTION

A. Simple grid resource allocation model

In this method, there are three roles in the auction. They are described as follows:

1) A user is the consumer of a grid service.
2) A resource provider is an organization that provides computational resources to users for money. Typically, resource provider and users are not part of the same organization.
3) A broker is responsible for submitting and monitoring jobs on the user's behalf. The broker creates an auction and sets additional parameters of the auction such as job length, the quantity of auction rounds, the reserve price and the policy to be used. As the broker also plays the role of auctioneer, it posts the auction to itself; otherwise, the auction would be posted to an external auctioneer.

In reverse auctions, the user starts the auction and the resource providers bid to sell a service to the buyer. A simple Grid resource allocation model is described in Figure 1

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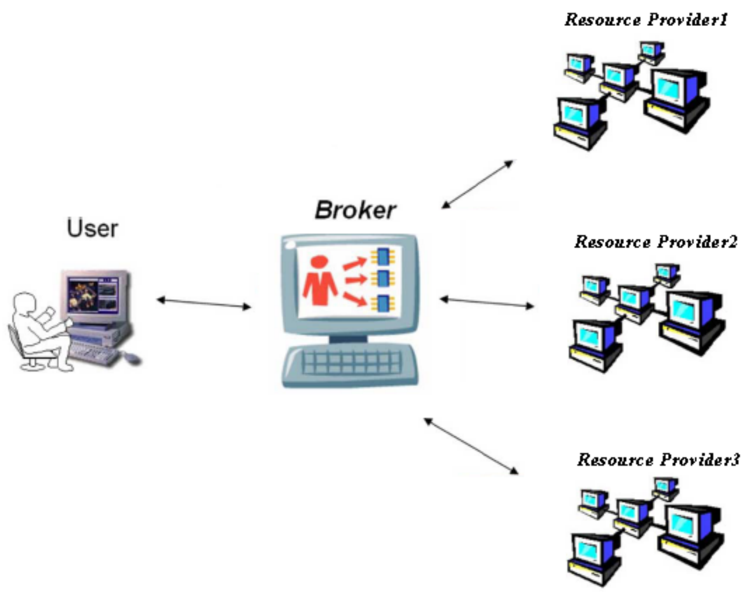

Figure 1. A simple Grid resource allocation model

B. *Auction protocol*

In this paper, we use on-line reverse auction and its online mean pricing algorithm as the auction protocol. On-line reverse auction is an auction protocol that bidders arrive one by one and on-line buyer must be required to make a decision immediately about each bid as it is received. Online mean pricing algorithm is that the current price can be set using former bids.

The auction protocol must work at some basic assumptions: each bidder in the tender process could be allowed to bid only once and can not see the other bids and the bid order; there are no binding agreements of cooperation among the bidders. The process of the auction can be described as Figure 2.

Initially, the user submits jobs to the broker with the initial price b_0 and the budget of the job and the deadline of the auction. The initial price b_0 is the highest price that the user can't regret when he trades with the first bidder at this price. The budget is the most money the user can spend on the job. The broker creates an auction and sets additional parameters of the auction mention before. It posts the auction to itself.

The broke informs the bidders that an auction is about to start. Then, the broke creates a call for proposals (CFP) and broadcasts the CFP to all the bidders. Then one auction is begun. In the process of auction, when the broker receives a bid, it will make a decision immediately. If one bid is below the current price the auction is stopped. Otherwise the current will be adjusted using the bid.

The algorithm is as follow:

```
BEGIN
    current_price = initial_price;
    sum = initial_price;
    while (if before the deadline )
    {
      Receive bid;   // Receive one resource
    provider's bid.
      If ( bid<=budget )
      {
        LastBid=bid;
        if (LastBid< =current_price ) // The
    user purchases the resources at current_price.
            return current_price;
        else   // Adjust the current price
    according online mean pricing algorithm.
        {
            sum+=LastBid;
            current_price = sum/2;
        }
      }
    }
    return LastBid; // If there is no agreement
    before deadline, the user will purchases the
            // resources at the last bid.
END
```

If the auction is end before the deadline, the user and resource providers will trade at current price. Otherwise the user will purchase the resources at the last bid.

When the auction ends the broker informs the outcome of the auction to the user and the resource providers.

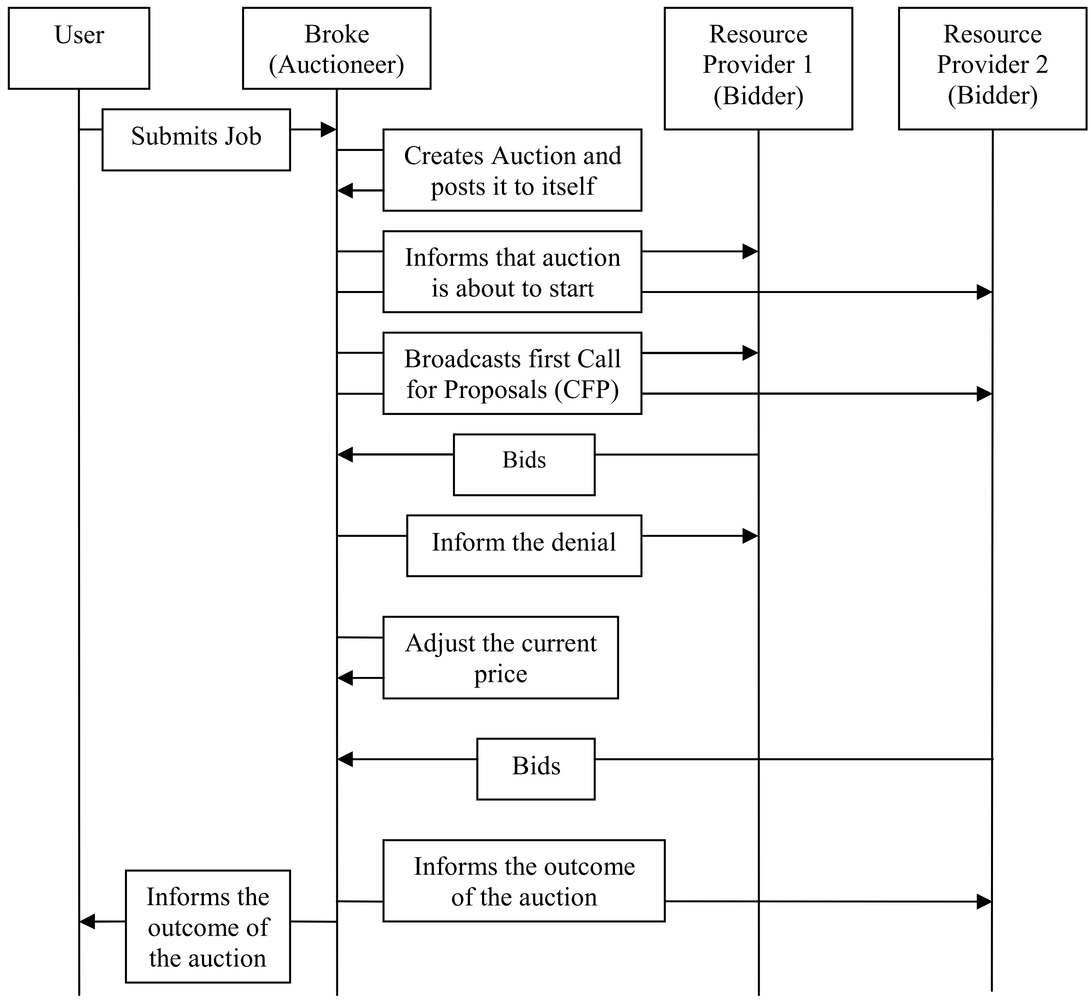

Figure 2. General view of our auction model

C. *Incentive compatible*

An auction is incentive compatible [8] if the bidders in the auction are rationally motivated to reveal their truthful valuations. In the environment mentioned before, information cannot be exchanged among bidders and the buyer can not acquire the bid information before the auction begins. The buyer wishes the sellers can bid their truthful valuation and the sellers wish to maximize their utility without too much considering their own biding algorithms, so it is necessary to design an incentive compatible mechanism for on-line reverse auctions. In an incentive compatible on-line reverse auction, the price set to the bidder is independent of his bid, and the bidder can maximize his utility value by bidding truthfully.

For an on-line reverse auction, let v_i be the i-th bidder's truthful valuation, b_i be his bid, and p_i be the broker's current price paid to the i-th bidder, i = 1, 2, ..., n..

If $b_i > v_i$, we can assume $b_i > p_i > v_i$. Because the transaction doesn't occur the utility of the bidder is $U_i = 0$. But if the bid is truthful, the bidder can get the utility is $U_i = p_i - v_i > 0$.

If $b_i < v_i$, we can assume $b_i < p_i < v_i$. The bidder's utility is $U_i = p_i - v_i < 0$. But if the bid is truthful, the utility is $U_i = 0$ because the transaction doesn't occur.

In conclusion, if the bidder's bid isn't truthful, the bidder's utility is less than the utility when the bid is truthful. So the bidders are rationally motivated to reveal their truthful valuations in order to maximize their utilities.

III. SIMULATE EXPERIMENTS

We will simulate this resource allocation method in a Grid simulator called the GridSim [3] and compare the communication requirements with three one side auction protocols, namely English, Dutch, First-Price Sealed auction to evaluate its communication demand.

In our first simulation, we follow the experimental method present in [3]. A user submits experiments (jobs) to her broker, which in turn initiates an auction for each job.

We have implemented policies and responders for English, Dutch, First-Price sealed, and on-line reverse auctions. We simulated configurations of 1, 5, 10, 20, 30, 40 and 50 resources, each with 1000 MIPS (million instructions per second) processing capacity. The configurations have 2, 10, 20, 40, 60, 80 and 100 users respectively. The cost per second of CPU is uniformly distributed in 20% around 10. The limit of auction rounds for English and Dutch is set to 10 and each round with timeout of 1 minute. The First-Price sealed auction and on-line reverse auction has only one round. Each user generates 10 jobs uniformly distributed in an interval of 5 hours. The job length follows a uniform distribution from 2000 to 5000 MIs (Millions of Instructions). A user receives a budget uniformly distributed between 300 and 900 to spend with the execution of jobs. We consider that a user wishes may spend from a minimum of 10% to a maximum of 100% of this budget to have her jobs executed. To choose the price paid to execute a job, the user utilizes her budged proportionally to the length of the jobs.

Figure 3 shows the number of messages exchanged for the different configurations of resources in each kind of auction. The First-Price Sealed auction model presents the least requirements of communication among one side auction in the experiment of [3]. The on-line reverse auction model also has one round like the First-Price Sealed auction, and it always has a outcome before the end of the round unlike the First-Price Sealed auction must wait until the end of the round. So the on-line reverse auction has better performance than the First-Price Sealed auction.

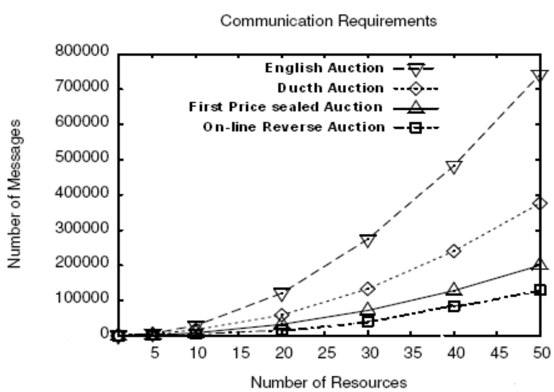

Figure 3. The communication demand of different protocols

We have also measured the spending of the users in each auction model. The cost of per second of CPU is distributed in 10%, 20% and 30% around 10. There are 100 users and 50 resources. The job length is uniform 3000 MIs. Figure 4 show that with the reduce decrease of the range of the cost of CPU, the spending of the users in on-line reverse auction model are more and more near that in First-Price Sealed auction model. Because in on-line reverse auction model the current price is set using former bids, the spending is less than that in English and Dutch auction model. So we can conclude that if bid in a small range, the closed price is near the maximum.

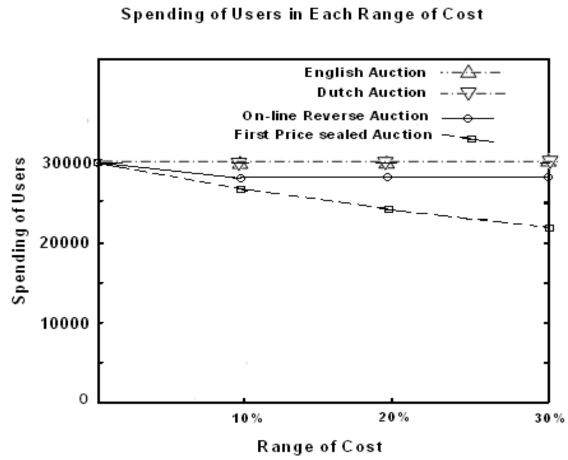

Figure 4. Spending of users in each range of cost

IV. CONCLUSIONS

We apply the on-line reverse auction to computational grid resource allocation. The broker set the current price according former bids. The bidder are acquainted the result of his bid immediately without need to wait for all bids. This auction algorithm is incentive compatible. We simulate the auction protocol in Gridsim. Experiments showed that the communication requirements of on-line reverse auction are less than traditional auctions.

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